Eramet-PT Weda Bay Nickel Exploration and Development ESIA

Prepared for:

Eramet-PT Weda Bay Nickel

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Summary. Included in this report.					Date. Approved by **Luiz Guimarães** *President Director* *ERM Indonesia*			
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List of Acronyms and Abbreviations

AMDAL	Analisis Mengenai Dampak Lingkungan (EIA)
BAT	Best Available Techniques
BFS	Bankable Feasibility Study
CHA	Cultural Heritage Assessment
CHPP	Cultural Heritage Preservation Plan
CIPDP	Community and Indigenous Peoples Development Plan
CLO	Community Liaison Officer (desa level)
CRO	Community Relations Officer (kecamatan level)
COW	Contract of Work
CSA	Community Social Assessment
ESAP	Environmental and Social Action Plan
EHS	Environmental Health and Safety
EP	Equator Principles
ESHIA	Environmental, Social & Health Impact Assessment
GHG	Greenhouse Gases
IFC	International Finance Corporation
ISP	Integrated Social Program
KADES	Kepala Desa, Village Head
LARAP	Land Acquisition and Resettlement Action Plan
LDS	Local Development Support
OP	(World Bank) Operational Policy
PCDP	Public Consultation and Disclosure Plan
PS	IFC Performance Standards (1 through 8)
RENSTRA	*Rencana Strategis*, Strategic Development Plan
RKL	Rencana Pengelolaan Lingkungan (Environmental Management Plan)
RPL	Rencana Pemantauan Lingkungan (Environmental Monitoring Plan)
TM	Technical Memorandum
TOR	Terms of Reference
TSS	Total Suspended Solids
WBN	Weda Bay Nickel

BACKGROUND

PT Weda Bay Nickel (WBN) is proposing to develop a nickel and cobalt mine and a hydrometallurgical processing plant in Central Halmahera and East Halmahera Regencies, North Maluku Province. WBN is the holder of a Seventh Generation Contract of Work (CoW) based on President of Republic of Indonesia Decree No. B.53/PRES/1/1998 dated 19 January 1998 for nickel mining and processing in Central Halmahera and East Halmahera Regencies, in a post-relinquishment contract area of 54,874 hectares.

The Weda Bay Nickel Project is be operated and managed by PT Weda Bay Nickel, which is owned 90% by Singapore-based Strand Minerals (Pte) Ltd and 10% by State-owned mining corporation PT Aneka Tambang. Strand Minerals is majority owned by Eramet S.A. with the remainder on is owned by Mitsubishi Corporation. Eramet SA is a French corporation that manages mining, processing and metallurgical operations worldwide. Eramet has had control of the project since acquiring PT Weda Bay Nickel in 2006.

The main objectives of this Exploration and Development Environmental and Social Impact Assessment (ESIA) are to document early 2010 conditions at the project site, assess in general terms the history and impacts of the past 13 to 14 years of operations and document impact mitigation measures that have been, or will be, implemented. This will provide a picture of the present and immediate future conditions in the interim period prior to the project construction startup in 2011. The map location of the Weda Bay Nickel Project is presented below.

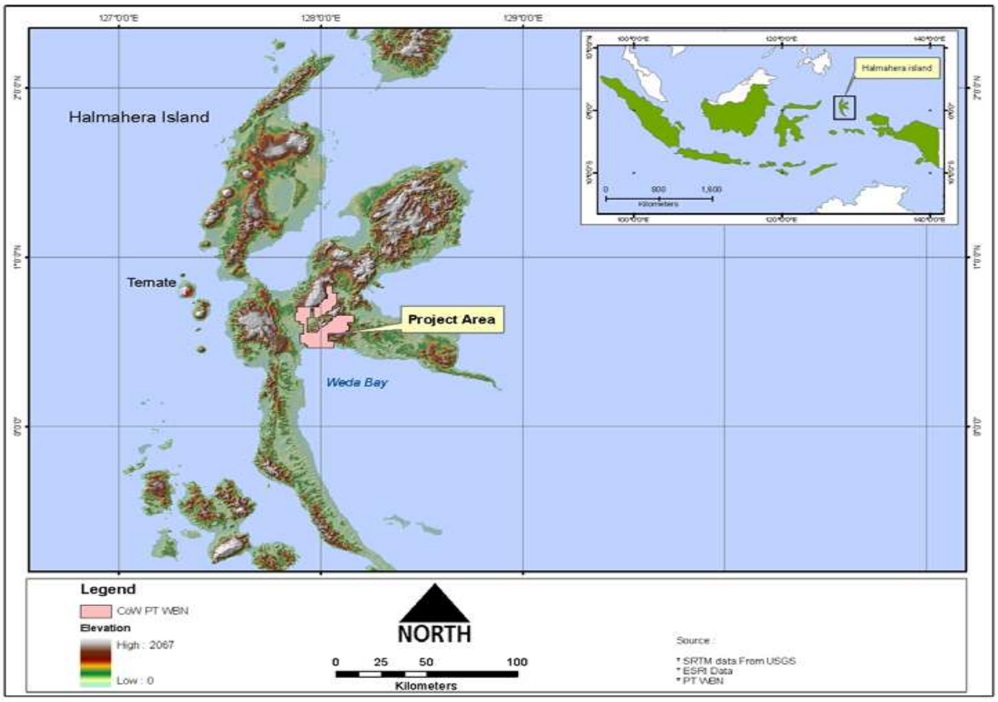

Figure ES-1 Project Location

Project Overview. After construction, the mine will be developed in a dispersed surface mining system. Topsoil and overburden will be excavated, hauled, and placed on selected areas, then used for mine rehabilitation. Lateritic nickel ore will be mined and transported to a processing plant where hydrometallurgical processes will be used to separate economically valuable nickel and cobalt from other components. Further refining will produce nickel and cobalt concentrates, ready for export. To support ore mining and processing, WBN will construct and operate several ancillary facilities including limestone quarries, sulfuric acid plant, power plant, permanent accommodation facilities, dedicated seaport and dedicated airport. The planned operational stage development program will accommodate local interests and human resources development according to the RENSTRA (Strategic Development Plan) of Central and East Halmahera Regencies of North Maluku Province.

Products and Markets. The project will produce nickel as nickel carbonate and cobalt as cobalt sulfide which will be shipped offsite for further processing. Production will increase progressively up to 60,000 t/yr. The main use of nickel is in metal alloys (due to mechanical characteristics and corrosion resistance), particularly stainless steel, followed by non-ferrous alloys, foundry and plating. The stainless steel market represents over 60% of nickel consumption. "Austenitic" stainless steels are used to a large extent in chemical and petrochemical industries, pulp and paper production, food industries, transport, consumer goods, and construction. Nickel-based alloys are important in the aerospace, nuclear, electronics, electrical, marine, desalinization, and LNG tanker industries. In recent years, export markets in India and particularly China have increased demand levels beyond those prevailing in the traditional markets for Indonesia's nickel exports in Japan, Europe, and North America.

Objectives and Benefits. The overall objectives of the Weda Bay Nickel Project are:

- Maintain and increase Indonesia's shares of the nickel world market;
- Meet projected world-wide nickel demand post 2012;
- Contribute to national income through increasing exports, taxes; and royalties;
- Contribute to development of the local economy in Halmahera and North Maluku.

The Weda Bay Nickel Project will generate the following benefits:

- Enhance the role of Indonesia as an important world supplier of valuable metals;
- Pioneer in production of cobalt from laterite nickel ores;

- Provide secure, long term employment for a workforce of 2,500 to 3,000 employees, as possible recruited locally;
- Provide training for local people, augmenting and improving skills for employment;
- Diversify economic base of North Maluku Province, decreasing dependence on subsistence agriculture and fishing;
- Provide substantial revenues at national, regional, and local government levels that can be allocated for the improvement of public services and basic infrastructure; and
- Stimulate supporting secondary business opportunities such as provision of fresh food, transportation, accommodation, catering, cleaning, repairs, and maintenance.

This study summarizes environmental and social impacts during the pre-construction (exploration and development) activities at the WBN Project. It has largely been based on data available from the Indonesian environmental and social impact analysis (AMDAL) process completed in June 2009. Information is also available from the earliest findings of a series of baseline studies being implemented according to Equator Principles Standards within the framework of WBN's Bankable Feasibility Study Environmental, Social and Health Impact Assessment (BFS ESHIA). This study serves as an advance, abbreviated, and focused version of the Bankable Feasibility Study environmental and social assessment, for purposes of pre-testing the WBN Project's ability to complete the Equator Principles/Performance Standards Environmental and Social Clearance process. A brief site visit was undertaken by ERM specialists at the end of January 2010 to conduct interviews with personnel onsite, which are major sources of information for this document. Because ERM has already been engaged in providing environmental and social assessment and management services to the WBN project for several years, this document is also based on a combination of original observations, previous documents (particularly the AMDAL environmental and social permitting effort), WBN internal documents, and other sources as appropriate.

ORGANIZATION OF THIS REPORT

In order to address directly the requirements of the MIGA Environmental Environmental and Social Clearance Process, this report contains eight sections corresponding to the eight IFC Performance Standards (PS):

- IFC PS1: Environmental and Social Impact Assessment
- IFC PS2: Labor and Working Conditions
- IFC PS3: Pollution Prevention and Abatement
- IFC PS4: Community Health, Safety and Security

- IFC PS5: Land Acquisition and Involuntary Resettlement
- IFC PS6: Biodiversity Conservation and Sustainable Natural Resource Management
- IFC PS7: Indigenous Peoples
- IFC PS8: Cultural Heritage

These Standards are addressed in this document at levels of detail varying with the importance of the issues to the WBN project and the available use.

Various annexes are attached, as referenced in the body of the report, to provide a detailed description of the ore bodies to be exploited in the project, an annotated (and translated) listing of Indonesian laws and regulations that form the institutional and legal context of the project, a complete environmental and social baseline, and a list of source documents.

As the Bankable Feasibility Study (BFS) ESHIA baseline development process is expected to continue through 2010, information in this document does not take into account all findings of various investigations. This report's findings and conclusions can be updated, once the BFS studies concerning terrestrial and marine biodiversity, water resources, and social and socioeconomic baseline conditions in the WBN Contract of Work (COW) area have been documented. Summaries of the scopes and objectives of these studies are provided in appropriate sections of this document.

It must be noted that due to the variety of sources used to compile this document, and to the ongoing challenges with standardizing orography of place names in eastern Indonesia, there is some variability in the spellings of village names. Any confusion this causes is regretted.

CHAPTER I
ENVIRONMENTAL AND SOCIAL ASSESSMENT AND MANAGEMENT SYSTEM (IFC PS1)

The objectives of IFC Performance Standard (PS) 1 are:

- *Identify and assess social and environment impacts, both adverse and beneficial, in the project's area of influence*
- *Avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities , and the environment*
- *Ensure that affected communities are appropriately engaged on issues that could potentially affect them*
- *Promote improved social and environment performance of companies through the effective use of management systems*

1.1 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Environmental impacts of the Weda Bay Nickel Project Exploration and Development phase are addressed in the following sections, starting with a description of the important pre-construction activities, most of which have already been undertaken or initiated. As pre-construction activities are primarily land-based, with relatively little expected impact on marine environments, this analysis largely focuses on impacts of exploration and development activities on terrestrial habitats and biodiversity, water and other natural resources, and the human environment.

1.1.1 *Exploration and Development Period Activities*

Exploration and development activities that have caused impacts include mineral exploration surveys, access road construction and maintenance, a large-scale mine test pit, an aircraft landing strip, and the exploration and development camp. The Tanjung (Tg) Ulie Camp, first established in 1998, now includes offices, maintenance workshops, warehouses, a small laboratory and supporting infrastructure, a helipad and and three small wooden jetties. Geotechnical investigations and other design studies are also under way. Other activities with less visible presence and less obvious impacts include an environmental monitoring network of weather stations and stream gauges, a community consultation-outreach program, and community development efforts.

Perhaps the most important impacts during the remaining Exploration and Development period will result directly or indirectly from land acquisition. Very minor land acquisitions were needed in the past to site the exploration and development activities and infrastructure, but the local consultation and other groundwork for the main program of land acquisition needed for mine development began during this period as well. The land acquisition program program for the land to be acquired for the construction of the Plant Site and the Permanent Accomodation Facilities was initiated in 2009.

The broad chronology of PT Weda Bay Nickel's (WBN) Contract of Work (COW) after the 1996-1998 startup period follows:

- 1999: Three-year exploration phase begins (20 February 1999 through 19 February 2002).
- 2000: Approval of WBN one-year exploration activities in forest area by the Directorate General of Forestry (28 March 2000 through 27 March 2001).
- 2001: Extension of exploration period proposed.
- 2002: Approval of WBN one-year exploration extension (20 Feburary 2002 through 19 Feburary 2003).
- 2004: 2nd extension of permission for exploration of Bukit Limber (Santa Monica) and Pintu (26 Feburary 2004 through 25 February 2005).
- 2005: Various extensions of permission for exploration.
- 2007: Approval of one-year Test Pit Exploration Activity (6 November 2007 through 5 November 2008), and approval for exploration in the forest area of North Maluku.
- 2008 – 2010: Development activities accelerate in the direction of beginning construction in 2011.
- 2009 2010: Commencement of socialization and negotiations for the land acquisition associated with the processing plant and accommodation areas begins.

An overview of planned infrastructure within the COW area is shown in **Figure I-1**. Much of this construction will be planned, and some minor construction activities will commence, during the remaining Exploration and Development period. Most of the roads already exist in some form, and geotechnical site studies of many infrastructure elements are being carried out from mid 2009 through mid 2010.

Drilling and additional resource studies at Bukit Limber and other field activitiese were suspended in the third quarter of 2001 because the Ministry of Forestry declined to grant the required license, in keeping with Law

41/1999 on Forestry.[1] Most mining concessions in Indonesia are on state-owned forestry land, which according to Forestry Law No. 41/1999 falls under the control of the Department of Forestry. Under Indonesian law, forestry land is divided into three categories: production forests, protected forest areas, and conservation areas. The Law does not allow any mining operations to be conducted in protected and conservation forest areas. There are currently 22 mining companies holding concessions issued before 1999 in protected forest areas.[2] WBN continued implementation of off-site project development activities.

Meanwhile, an executive regulation in lieu of law (Peraturan Pemerintah Pengganti Undang-undang, or Perpu), which can override parliamentary legislations, was issued. Perpu No. 1/2004, signed on 11 March 2004, amends Forestry Law No. 41/1999 to allow the 13 companies that had been given permits before 1999 to continue mining operations in protected forests. The Perpu was followed by Presidential Decree (Keputusan Presiden, Keppres) No. 41/2004, which gave permission for mining operations in several protected forest areas around Indonesia. Law 19/2004 affirmed WBN as one of 13 companies that met the criteria to enable them to proceed under the terms of the COW. This allowed WBN to reesume field work. Nevertheless, field work was again reduced in early 2005 following a challenge in the Constitutional Court on the ligitimacy of Law 19/2004. This challenge was rejected in July 2005, thus removing the last remaining legal impediment to exploration and development activities.

Eramet S.A. acquired the major share of WBN in May 2006 through a 100% public buyout of the Canadian parent company, Weda Bay Minterals Inc.

1.1.2 Exploration Surveys

Exploration activities to identify and quantify the location and characteristics of nickel-bearing laterite resources comprise the first and most fundamental activity in the development of a mining project. WBN has conducted exploration activities over a period of almost 14 years and has identified nickel laterite resources throughout the CoW.

[1] Article 38, Clause 4 of this law states that "Open-cast mining is prohibited in protection forest." Furthermore Article 7.3 of Government Regulation No. 28/1995 which states: "In protected and conservation forest areas, it is prohibited to collect forest products by using inappropriate methods, or carry out activities which damage the soil, or destroy the land or the trees." This would certainly include mining activities.

[2] See Inside Indonesia (http://www.insideindonesia.org/content/view/203/29/).

Exploration has usually proceeded in a sequential fashion as follows:

- Target generation–-assessment of available regional geological information, completion of helicopter-borne aerial surveys, interpretation of remotely sensed images, and consultation with local people. The focus is on surveying areas where potential resources with a high economic value have been identified.
- Reconnaissance surveys--geologists traverse the potential locations and record (map) geological features, including rock types, topographic features and the extent of laterite development. This activity is generally accompanied by sampling, usually by hand excavated test-pits, hand-held augers, or limited machine drilling to obtain samples for analysis.
- Prospect ranking--results of reconnaissance surveys are used to rank areas in terms of prospect viability which includes assessments of deposit size, geomorphology, location/accessibility, laterite thickness, and nickel grade, to determine which deposits require further detailed studies.
- Resource definition--drilling is conducted in the most prospective deposits on a regular grid established by taping crews. Diamond drilling required for resource estimation has been carried out by Indonesian drilling contractors using portable rigs. All holes drilled for this purpose used triple tube NQ core barrels. All resource drilling was conducted on regular grids oriented north-south and east-west, with grid spacing varied according to the stage of resource development. The process is generally iterative, in that wide-spaced drilling (nominally at 400 m intervals) is first completed to characterize the general properties of deposits. The most prospective deposits (or sub-areas within) are systematically drilled at closer spacings to (nominally) 200 m, 100 m, and 50 m. The spacing is considered sufficient to measure geological resources adequately to support the estimation of proven mine reserves and provide input for detailed mine planning.

All drilling is carried out using portable rigs, requiring only that sufficient undergrowth be cleared by hand to enable safe access along drilling traverse lines, with appropriate waste mangement practices implemented. In areas of high potential, drilling is sometimes supplemented by application of ground geophysical surveys (Ground Penetrating Radar) that provide additional information on the subsurface geometry of nickel-bearing layers. Previously established drilling traverses are used for the geophysical traverses.

Appendix A to this report presents in detail all the important ore deposit areas explored by WBN, with borehole maps showing the overall footprint of the exploration program in detail.

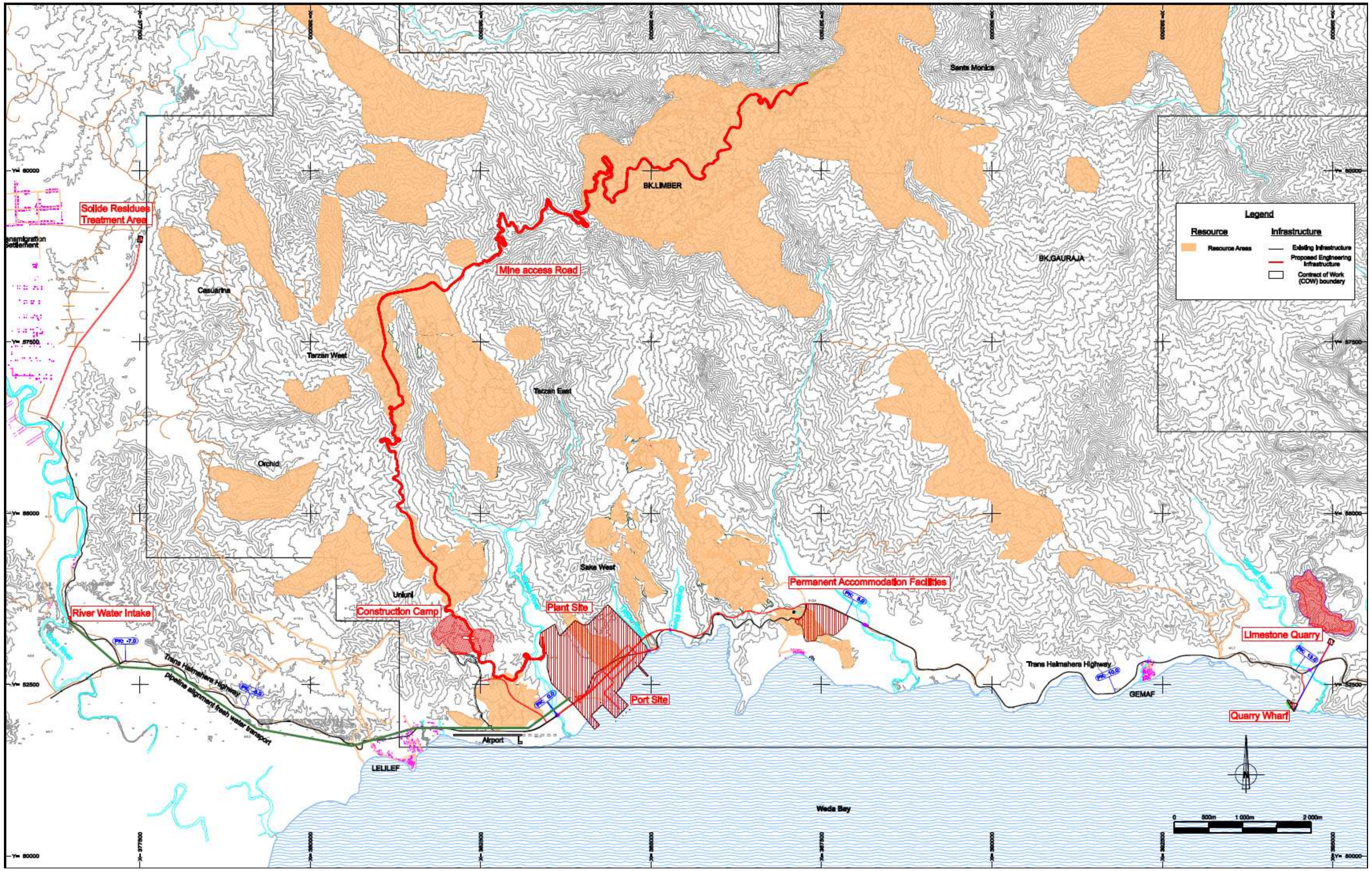

Figure I-1 Overview of general infrastructure

1.1.3 *Road Construction and Maintenance*

Road construction during the Exploration and Development stage has been limited to improvements and upgrading of the vital coastal road, officially designated the Trans Halmahera Highway from Tanjung Ulie to Lelilef. Limited maintenance has been carried out in other locations along this road to improve safe passage for light vehicles. WBN has upgraded approximately 22 km of a former logging road into the interior, and extended it by 14 km to reach Bukit Limber. WBN also established a number of tracks for geotechnical drilling at key proposed Project Locations (Plant Site, Residue Storage Facility, and Construction Camp location).

Logging operations within the COW area established a network of roads and tracks that have provided access to previously inaccessible areas. WBN has upgraded and used some of these logging tracks, and to some extent this has both limited access to such tracks by illegal loggers and avoiding the need to establish new access roads.

1.1.4 *Mining Test Pit*

In 2007 WBN excavated a large trial mine test pit within the Bukit Limber ore body (referred to in some documents as Santa Monica), at an elevation 900 meters above sea level. This trial mining pit served the following purposes:

- Enable mining methods to be evaluated;
- Expose and assess the variability of ore;
- Reconcile drilling results with bulk ore characteristics;
- Provide a location where rehabilitation procedures can be tried under operating conditions; and
- Evaluate surface water management and potential impacts.

Bukit Limber will itself support a significant proportion of mining in the first development stage of the project. Because Bukit Limber deposits occur in the central region of the Weda Bay terrain, the test pit operations there also were representative of likely conditions throughout much of the COW area.

The 125 m by 125 m by 25 m deep test pit produced an estimated 300,000 tons of bulk sample material for use in pilot metallurgical testing at Eramet's research facility in Trappes, France, to develop the metallurgical flow sheet and criteria for process plant design. This provided residue samples whose characteristics are studied for engineering the residue management facility.

Small, manually excavated test pits routinely excavated in the early period of exploration activity (as described in subsection 1.1.1) were used to obtain initial information on laterite characteristics. The effectiveness of these test pits was limited because the full laterite profile could not be penetrated. These methods were replaced after the year 2000 by alternative methods, including hand and power auger drilling (for regional reconnaissance sampling), diamond drilling (to obtain samples for density measurements), and a combination of drilling and trenching (to obtain bulk samples for metallurgical tests). The mining test pit was the culmination of these investigations. Mine design criteria were tested at the Bukit Limber test pit, benchmarking to full scale mining operations in New Caledonia that best compare to Weda Bay conditions.

1.1.5 Exploration and Development Camps

The Tanjung Ulie Camp was established in 1998 during the startup period, after a period in which the exploration geologists lived in a local village. Conveniently located on the coast and centered on the high-interest portions of the CoW, it has grown from housing about 30 persons to its present configuration accommodating more than 300 employees.

The Camp contains housing, food service, light vehicle maintenance, and most of the administrative and technical offices of the project within the COW, including the Environment and Community offices and the main nursery. The Camp also has three docks, a small tank farm, and the helipad and helicopter support facilities.

Smaller camps have been used throughout the Exploration and Development period. Short term camps are termed "fly camps." The largest permanent camp outside Tanjung Ulie are Camp 2 at Bukit Limber near the mining test pit and Camp 8 located in the North Province (ie Tofu Blewuen deposit).

1.1.6 Aviation Facilities

Central Halmahera is remote and transportation infrastructure is largely undeveloped. Since about 2000, light helicopters have been used in the exploration effort, and the Tanjung Ulie camp has had a permanent helipad/heliport throughout this time. At present, three improved landing zones are in use at Bukit Limber (Camp 2), Ake Jira, and in the Northern Province. The helicopters are not only used for personnel mobility and logistics around the COW, but also to bring personnel, documents, and priority packages from Ternate. Currently, S3 Lama and Hughes 500 helicopters are in use.

The light helicopters have been the key means of moving partially dismantled small drill rigs to remote sites with poor overland access. They have also been essential for drilling sites' logistics needs, and for moving personnel to and from exploration sites. The noise and vibration impacts of the helicopters have thus been experienced over a vast area for a duration of more than 10 years. The intensity of these impacts at any specific point has been in total quite insignificant, however.

WBN constructed a fixed wing aircraft landing strip in 2001. This basic airfield occupies 431,039 square meters (43.1 hectares) on the coast immediately east of the villages of Lelilef and west of the planned sites for the process plant and port. The airstrip will require upgrading to service project needs during the construction and operational phases. It has been constructed to the ICAO 2B standard with a length of 940 m, a 90 m wide runway strip, a taxiway, and an apron area suitable for CASA 212/CN 235 aircraft.

The airstrip is currently operated by WBN as a private unmanned facility under a permit issued by the Regent of Central Halmahera in October 2007. This permit was issued in response to a recommendation from the Indonesian civil aviation authority after an inspection in mid-2007 following upgrades to the airstrip. These upgrades included reworking and re-compacting the runway surface, which has been constructed of local coralline material quarried in the Doro Mesmesan area. The Project site is currently serviced by a regular weekly charter from Manado direct to the airstrip, a one-way trip of approximately 80 minutes, using CASA 212 (18 passenger) aircraft.

Future developments in the transition to the Construction period will include an extension of the runway to 1,500 m, complying with the ICAO 3 standard suitable for DASH 8 300 aircraft. Improvements to the airstrip will include upgrading the existing pavement on the runway, taxiway and apron area; upgrading the existing terminal building; and installing outdoor lighting. For the runway extension, an access road will be constructed and additional fencing installed.

The upgrading of the landing strip to 1,500 m in length will make it suitable for larger aircraft than the CASA 212. Currently the frequency of use of the air strip is once each week, but this will increase significantly during construction and operations. The upgrade will facilitate air transportation between Manado/Ternate and PT WBN site, and will in general improve access to the site and the Weda region.

Figure I-2 Airstrip Development

1.1.7 Geotechnical and Design Studies

Geotechnical testing is implemented to determine the physical and mechanical properties of Weda Bay laterites and the soils at various infrastructure sites, including:

- Pit and waste disposal area stability design parameters
- Equipment movement
- Road design (within and outside of the planned mining pits)
- General material handling
- Large processing and other equipment foundation designs
- Residue Storage Facility.

Since mid-2009, geotechnical drilling and testing has been in progress within the planned processing plant site and key infrastructure and support facility sites. Superficially, this work does not differ greatly from the exploration drilling, using similar small rotary drilling machines and retaining core samples. The difference, of course, is that these activities are not taking place on laterite ore bodies but generally at what will become major construction sites near the coast. Geotechnical studies thus clearly indicate where land will be acquired and can trigger land speculation activities.

1.1.8 Land Acquisition

WBN's main efforts at land acquisition began in 2009. At the same time, residents in the vicinity have been preparing to make claims on lands they believe are likely to be needed for the Project. The impacts of this are already being experienced, as assessed below.

1.2 *ENVIRONMENTAL SETTING*

The Weda Bay Nickel Project Contract of Work (CoW) is located on Halmahera Island in the wet tropics, just north of the equator. The topography is typified by a narrow coastal strip, between 3 -5km in width with fringing coral reef. Behind the coastal strip the landscape rapidly rises to a plateau which varies between 750 m to over 1000 m above sea level. Significantly higher rainfall is experienced on the plateau (averaging 4000mm) when compared with the coastal strip (averaging 2600 mm).

Key environmental features of the Weda Bay Nickel project area are discussed below, beginning with ore deposits, the basis for the overall Project, whose discovery and delineation were the main activities of the Exploration and Development period outlined above. Brief summary descriptions of the natural resources in the area, and natural-resource based human activities are also presented. Much more detailed information on the overall physical, biological, and human environment conditions in the project area, organized by environmental component and by scientific discipline, is presented in the Environmental and Social Baseline Description, Appendix C.

1.2.1 *Nickel and Cobalt Ore Deposits*

Nickel and cobalt occur in near-surface laterites (red tropical soils) formed from intense weathering of ultramafic intrusive igneous rocks including hartzburgite and dunite. The laterite profile has an averagethickness ranging between 10 m and 20 m, which is typical of laterite profiles in tropical forest regions. Overburden, containing un-economic grades of nickel, is about 2 meters in thickness, and overlies a limonite zone 4 to 8 meters thick that commonly contains 1.2% to 1.6% nickel and more than 0.1% cobalt. Beneath the limonite zone is saprolite, an intensely weathered material that becomes rockier with depth. The saprolite commonly contains 1.5% to 2.5% nickel, with low iron and cobalt content, but high magnesium content (see Figure Figure I-3 for an illustration of the laterite profile as expressed in some of the major deposits).

The survey and exploration studies described above, with followup information processing, provided a prediction of ore reserves of several classifications totalling approximately 344 million tonnes at 1.48% nickel and 0.07% cobalt at a 1% nickel cutoff grade (CoG). In total metals calculations, the ore reserves equal 5 million tonnes of nickel and 250,000 tonnes of cobalt.

Weda Bay laterite profiles vary in thickness and grade. Profiles mineralised in excess of 1% nickel in the Bukit Limber(Santa Monica) and Tofu Bleuwen regions average 15 – 17 m in thickness, while those in other regions typically average 7 – 8 m. (Mining districts and regions are identified and described in

Appendix A.) Profiles in all areas display the general layered characteristics typical of tropical laterites, comprising an upper, iron-rich component (limonite) and a lower magnesia/silica-rich component (saprolite) in an overall ratio of approximately 40:60 at a 1% Ni cutoff grade. However, this ratio varies between the major deposits. A ferricrete capping (hardpan), comprising indurated iron oxides that are commonly developed in tropical laterites elsewhere, is not a well-developed feature at Weda Bay, having been removed by erosion. The only remnants are small ironstone cobbles and, more commonly, small ferruginous pisolites that are incorporated into the upper part of the profile.

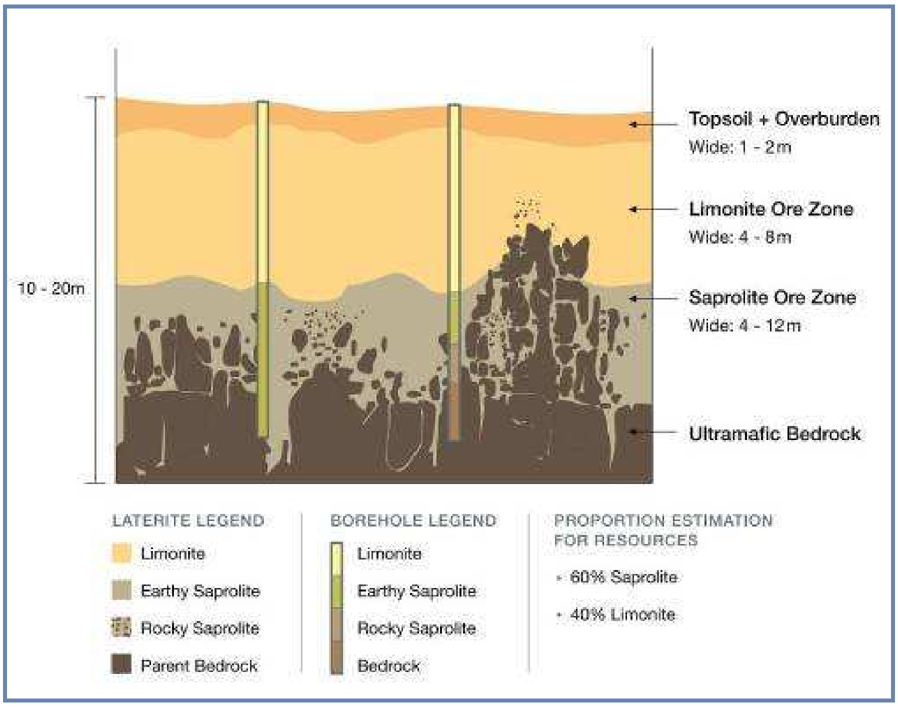

Figure I-3 Typical Weda Bay Laterite Profile

The uppermost part of the profile commonly displays local development of a thin layer (1–2 m) of aluminum rich limonite that is depleted in both nickel and cobalt (< 0.5% Ni and ~ 0.03% Co). This material grades vertically into an economically mineralized limonite profile that typically exhibits nickel grades ranging from 0.8% to 1.5% (and sometimes up to 2.0%). Nickel grades generally increase with depth in the limonite zone, while cobalt grade trends are more variable and intimately associated with the presence of manganese oxides. Cobalt grade in limonite is generally in the order of 0.1 to 0.2%, but rare intervals have been enriched to grades in excess of 1.0%. Characteristics are summarized in the table below.

Table I-1 Mineral Characteristics of Ore

Constituent	Ore Type			
	Limonite	Saprolite upper layer	Saprolite lower layer	Saprolite
Ni	1.2	1.6	1.7	1.65
MgO	2.1	21.0	28.6	24.0
SiO_2	12.7	38.7	42.0	39.97
Fe_2O_3	60.1	23.3	13.8	19.60
Al_2O_3	6.0	1.7	0.8	1.33
Cr_2O_3	3.2	1.25	0.8	1.06
Co	0.2	0.04	0.02	0.04
MnO	1.4	0.4	0.2	0.34

Units in %; source: CoWFS WBN, 2008

Detailed descriptions including borehole maps of the major deposits in the initial mining sequence are provided in Appendix A for the main targets of exploration activities, which are grouped:

- Bukit Limber (Santa Monica)
- Coastal deposits
- Ake Jira/Bongo Kfan
- Northern Province.

Current mine planning indicates ore for the first 30 years of operations will be mined mainly from the Tofu Bleuwen, Bukit Limber (Santa Monica), Ake Jira/Bongko Kfan, deposits and from the Coastal deposits of Nuspera, Ake Sake, Uni-Uni, Biri-biri, and Kakara. In the subsequent 20 plus years the deposits of Boki Mekot, Ake Lipe, Ngowen, and Jiguru will be mined.

1.2.2 Land and Forest Resources

The WBN operational area is largely covered by tropical forests of various types, specifically:

- Mangrove and freshwater swamp forest;
- Lowland forest on Ultra Basic Soils;
- Lowland forest on Alluvial Soils;
- Lower montane forest; and
- Lowland forest on limestone (i.e. Karst).

Extensive studies of all these ecosystems in terms of forest structure and composition have been carried out, as summarized in the Baseline Description. Because of its historic and present low population density, there is a greater extent of uniformity of forest land in the project area than is normally found in Indonesia. The Lower Montane Forest covers the most extensive areas within the Project region.

1.2.3 Water Resources

Several rivers (Sagea, Gemaf, Sake, Wosia, and Kobe) flow into Weda Bay in the vicinity of the project area. The two major rivers draining the WBN project area are the Kobe River on the west side, and Sagea River on the east side. While both these rivers are located mainly outside the CoW boundary, major portions of the CoW are located within their watersheds. The headwaters of the watersheds are in the mountains to the north and flow to the south, southwest and southeast. Smaller watersheds in the project area are drained by the Doma, Wosea, Tjetju, Gowomdi, Sake, Sesliwisini, and Gemaf Rivers, which all flow into Weda Bay. The spring fed Sagea Lagoon also has an outlet stream that flows south to Weda Bay. Watershed descriptions are provided in the Environmental and Social Baseline (Appendix C).

Metallurgical test work has demonstrated that the hydrometallurgical process can use seawater. However, fresh water is required for some parts of the process, including steam production and rinsing of the product, as well as for potable and sanitary water and fire fighting.

The Sagea River flows through karst terrain, which could be under Indonesian law considered a conservation area. As reservoirs in karst areas are subject to large water losses, the Sagea River was not considered as a source of water. Of the other options, the Kobe River has the largest catchment and the largest flows. When considering the required volume, the Kobe River appears to be the only source able to supply enough fresh water cost-effectively from a single river.

During the pre-construction phase water is sourced from the Sake River via a sump located adjacent to the river. The system has been installed for a number of years. Current water usage is the in the vicinity of $100m^3$/day while weekly monitoring of the flow rate of this river, since 2006, has shown the minimum flow rate to be 0.01m3/s (or approximately 860m3/s).

1.2.4 Flora and Fauna

Surveys in the CoW found that the lowland forests of the coastal strip varied in composition depending on soil type and geology (karst, ultramafic soils, and alluvial soils), and in all supports some 530 flora species. Much of the forest in the coastal strip has been modified either by the development of coconut plantations or logging activities. The lower montane forest, which corresponds to the plateau, has lower flora species diversity (231 species). The condition of these forests remains relatively intact, with only some isolated impacts associated with fire.

Fauna biodiversity on the island is generally considered poor in comparison with other Indonesian Islands, due mainly to its low mammalian and herpetofauna diversity. However Halmahera is home to many endemic species of birds, and several endemic species of reptiles and mammals. The following table presents data from biodiversity surveys in the Contract of Work area, on the number of species for each class of animal, the number of endemic species (to Halmahera Island or North Maluku region) and the number of protected species (either under Indonesian Law or International Convention).

Table I-2 Endemic and Protected Vertebrate Species in Study Area

Class	*No. species*	*No. endemic*	*No. Protected*
Birds	130	27	71
Herpetofauna	49	7	19
Mammals	22	2	10

During the 2001 and 2007 baseline surveys, 17 mammal species were found in the most extensive ecosystem, the lower montane forest, including two species protected by law, the Ornate Cuscus (Phalanger ornatu) and Rusa Timor (deer) (*Cervus timoriensis*). A low abundance of Rusa Timor was found in all types of forests. Baseline surveys also indicated 83 bird species live in the lower montane forest habitats, of which 35 are protected by law and 16 species are endemic to North Maluku or Halmahera. Overall, 9 species of reptile and 14 species of amphibians live in the lower montane forest habitat. One amphibian is endemic to Halmahera and one reptile species is endemic to North Maluku.

1.2.5 Local Resource-based Economic Activities

The rich and diverse tropical fauna and flora in the area are exploited along with soil and water resources, as summarized below:

Commercial logging Commercial logging activities are present within the project area. There is widespread evidence of both clear-cutting and selective logging, mainly in lowland rainforest areas where the largest trees exist. As noted above, an effect of logging operations has been the establishment of a network of roads and tracks that have provided access to previously inaccessible areas. WBN has upgraded and used some of these logging tracks, thereby limiting access to such tracks and avoiding the need to establish new ones. The nickel ore body areas themselves support dense but relatively low forest with trees less than 20 m in height and with bole diameters less than 30 cm. In general, these areas have not been subject to commercial logging.

Small scale logging Selective logging is carried out by local villagers to provide timber for construction of boats, buildings, bridges, and other other structures. These activities have mainly affected lowland forests and the landward fringes of mangrove forest, close to the villages.

Farming and harvesting of terrestrial resources Within the project area, there is a discontinuous coastal plain up to 500 m in width, which is partly occupied by coconut plantations. The villages are also situated on the coastal plain, together with small farms and gardens growing annual crops such as corn as well as a variety of fruit trees. Sago palms are not cultivated, but grow in swampy parts of the coastal plain as well as in swampy alluvial areas bordering the larger rivers and their estuaries. Sago is harvested extensively by local villagers in a simple leaching process. Other palm materials are used for thatching of roofs and walls of permanent and temporary dwellings. In general, the utilization of these resources appears to be at sustainable levels. Small numbers of livestock, mainly goats and cattle, are kept by some villagers.

Small farms are also present along the alluvial valley of the Kobe River. An extensive area has been cleared and developed for more intensive farming as part of a Government of Indonesia Transmigration Project. The project included the construction of irrigation systems using the Jira and Seloi Rivers. The Transmigration scheme was not particularly successful, and many of the settlers transplanted from other islands abandoned their farms at the end of the last century.

Fishing Harvesting of fish and other marine products is widely practiced within Weda Bay, using a variety of methods. Fishing activities cluster near the shore, particularly around the coral reefs that occur in patches in shallow, near shore areas. The calm conditions that occur in the Bay for much of the year also enable the fishermen to venture out to sea for several kilometers, where both pelagic fish and deep water demersal fish are caught. Fish are also prevalent in the freshwater rivers and streams, but these do not appear to be exploited to the same extent as marine fish.

Hunting Small numbers of hunter-gatherer people live in the interior of Halmahera, mainly to the north and west of the project area. These people hunt wild animals, including wild pigs, deer and birds. Birds, including protected species of parrots and cockatoos, are also captured and sold to the caged bird trade. However, observations suggest that these species are still relatively common in comparison with the situation in other parts of Indonesia.

Mining Several companies hold local Mining Authorisation Permits, or KP (*Kuasa Pertambangan*) with in the Regencies of Central and East Halmahera. A number of KPs are located adjacent to the WBN CoW in Central and East Halmahera Regencies. (Note : A number of KPs were overlapping the CoW in East Halmahera however this has been rectified by the Regency Government). Not all KPs are currently operational. Activities of companies holding operational KPs vary depending on the stage of development, and include exploration drilling, mining and ore transportation. There are no processing facilities associated with KP mining and as such all ore is currently exported by barge from the island of Halmahera. Due to the their small scale, mining operations of KPs are highly susceptible to market fluctuations and thus activity in the KPs is directly proportional to the nickel price. Although some baseline data had been collected prior to activities associated with the KPs , it may be possible that irreversible impacts resulting from these operations have been experienced prior to any PT WBN activity.

For locations of other activities surrounding the COW, see **Figure I-4**.

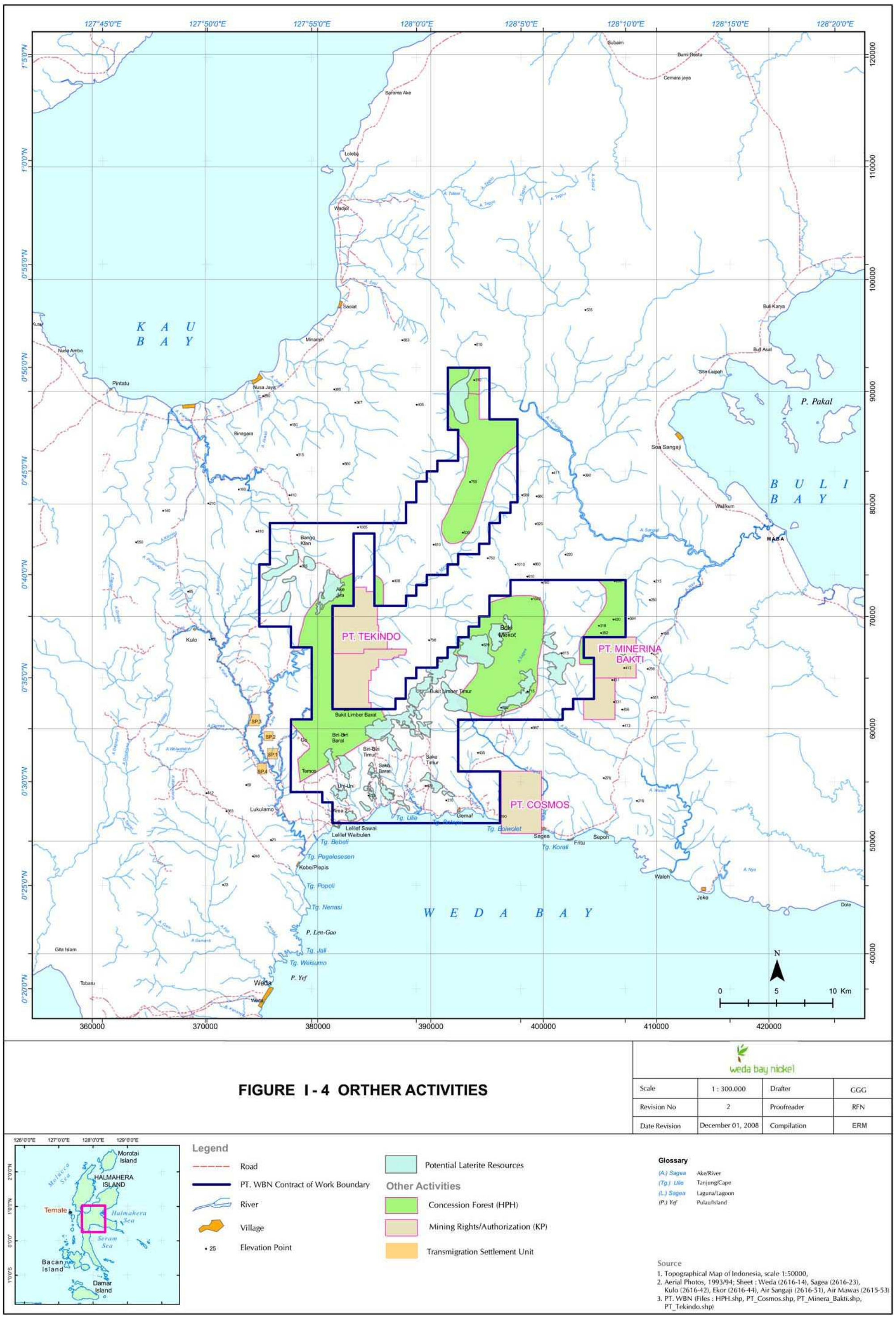

Figure I-4 Other Activities

1.3 *IMPACT ASSESSMENT*

For context, a description of the spatial scope of the project and study is provided, then a summary of overall project cycle impacts, followed by an assessment of impacts of the key activities carried out during the exploration and development phase.

1.3.1 *Spatial Scope of Impact Assessment*

Based on the extent of activities and impacts, four study boundaries were delineated for the ANDAL study, and are more or less applicable to this Exploration and Development ESIA. The rationale for selecting each of these boundaries is noted below:

Project Scope encompasses all areas where mining, processing and supporting activities will take place during the pre-construction, construction, operations, and post-operation stages. In practice, it covers most of the Contract of Work area.

Ecological Scope is defined by the potential spatial distribution of pollutants through soil, surface and groundwater and air, and includes all terrestrial and aquatic (including marine) ecosystems likely to be affected by the mining project.

Social Scope includes the area of existing social structure/systems likely to be directly affected by activities. The social boundary was determined after considering:

- Locations of communities, economic activities and public facilities, including social facilities located outside the project and ecological boundaries that may experience fundamental changes as the result of project activities, including mobilization of workforce, construction of public and social facilities, and growth of facilities for temporary economic activities.
- Boundaries of natural resources ownership, both formal and driven by local custom or tradition, likely to experience fundamental changes as a result of project activities.
- Social interactions and relationships among different community groups that will experience changes as the result of project activities.

Administrative Scope of the study area includes Halmahera Tengah (Central) Regency and Halmahera Timur (East) Regency. Weda and Weda Utara districts in Halmahera Tengah as well as Wasile Selatan (South) and Kota Maba districts in Halmahera Timur are directly or indirectly affected by the project activities. Villages in Weda and Weda Utara districts that are affected by the project include the four villages formerly known as Weda – Were, Yefetu, Fridijaya and Sidanga, Kobe Peplis, Lelief Waibulen, Leleif Sawai, Kobe Kulo Transmigration Unit, Gemaf, Sagea, and Fritu. Villages in Wasile Selatan and Kota Maba districts include Nusajaya, Minamin, Saolat, Waijoi, Loleba, Wailukum, Soa Sangaji, and Soa Gimalaha.

The ecological, social, and administrative boundaries (and the ANDAL or permitting EIA study boundary) for the Weda Bay Nickel mining and processing Project are depicted on Map IV-1 in the Baseline Description.

1.3.2 Overall Project Cycle Impact Summary

This Exploration and Development ESIA addresses the "preconstruction" phase or period. This subsection briefly looks ahead to the overall project activities and impacts that will occur after exploration and development. The context of the preconstruction Exploration and Development period can only be understood in the context of what is expected to follow. The construction phase will generate the normal impacts of any large mining-processing project in an isolated area with minimal infrastructure. The total area to be used for mining and processing for the first 30 years will be approximately 2,650 ha, which includes

- Mining areas - 1,800 ha;
- Processing plant area – 120 ha;
- Residue storage facility – 400 ha;
- Limestone Quarry and crushing plant – 100 ha;
- Temporary Accommodation Facility – 48 ha;
- Permanent Accommodation Facility – 29 ha;
- Airport – 36 ha;
- Mining and access roads – 80 ha; and
- Other infrastucture – 250 ha.

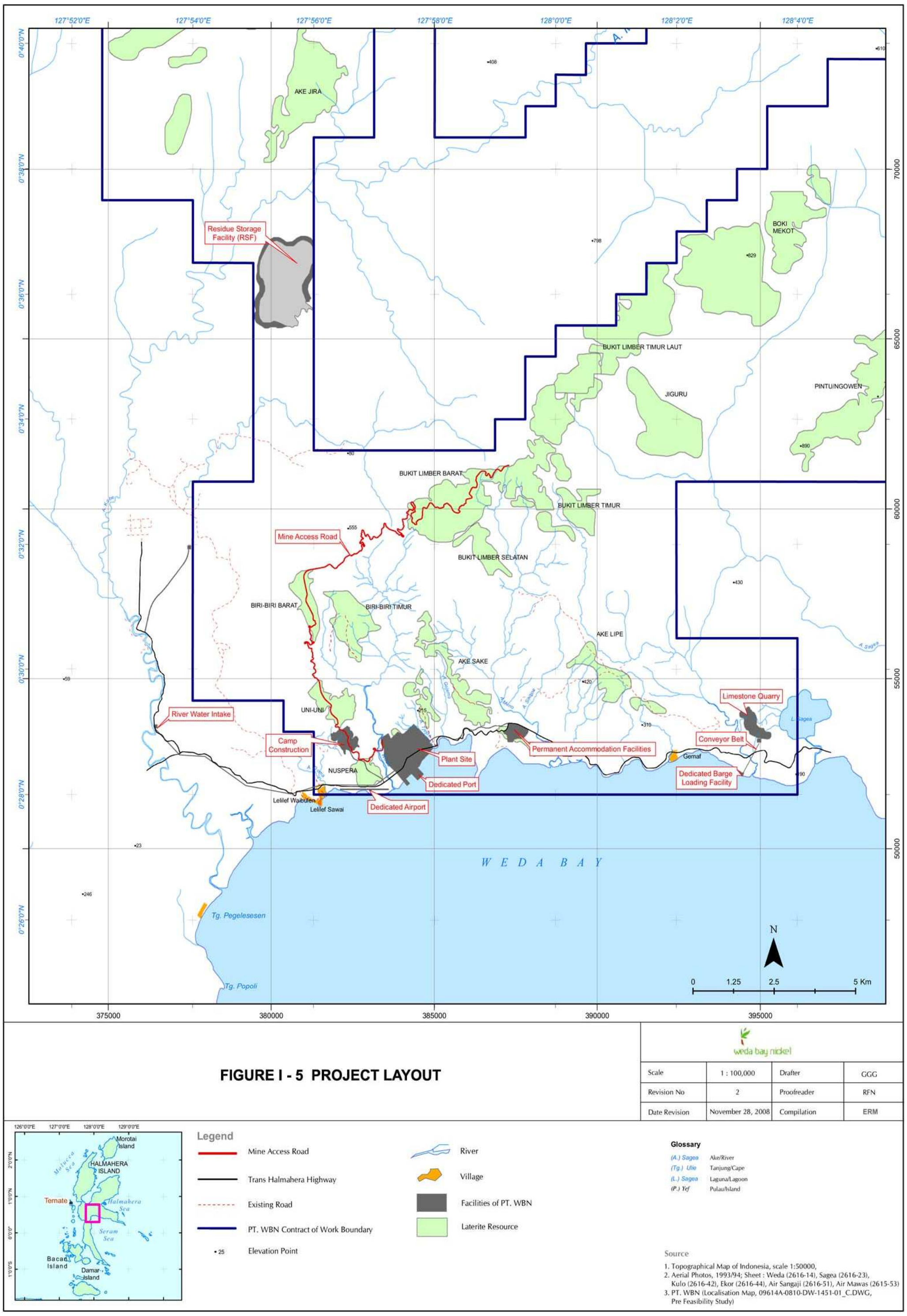

Figure I-5 Project layout

Mining and processing of ore will include not only laterite mining in dispersed locations and ore processing in the mill complex, but also a variety of supporting facilities/infrastructure operation. Identified activities that will result in significant impacts on the environment during construction, and operation include: construction and operational workforce employment; mobilization of equipment and material; land clearing; construction of supporting facilities; ore transportation ; land reclamation post-mining; limestone quarrying and processing. Mining activities mainly impact significantly on various environmental components including dust, soil erosion, landform, surface water quality including trace metals, terrestrial and freshwater biota, employment and business opportunity, and wildlife habitat and indigenous peoples' activity areas. Mined areas will be rehabilitated progressively (with Government-approved annual targets, which means the total area disturbed by mining will be much less than 1,800 ha at th end of operations. Rehabilitation is expected to stabilize the surface and provide a cover of vegetation within five years of mining; hence, the total area of disturbance from mining will always be less than 500 ha.

During operation, ore processing will generate significant impacts from: hydrometallurgical process including solid residue management; and waste water management. Other significant impacts are generated by functioning of the supporting facilities during operation, specifically the sulfuric acid plant; water supply facilities; power plant; maintenance facilities; permanent accommodation facilities; non process waste management; special seaport and special airport. Environmental components impacted are air quality, noise, surface flow rate, surface water, groundwater and seawater quality, marine biota, business opportunity, community income, and accessibility.

After the initial 30 years of mining, additional areas will be required for haulage and access roads, although most other facilities, including the processing plant and port, will be unchanged. The additional mining areas include Lipe, Ake Jira, Jiguru, Boki Mekot, Bangi Kfan and Ngowen and it is anticipated that the area of disturbance required for development of these areas will be up to 2,000 ha.

Identified post operation activities that will generate significant impacts on environment are: employee release; dismantling/removal, abandonment, and reuse of equipment and infrastructure; and reclamation. WBN plans to prepare a Sustainable Mine Closure Plan in accordance with prevailing regulations.

1.3.3 Exploration and Development Impacts

During the pre-construction stage, the main activities that may cause significant impacts are topographic and exploration surveys, test pit excavation, quarry development, and land clearing, as well as operation and maintenance of camps, aviation facilities, and other infrastructure. The activity with the greatest impacts will be land acquisition. Most pre-construction activities relating to planning for ore processing have occurred outside the project area, including the metallurgical test-work for developing the process trains, and thus the basis for designs of process plants, facilities, and infrastructure.

WBN exploration operations have been on the ground almost continuously since 1997, although with several periods of low-level operations due to civil unrest in the province, project financial challenges, and suspensions for regulatory issues. The most succinct indicator of the project impacts to date is the annual expenditure in US Dollars during the exploration and development period, as listed below. After startup a large portion of these budgets was expended in, or for activities in, the operational area. This chronology provides an indication of the temporal flux of impacts through the Project's history.

1996-97	Incorporation and Startup	2,951,413
1998	General Survey	1,735,820
1999	Exploration Year 1	828,089
2000	Exploration Year 2	2,378,964
2001	Exploration Year 3	4,826,635
2002	Exploration 1st Extension	1,154,321
2003	Suspension (Forestry Issues)	441,664
2004	Exploration 2nd Extension	1,921,341
2005	Exploration 3rd Extension	1,867,353
2006	Exploration 4th Extension	8,280,897
2007	Development	21,897,372
2008	Development	37,512,454
2009	Development	53,000,000 (forecast)

Preconstruction activities have created direct employment opportunities for local communities. Following consultation with village leaders, a rotational ("rolling") system for casual employment was implemented, in order to distribute the benefits of employment over all the villages in the immediate operational area.

1.3.4 *Exploration Survey Impacts*

Mineral exploration into relatively pristine ecosystems, although minimal in surface disturbance, has the potential to disrupt wildlife. Experience shows that the siting of dispersed drill pads over an extended area (as was the case in the WBN COW area) may prevent wildlife from finding seclusion from this type of activity. The frequent use of helicopters to move drilling rigs and camps throughout the operational areas has meant widespread noise and vibration impacts on fauna. Disposal of drill cuttings and wastewater and waste from test pits may also impact forest ecosystems.

Virtually all lands prospective for mining are within production, protection, or conversion forests, all under the authority of the Minister of Forestry and Plantations. (Forest classifications and their significance for the project are explained in Chapter VI.) The exploration process includes surveying the drill pad sites, including timber counts. Trees are cleared as required, first harvesting the economically valuable timber, for which the Government is paid established rates. Vegetation without economic use is shredded to produce mulch, which is stockpiled for subsequent use in rehabilitation.

Vegetation on drill pads recovers fairly quickly after bore holes are plugged and drill rigs moved to the next drilling site. Appendix A shows maps of the boreholes drilled at each of the major ore deposits.

1.3.5 *Road Construction and Maintenance Impacts*

Road construction during the Exploration and Development stage has been limited to improvements and upgrading of the vital coastal road, officially designated the Trans Halmahera Highway from Tanjung Ulie to Lelilef. Limited maintenance has been carried out in other locations along this road to improve safe passage for light vehicles. WBN has upgraded approximately 22 km of a former logging road into the interior, and extended it by 14 km to reach Bukit Limber. WBN also established a number of tracks for geotechnical drilling at key proposed Project Locations (Plant Site, Residue Storage Facility, and Construction Camp location).

The positive side of road construction and improvement is that portions of the COW have become much more accessible in recent years, benefiting local populations. However, this also increases the potential for adverse impacts in making timber and other forest resources more accessible for unsustainable exploitation.

1.3.6 *Mine Test Pit Impacts*

The Mining Test Pit was also conducted in the Exploration and Development period (2007). Development of the Test Pit allowed for a series of mining, rehabilitation, and water management strategies to be tested at a small scale, to determine their appropriateness and define some implementation details for the site specific conditions. Soil erosion was identified as a significant impact based on the locally intense erosion in the wet climate, the potential downstream impacts (i.e. TSS and freshwater biota), and the cumulative nature of soil erosion.

Erosion and Sedimentation. Strategies for minimizing the impact of soil erosion included appropriate stockpiling of topsoil for later use in rehabilitation, design and construction of drainage ways, and contouring of areas prior to rehabilitation. These measures were found to be effective for soil erosion and the secondary impacts. Significant soil erosion and sediment transport were experienced down slope from the Test Pit disturbed area before the now-existing, two-stage detention pond system was installed.

Erosion rates before land clearing in the general Bukit Limber area were predicted at around 7.75 ton/ha/year (based on the USLE Model). After land clearing, the erosion rates in the vicinity of the test pit increased to 250 ton/ha/year, based on the sediment volume accumulated in the sedimentation pond and adjusted for its assumed efficiency of 80%. Thus, 20% (or 50 ton/ha/year) would not settle in the sedimentation pond and would cause increased Total Suspended Solids (TSS) concentrations in the Ake Sake over the low TSS shown in baseline studies. This increase is largely reversible as vegetation recovers in the disturbed area. Much and perhaps most of the actual erosion increase was attributable to the access road rather than the test pit itself.

Vegetation. The immediate/intense loss of vegetation from the small area of land cleared for the Test Pit (11 ha) resulted in floral species composition and structure being identified as a significant localized impact. Rehabilitation of the Test Pit is the key mitigating strategy for impacts on flora (and fauna). The Test Pit has allowed for various rehabilitation methods to be tested to ensure that an established rehabilitation strategy is in place prior to commencement of the Operations stage of the Project.

Vegetation was surveyed over 15 ha in the test pit area, slightly larger than the test pit area of 11.3 ha. The survey recorded 31 species of flora, including two protected species of pitcher plants (*Nepenthes* sp. and *Nepenthes maxima Nees*). The larger surveys of lower montane forests indicate these species are distributed widely within the Contract of Work Area and elsewhere in Halmahera and Indonesia. Forests at the test pit site contained on average 253 trees/ha (diameter >20 cm), with timber volume estimated at 225 m^3/ha. Distribution of tree diameters (Table I-3) indicates sustainable regeneration is likely, with the largest portion (58.11%) being trees with the smallest trunks (20-29 cm) (table below). Impacts on the forest as terrestrial habitat are reversible and full recovery is expected in about 20 years.

Table I-3 Diameter Class of Trees in Test Pit Area (15 ha)

No	Diameter Class (cm)	Number of Trees	Percentage (%)
1	20 – 29	2,203	58.11
2	30 – 39	1,040	27.43
3	40 – 49	392	10.34
4	> 50	156	4.12
Total		3,791	100.00

Source: Hatfield Indonesia, 2007

The re-vegetation program of the Test Pit commenced soon after the completion of earthworks in late 2007. Trials were established to identify the best formula for achieve the two goals for rehabilitation:

- Stabilized landform through the rapid cover of the soil and control of drainage.
- Create a long term landform that meets the expectations of the key stakeholders.

In respect to the first objective, various trials were conducted in the use of fast growing legume cover crops. Results showed that in most cases the legume cover crops were not able to adapt to the low nutrient disturbed soils resulting from the Test Pit. Subsequent trials using local grasses proved much more successful.

Trials were also undertaken to determine the most appropriate propagation techniques for local tree species with an emphasis on forestry products (as the key stakeholder for the area associated with the Test Pit is the Forestry Department). Over 30 species have been successfully propagated in the Test Pit Nursery and 19 species have been planted as part of the Test Pit re-vegetation program.

Terrestrial Fauna In general, there were impacts on all terrestrial fauna inhabiting the forest plot that was cleared for the test pit, reducing the availability of habitat. However, the cleared areas are very small compared to the overall extent of lower montane forest in Halmahera. Many of these impacts are temporary and reversible, and complete recovery of terrestrial fauna in restored areas is expected after about 10 years (in 2017 at the Test Pit, although production mining in this area is likely to start before then).

Aquatic Biota Soil erosion caused increased rates of suspended solids, and then sedimentation, respectively affecting plankton and fish, and then benthic organisms. Although these impacts were not detected, it is suspected that the channels of Ake (stream) Bukit Limber, the lower Ake Sake, and eventually Teluk (Bay of) Weda would have experienced short term, intense but reversible impacts on aquatic biota.

Socio-Economic Job opportunities in Test Pit development included heavy equipment operators, truck drivers, surveyor assistants, geological field assistants, environmental field assistants, as well as opportunities associated with support services such as catering. These mirror the types of employment that will become available in the construction and operation periods. Test pit employment was however of quite short duration, with the exception of personnel employed on re-vegetation activities.

1.3.7 Exploration and Development Camps Impacts

The key impact of Tanjung Ulie Camp has been to facilitate all activities of the exploration and development period.

About 7 hectares of coconut palm and other coastal zone vegetation were cleared for the Camp, and the land has not been available for agricultural uses. The site is however a minor portion of the coastal zone land available in the Project Area. For the past 10 years, Tg Ulie has functioned as the busiest center of economic activity in the project area, and its real impacts have been the benefits of employment centered at the Camp on the project area villages.

Tanjung Ulie has the usual human settlement effects of producing sewage and solid waste, which are managed by a small sewage treatment system and a well developed program of recycling, both operated by the Environment Department. There are minor noise and air quality impacts from the approximately 25 light vehicles and 5 medium trucks that operate out of Tanjung Ulie, as well as the electricity generators. In late 2009, a small fuel tank farm was constructed at the west end of the Camp, with each tank enclosed in a secondary containment berm in accordance with Indonesian Government Regulations.

1.3.8 Aviation Facilities Impacts

The key impact of the aviation operations during the exploration and development period has been to greatly improve the accessibility of the project area, almost exclusively for the benefit of WBN personnel, though local residents and government officials have been transported at times. There have been widespread impacts of noise and vibration from aircraft and particularly the helicopters throughout the exploration period, as aviation provided the logistic connection between Tanjung Ulie and the drilling sites. While these impacts have been quite frequent at the airstrip, helipad, and improved landing zones, for most portions of the large operational area they have been transient and short term.

- ***Special Airport Construction.*** Construction of the airstrip removed 43 hectares of lowland and coastal zone vegetation, replacing it primarily with bare compacted soil and low shrubs and grasses. While there has likely been some erosion from this area, this seems to have been minimal, as the airstrip site is of course almost completely level, and the coastal zone soils are not particularly dispersive. Sedimentation effects on near-shore coral reefs have not been noted to date.

- Herbicide (Roundup) has been used to control vegetation on the airstrip. Application has been from manually-pumped backpack dispensers to individual weed clusters and shrubs. The main active ingredient of Roundup is the isopropylamine salt of glyphosate, with the surfactant polyethoxylated tallow amine (POEA) another important ingredient. Most of these ingredients not absorbed by plants rapidly bind to soil particles and are inactivated, or are degraded by bacteria. Small amounts of the herbicide may at times be carried with runoff into the nearshore marine environment. Aquatic organisms are more sensitive to glyphosate than terrestrial life, but the impacts are unlikely to be continuous, cumulative, or even measurable.
- ***Helipads and Helicopter Landing Zones*** The heliport at Tanjung Ulie stores Avtur (jet fuel) and routine helicopter maintenance is carried out there. Some very minor spills of fuel and turbine and hydraulic oil may have occurred over the years, but there is no obvious evidence of this. Improved landing zones have caused somewhat more extensive tree clearing than would have otherwise been needed for the distant camps, but this involves a hectare or less in most cases, and sometimes meant that it was unnecessary to clear a vehicle route into exploration camps.

1.3.9 Geotechnical and Design Studies Impacts

Superficially, geotechnical drilling is quite similar to exploration drilling, with similar technology. Drilling fluids other than water are seldom used, and most wastes are ordinary trash and some scrap metal, which are collected and sold for recycling. Most drill crews are close enough to Tanjung Ulie to be housed there, so there are few of the impacts from temporary camp sites that occur with much of the exploration drilling. In general, the direct impacts of this program are minor. Other types of design and engineering studies to date, such as the ore transportability testing (trial use of conveyor belt systems) being conducted in January 2010, appear to be brief and have even fewer impacts.

There has been an indirect impact of the geotechnical program, however, that appears not to have been anticipated. As geotechnical bores have been drilled out around the main processing plant and support facility sites, there has been intense activity by local residents to clear trees and brush at numerous points over a large area, estimated at more than 100 hectares, to establish claims for land and crop compensation.

1.3.10 *Land Acquisition*

Land acquisition during exploration and development has been minor, approximately 50 hectares for the airfield and Tanjung Ulie Camp. However, this has all been land near or on the coast, and so has encroached disproportionately on coconut land. Copra production has been the most important economic activity in the Project region for at least a century, at least until WBN began nickel-cobalt exploration. Most of the exploration work in the interior around the ore bodies has been on Forestry land, requiring no interaction with landowners.

Prior to construction, the acquisition of significant areas of land for the Project footprint, again mostly on the coast, will be among the most important activities in the remaining year or two of the exploration and development period. This program will result in various impacts on the local community. Community incomes will increase temporarily; however this will be balanced by changes in land ownership and resulting changes in livelihood, which unless closely managed, may be induced negative impacts.

In general, it appears there will be little or no physical displacement in the land acquisition process, as most project sites are unoccupied. Economic displacement will occur, particularly where coconut plantings along the coastal strip must be acquired. Scheduling and estimating costs for land acquisition will be difficult.

As noted above, an unpredicted impact of geotechnical drilling has been widespread clearing and planting of plots on the processing plant site to acquire rights to compensation. Clearing these areas, and later planting with food crops and fruit trees, is aimed at establishing individual land claims that will later require compensation. Direct impacts of these clearings/plantings are relatively minor; much of the ground cover remains intact and the soils are cohesive and not particularly prone to erosion. Biodiversity losses appear to be small, and almost the entire area will be completely cleared of vegetation prior to construction in any case. However, a fairly large area north of the coastal road that WBN will not acquire has also been cleared, causing both direct impacts and likely social dissatisfaction if it becomes clear no compensation for this area will be paid. Unverified information indicates this area was largely cleared by newcomers to the region, as they were not permitted to establish claims within the areas where geotechnical drilling was carried out. The overall situation clearly indicates increasing challenges for WBN's land acquisition-compensation program, in terms of costs and delays and also unintended side effects.

1.3.11 *Cumulative Socioeconomic Impacts*

Most project employment of unskilled and semiskilled local residents was in support of exploration surveys, though some have worked in the Tanjung

Ulie Camp and on other activities such as the Mining Test Pit. Through the end of 2006, up to 350 local people at a time were employed during exploration activities. In the past 4 years, activities have increased and as many as 500 local residents have been employed at times.

As the biggest economic actor in the Project region, WBN has greatly changed conditions in the villages in a process that has increased in magnitude over time and appears to be cumulative. Much of the information below has been developed in the course of late 2009 and early 2010 social investigations in the WBN Project area, particularly the Focus Group Discussions (FGDs) that have been carried out to date.

Employment. Agreements early in the exploration and development period with local community leaders, notably the Kepala Desa or Village Heads, led to a system of "rotational" or "rolling" employment, such that in 2006 some 1,100 people were at some time employed on Project work. While needs for casual labor fluctuate in any exploration program, the rotational system has meant that every job is held by at least three people. This has dispersed the benefits of Project employment, and prevented inter-village disputes.

FGDs in every village have indicated widespread dissatisfaction with what is perceived as the Village Heads' abuse of their power to list candidates for WBN jobs. Apparently all Village Heads favor their relatives and political supporters for these nominations, including in-migrants

It is important to realize that even intermittent Project employment has been quite significant, as other opportunities for paid work are limited in this region. Project employees report improved family housing and health, though some benefits have been reversible when employment ceases. A clear build-up of frustration among village residents is evident to Project management; obviously, many workers with years of WBN work experience want full-time employment. Controlling expectations as the construction period approaches will be difficult.

Migration Effects. Due to the large number of workers required for the construction period, peaking at around 10,000, the run-up to this period will almost certainly raise the number of in-migrants to the Weda Bay Project coastal strip significantly. As noted above there has been a certain amount of this in-movement already. As WBN's activities and public information programs signal that construction is approaching, in-migration obviously will increase. Apart from direct opportunities with the Project or its contractors, people will be drawn in search of general economic opportunities. Such people might bring or start families in the area. It is likely the bulk of the migrants will come from Ternate, elsewhere in eastern Indonesia, and even farther afield, and that they will bring customs and languages quite distinct from those of the local Sawai and Forest Tobelo people. Such an influx, continuing into the construction and production phases, might exacerbate some socio-cultural trends already in evidence and may initiate some others, including:

- Decreasing use of the local languages, Tobelo and Sawai
- Further undermining of the local customs (*adat*) of *Adat Sawai* and *Adat Tobelo*
- Rising incidences of HIV and venereal disease infections; rising numbers of pregnancies out of wedlock, and establishment (or possibly augmentation) of a local sex worker industry
- Increasing consumption of alcohol and prohibited drugs
- Squatters/job-seekers in villages near the Project facilities and also in the places where the construction force labour recruiting is done; in-migration will provide an income source for some households by allowing them to rent out rooms, but it might lead to an inflation in local housing prices in particular and all local prices, in general.

Social Envy and Inequalities Distribution of Project benefits among communities is a perennial issue. Regardless of whether it bears some truth or is simply a mistaken perception, the "unfair" distribution of benefits complaint was raised in all Project-affected villages, for example the feeling that Leilelef Sawai and Leilelef Woebulen receive a disproportionate share of project benefits. Related to this concern is the potential for unequal distribution of project effects (both positive and negative) within communities, with women, the elderly, or the poor appearing to be at risk of being effectively excluded from Project-induced benefits.

Religious Conflict Given North Maluku's and Halmahera's recent history of religious communal violence(1999 and again in 2001), the Project must continue to be hyper-sensitive to religious community sensibilities and to maintain absolute neutrality with respect to religious issues. At all costs, the Project must avoid doing anything that might, even inadvertently, contribute to a re-ignition of religious conflict. During the Exploration and Development phase, the Project has been very careful to balance support and respect equally between Christian and Moslem communities—holding religious services for and providing benefits to both groups.

1.4 ENVIRONMENTAL AND SOCIAL MANAGEMENT PROGRAM

As detailed above, this ESIA has identified environmental and social impacts that have already been experienced during the pre-construction or Exploration and Development period, with other impacts expected to arise during the remainder of the period prior to construction. Various actions have been taken by Eramet/WBN to mitigate or compensate for negative impacts of its activities. Various other complementary or supplementary measures for mitigating future impacts are planned be taken to reduce or eliminate these impacts through the end of pre-construction activities.

Proposed measures will be communicated adequately to stakeholders and implemented. For this reason, best international practice calls for development of an Environmental and Social Management Plan (ESMP) that defines the means of communicating the proposed measures to key stakeholders and implementing these measures, following the MIGA-IFC Performance Standards for Environmental and Social Sustainability.

The ESMP must reference various subsidiary management plans, including:

- Safety Management Plan
- Waste Management Plan
- Emergency Response Procedures
- Public Consultation and Communication Plan

The framework for the ESMP with respect to pre-construction activities is outlined in the following sections. It should be noted that the approved environmental permitting (AMDAL) for the project includes and Environmental Management Plan (RKL) and Environmental Monitoring Plan (RPL) that establish the legal basis for the ESMP. While the AMDAL is largely focused on the major impacts of the Construction and Operation periods, it also addresses the Pre-Construction period, with measures described in the next subsection.

1.4.1 Actions

WBN's approved Environmental Management Plan (RKL) for the Exploration and Development period requires the following management measures:

Managing soil erosion, surface water sedimentation, biodiversity impacts in/from test pit:

- Minimize land clearing area, as possible only to required sites for activities.
- Remove topsoil from clearing sites and pile it in specified area for reuse in reclamation
- Establish adequate and stable slopes and berms for the test pit
- Surface water runoff from the overburden placement site and test pit site are managed by constructing drainage channels and directing runoff water to sedimentation ponds
- Overburden placement and cleared area are immediately re-vegetated by cover crops, fast growing plant species.

- An extensive revegetation research program is in progress since 2006, under direction of specialists from PT Hatfield Indonesia.
- TSS is managed in conjunction with soil erosion control
- Check dams are constructed to limit TSS close to the source
- Sedimentation ponds in the test pit area are constructed and operated
- All surface water runoff from test pit is directed into sedimentation ponds.
- Inventory existing flora and fauna in the test pit area prior to clearing
- Native plant species seedlings from the test pit area were collected for use in reclamation
- Rehabilitation program is developed

Employment opportunities

- Maximize number of local people employed by WBN and contractor companies
- Provide training for local people who passed the selection process, to enhance their qualification as a candidate to be recruited by WBN and its contractors

Land Acquisition

- Encourage local community to save money/ income for improving their livelihood and living conditions
- Prepare comprehensive exploration and mining activities plans and coordinate with relevant authorities, should areas of interest be occupied by local community
- Gather information on land status and area used or occupied by community
- Trace and record a land ownership history to avoid multiple claims from family members of land owner
- Document the land compensation process to avoid multiple future claims on the land
- Coordinate and work together with relevant local government and authorities ("Kepala Desa", "Camat" and National Land Agency) during the land acquisition process
- Compensate land and vegetation in mutual agreements between WBN and land owners in accordance with applicable laws and regulations
- Prioritize employee recruitment from local communities in accordance with WBN's plan

Community Unrest

- Conduct communication with stakeholders periodically
- Manage the impacts of community unrest together with the management of job opportunities and land ownership.

Other specific measures that have been identified to mitigate or compensate for negative *environmental* impacts that will be undertaken by WBN include:

- Design future access roads to avoid creating barriers and fragmenting animal territories, and modify of current access roads to allow passage of animal species with minimal risk of harm.
- Minimise noise from vehicular traffic, including off-road vehicles, through strict control of speed, training of drivers, and proper vehicle maintenance.
- Restrict helicopter routes in the operational area to the extent possible.
- Ensure that previous or currently operated test pits will be properly closed, in line with international best practice and local conditions. Within this framework, priority is given to prevent or minimize erosion.
- Minimize use of agricultural land acquired for WBN operations, and apply appropriate safeguards to protect adjacent agricultural land.
- Fuel storage facility was designed and built according to international best practice adapted to local conditions, to reduce the risk of fire, leaks, and spills.

Measures that have been identified to mitigate or compensate for negative *social* impacts include:

- Claims established on land to be acquired are being addressed with stakeholders.
- Expectations for future full employment of local residents in pre-construction and construction activities must be addressed.
- Negative impacts on local people due to current and likely future influx of workers from other islands must be addressed, possibly in focus group sessions that include both local and in-migrant workers.
- A migrant management plan may be designed and implemented in conjunction with the workforce management plan.
- Design and monitor hiring practices to avoid religious hiring quotas or preference.

To counteract any induced deleterious trends as regards maintenance of the language and customs of the Sawai and Forest Tobelo ethnic groups, WBN (through the CIPDP or other appropriate vehicle) should consider developing mechanisms (e.g., language maintenance, adat strengthening, and cultural preservation activities) to bolster local cultures and folkways.

Positive impacts of Eramet/WBN practices should be reinforced. These include:

- Direct employment opportunities have been created for local communities, and some local residents have become permanent WBN staff.
- The rotational system has meant that every job is held by at least three people, which has dispersed the benefits of Project employment and prevented inter-village disputes. This system will not continue into Construction, and the replacement system for engaging unskilled or casual labor being developed that hopefully maintains the strengths of the rotational system while eliminating its negative aspects (facilitating cronyism and nepotism by Village Heads).
- Ongoing environmental monitoring throughout the Project.
- Updating the environmental, social and health baseline of the project as part of the current BFS ESHIA studies.
- Biodiversity management, including the establishment of a plant nursery and re-vegetation trials.
- Local Development Support (LDS) program of focused community development assistance.

1.4.2 *Organization and Responsibilities*

The Community and Environment functions at WBN are grouped together under a single manager who is a key person at Tanjung Ulie. There is close coordination of social and environmental management functions. Environmental and social issues are also the main responsibilities of three senior support staff in Jakarta and two in Paris.

It should be noted that WBN established an Environmental Department in 2001, and it has operated for most of the Exploration and Development period. WBN environmental staff have moved on to management positions in other departments in several cases. WBN's Environmental Department staff currently includes:

- Superintendent (newly hired).
- Supervisors (3), for the three subsections of Rehabilitation, Baseline Monitoring, and Environmental Support Services.
- Rehabilitation has 2 Junior Supervisors and 8 staff/field assistants

- Baseline Monitoring has 1 Junior Supervisor and 5 field assistants
- Environmental Support Services has 7 field assistants, and handles waste management and environmental education.
- Construction Specialist assists in building environmental infrastructure.

The Environmental Staff as of early 2010 totals 28 people plus casual labor as needed. The Field Assistants are mostly local residents on 12-month contracts, though some are permanent staff.

The community relations and social management function is provided by the Community Liaison Officers, or CLOs. There are locally-hired staff, most of whom are permanent with some on annual contracts. Some have been with WBN as long as 5 years, others are recently hires. The CLOs spend 2 days a week in camp and 3 days in their assigned villages. There are 10 CLOs assigned to the 10 villages in the operational area. Some are new, since the Regency capital Weda was split into 4 villages.

Focus Group Discussions, a recent demonstration, and intelligence reports have all indicated to WBN management that the CLOs are inadequate. Feedback is also to the effect that they spend too much time with the Village Heads and not enough with the people. Management response has been to add training for the CLOs. There was also a decision to add another management layer above the CLOs, the Community Relations Officers (CROs), who will need to demonstrate "significant community support."

WBN is in the process, together with its Engineering, Procurement, and Construction (EPC) contractor, in planning how the Environmental and Social Management Plan will be reorganized as the Project moves into the Construction period.

1.4.3 Training

For the most part, WBN's Community and Environment personnel are trained on the job. There has been some formal training in accredited water sampling, and study trips to the Gosowong gold mine in northern Halmahera, the Antam Nickel Mine in East Halmahera, and the Pomalaa nickel mine on the Island of Sulawesi. As the Project moves toward Construction, the management is aware training will be needed and is developing plans. At present, concentration is on establishing and reinforcing a culture of work safety.

1.4.4 Reporting

WBN's reports monitoring results to various Government agencies under its RPL (Environmental Monitoring Plan) at regular intervals that vary (as detailed in the Plan) according to the types of impacts being monitored (including every 3 months, 6 months, 1 year, and 2 years). Agencies receiving reports include:

- Department of Energy and Mineral Resources, Republic of Indonesia.
- Environmental Agency of North Maluku Province
- Office of Mines and Energy of North Maluku Province
- Environmental Management Agency (Badan Pengelola Lingkungan Hidup) of Central Halmahera Regency.
- Environmental Agency (Badan Lingkungan Hidup) of East Halmahera Regency.
- Office of Mines and Energy of Central Halmahera Regency.
- Office of Mines and Energy of East Halmahera Regency

The project also reports on environmental and social management to appropriate ERAMET management personnel, and, in all likelihood, to the financing institution.

1.5 COMMUNITY ENGAGEMENT

Public disclosure and public participation are essential to a major mine development under accepted international practice, as reflected in World Bank Operational Directive 4.01 and IFC Performance Standard 1 on Social and Environmental Assessment and Management System. The Government of Indonesia (GoI) regulatory system for Environment Impact Assessment (EIA), *Analisis Mengenai Dampak Lingkungan* (abbreviated AMDAL) has comparable requirements for disclosure, consultation, and public participation. Under Environment Impact Control Agency Decree No. 08 of 2000 concerning Information Transparency and Involvement of Impacted People, the EIA process requires community/public consultation as input to the AMDAL Terms of Reference. Stakeholders with interests in this proposed activity region, express their aspirations, needs, and community values in a public meeting, and also can give their suggestions for addressing impacts.

1.5.1 *Indonesian legal & regulatory framework*

The major GoI regulations related to community engagement are:

1) Law No. 23 of 1997 regarding Environmental Management, particularly article 5 concerning Community Right, i.e. (1) equally entitled to a good and healthy environment, (2) entitled to information about the environment, and (3) entitled to play a role in environmental management framework (role in decision making, discussion, etc) (This law has recently been superseded by Law No 32 of 2009, but the provisions are virtually the same.)

2) Government Regulation No. 27 of 1999 regarding Environmental Impact Assessment; article 33 (3) states that within 30 (thirty) working days of the date of the announcement of the activities, community members have the right to propose suggestions, opinions and provide input to the proponent;
3) Head of Environmental Impact Management Agency Decree No. 08 of 2000 regarding Community Involvement and Information Availability in the Process of An Environmental Impact Assessment;
4) Minister of Environment Regulation No. 08 of 2006 regarding Guidelines for the Preparation of Environmental Impact Assessment.

The purposes of public consultation undertaken by WBN have been to:

1) Protect the community who live near the project location from potential negative impacts;
2) Empower the community in the decision making process concerning the development plans for cobalt and nickel ore mining and processing;
3) Ensure transparency in all stages of the development plan;
4) Develop equal partnerships with all community stakeholders;
5) Provide access to information to all stakeholders.

1.5.2 Consultation and Disclosure Overview

Public disclosure and public participation have been carried out by WBN since 2001. In February 2001, informal consultation activities provided local stakeholders detailed explanations on proposed nickel mining activities, prior to the public announcement of project activities.

After the public announcement, meetings were held with regional government institutions and NGOs in Makassar, Manado, and Ternate; local government and institutions in Ternate and Tidore; Regional Environmental Impact Management Agency of North Maluku Province; and local universities. Key environmental and social issues identified during the consultations included community development, local labor, land reclamation, tailings disposal, land use and spatial planning, biodiversity, indigenous people considerations, and equity for local government. WBN affirmed that all the issues would be addressed in environmental impact studies during project planning and be adapted into WBN company policy. At the same time, WBN also stated the limitations on the level of detail that can be covered under AMDAL and that potentially further studies would be required in order to address such issues adequately. Following the meetings, further discussions were also held with the Central Environmental Impact Management Agency (now Ministry of Environment) in Jakarta.

Due to financial constraints and the political situation in Maluku, activities at the WBN project location ceased in 2002 and 2003. WBN re-started the AMDAL process by issuing an announcement in *Harian Maluku Post* (local newspaper) on 12 November 2007. There was only one written response to the announcement of the project plan in the newspaper during the comment period.

Afterward, public consultation was held on 15 December 2007 using a workshop involving leaders of the affected communities. The public consultation continued with stakeholder engagement on 17 December 2007 in Corner Hotel, Ternate City.

In the framework of public consultation implementation, the proponent informed stakeholders and the parties directly and indirectly affected by the project; discussed project aspects and environmental impacts; and considered all interested community points of view as inputs to the AMDAL process. WBN prepared the public consultation-presentation materials in easily-understandable formats and language.

Public (community) inputs, suggestions, and opinions, both written and oral, were received at and after the public meetings. Inputs concerned all aspects of the project, and included statements of community needs and social values, and also some alternative suggestions for solutions. All inputs were classified into main issues that were included and further discussed in the AMDAL Terms of Reference (KA/TOR).

Public consultation invitees included:

1) Representatives of stakeholders (village leaders and staff, religious public figures, respected public figures, community public figures, and youth public figures) directly and indirectly impacted,
2) Government institutions, especially Kecamatan (sub districts) in Central Halmahera and East Halmahera, the Kabupaten (Regencies) in the project area, regional representatives and government institutions of the regencies, and the Provincial Environment Impact Control Agency (BAPEDALDA)

1.5.3 Consultation Session Details

The first public consultation (15 December 2007) was held in Tanjung Ulie with communities near the WBN's project area as participants. The discussion was divided into two sessions: First session was an introduction from the proponent and North Maluku Province Environment Impact Control Agency. The second session was the explanation of activity plans, and continued with discussions between proponent and participants led by the Environment Impact Control Agency.

The second public consultation was held in Ternate. The event was divided into two sessions: First session was an introduction from North Maluku Province Environment Impact Control Agency and Province Government (North Maluku Provincial Secretary); and second session was an explanation of activity plans led by a moderator, and continued with discussions between the proponent and participants.

Participants were actively involved in providing important inputs for AMDAL preparation in both public consultations. Some of the important points discussed were:

- Local employment at PT WBN;
- Water quality alterations caused by tailings management;
- Air pollution, related to gas emissions from processing;
- Disturbance to marine biota and terrestrial flora and fauna;
- Erosion potential and surface water quality alterations;
- Landscape alterations;
- Land reclamation activities post-mining;
- Public health;
- Improvement of Community Development programs (education, health and economy).

Based on public consultation results and the issues raised, important issues focused on during the Environmental Impact Statement Terms of Reference and Environmental Impact Assessment study reflected the list above. A Public Consultation official report was issued by the North Maluku Regional Environment Impact Control Agency. ,

1.5.4 Consultation Outside AMDAL System

Other community engagement events included:

- 8 March 2005, with Local Government of Central Halmahera Regency, Local House Representatives of the Regency of Central Halmahera, and communities; community representatives requested WBN start real activities because they were concerned about job opportunities. Local House of Representatives suggested for WBN to carry out regular community engagement in order to overcome dissatisfaction among the communities.

- 25 June 2005, Q&A session with communities of Lelilef Webulen, Sawai and Gemaf.

- 16 June 2008 at Hotel Amara Ternate, with Local Government of Central Halmahera Regency, Local House of Representatives of Regency of Central Halmahera, and witnessed by Community Leaders. The consultation subject was the demand of the Local Government and communities of Central Halmahera to review the Contract of Work of PT WBN. A number of agreements were reached.

- Regular meetings between WBN representatives and Central Halmahera Regency's Head and Local Secretary (MoM 22 April 2009), to clarify issues (e.g., rumor that Mitsubishi owned 30% of WBN project was clarified), to discuss current activities in land acquisition, and Local Development Support program. There was a request by the community to supply residents with electricity but WBN agreed only to provide electricity to public facilities.

- WBNickel News is an information media for employees and stakeholders periodically issued.

- At the end of 2009, WBN published a booklet "Celebrating Our Stakeholders" as a token of appreciation to all stakeholders for their inputs during that year. The booklet included summary points of activities undertaken since Eramet took over and planned activities up to construction stage i.e. permitting and further studies and financing.

- Ambassador of France to Indonesia, Philippe Zeller, visited the site in May 2009. The Ambassador expressed his aspirations to enhance the development of the North Maluku Province, and reinforced the importance of WBN project to the French Government by confirming the certainty of this project as the biggest French investment in Indonesia.

- During his official visit to Eramet in Paris in May 2009, the North Maluku Governor, Thaib Armayn, presented a recommendation letter for a 50-year operation of WBN to the Eramet CEO to indicate his office's support for the project.

- Prior to the AMDAL approval on 19 June 2009, approximately 150 stakeholders participated in the AMDAL evaluation meeting in May 2009.

- The first round of the General Public Information Meetings included a presentation on the Project update (including the Project schedule), the Yayasan Seloi, an evaluation of the LDS program 2009 and the proposed program for 2010. Following the meetings the floor was opened for the Community to ask questions, raise concerns and make suggestions on all aspects of the Project.

- Commencement of community group visits to the Information Centre, starting with a group of women from Gemaf on 4 February 2010

1.5.5 Feedback from Social Investigators on Consultation and Disclosure

Information on community views concerning the level of trust and communication, as expressed to social investigators at Focus Group Discussions in November 2009, are of interest:

- Villagers reported that they sometimes felt that the Company was not being as transparent with information disclosures as the villagers wanted.

- Opinions clearly expressed by some villagers indicate a perceived lack of communication and at least the perception of Company non-responsiveness to community interests and concerns.

- Members of the Nurweda Village Youth Focus Group told the social investigators that the best way to get a message to WBN was to "Hold a demonstration!" Women's Focus Groups in Lelilef Woebulen and Sagea Villages similarly indicated that the way to persuade WBN to provide outreach or assistance programs was simply to start planning a demonstration.

There were, however, various positive and constructive comments made by participants at the Focus Group meetings.

The Public Consultation and Disclosure Plan currently being drafted should provide approaches to help clarify any concerns and respond to negative precepts, while the new Information Center at the Tanjung Ulie Camp, the instigation of the Quarterly General Public Information meetings in each village, the additional resources nominated for community relations, as well as the newsletter outreach efforts should provide a firm basis for improved community-company communication and trust.

CHAPTER II
LABOR AND WORKING CONDITIONS (IFC PS2)

> The objectives of IFC PS 2 are as follows:
>
> - Establish, maintain and improve the worker-management relationship
> - Promote the fair treatment, non-discrimination and equal opportunity of workers and compliance with national labor and employment laws
> - Protect the workforce by addressing child labor and forced labor
> - Promote safe and healthy working conditions, and protect and promote the health of workers.

The WBN labor force is a dynamic phenomenon that changes in size in response to Project needs and activities. While key employees are classified "fly in fly out," and rotate from Jakarta, Manado, Ternate, or other places, the largest portion of the work force is recruited locally on a variety of employment arrangements that can include being permanent WBN staff. The size of the Project Camps in terms of overnight residents probably gives the clearest indication of the work force size:

- Tanjung Ulie 200
- Camp 2 90
- Ake Jira 90
- Camp 8 100.

The WBN Project labor situation is complicated by the effects of the large local labor force, which has been highly cost effective, but has required rotating each unskilled position among workers from three villages. The real complication is that labor, land acquisition, and community relations issues are tightly intertwined in the Project area, and are associated with indigenous people and cultural heritage issues as well. There have been labor actions—averaging one strike per year in the past few years. In all cases, labor conflicts have involved only local employees.

WBN currently employs about 873 employees with 194 local employees (174 exploration workers and about 20 supervisory and support workers) and on average 160 local daily hires as shown on Table II-1. The existing project camps can accommodate the existing employees.

Table II-1 WBN Employee in Semester 2 of 2009

Position	National	Local	Expatriate
Management Jakarta	8	-	4
Office Staff Jakarta	28	-	-
Management Site	2	-	3
Supervisor/ Expert	16	-	-
Staff Permanent/ Contract Site	24	194	-
Daily Labor	-	160	-
Sub-Contractor Worker	-	246	-
Contractor	184	-	4
Total	262	600	11
Grand Total	873		

Source : Implementation Report of RKL RPL Semester 2 2009 and Internal Q-3 Report 2009.

2.1 *HUMAN RESOURCES POLICY AND MANAGEMENT*

WBN has developed a human resources (HR) policy and procedures effective up to construction, as summarized below. A description of background events and the actual management situation through February 2010 is also provided in this section. HR policies are outlined and described in Feasibility Study Chapter VII (Organization and Manpower), and also in the Prefeasibility Study Chapter 4 Human Resources. They are adequately summarized in the Company Regulation, information from which is summarized below (version of 26 October 2009). The Regulation is checked and amended every 2 years. The Company Regulation, required under Indonesian labor laws, effectively serves as a Human Resources policy. WBN's Regulation must acknowledge slightly different policies and procedures for different categories of employee status, which are:

- Permanent Employees, employed under Indefinite Employment Agreements of indefinite term
- Non Permanent Employees, employed under Fixed Term Employment Contracts
- Daily Workers at the Halmahera Field Site.

The company regulation has been developed in accordance with prevailing laws and regulations and has been approved by Department of Manpower and Transmigration, Directorate General of Industrial Relations and Social Assurance of Manpower No. KEP.611/PHIJSK-PKKAD/X/2009 dated 27 October 2009. The Regulation provides policy and procedures for status categories listed above, probationary hire, medical examinations, working days and hours, certification of illness or injury and payment for sick leave, overtime payments, performance-based compensation, religious holiday allowance, leave entitlements (annual, religious, and maternity), recognition awards, health and safety considerations, occupational illness and injuries, medical treatment onsite and medical insurance, travel and duty changes, rules of conduct and disciplinary actions, suspensions, terminations, resignations, severance, social security (JAMSOSTEK program), retirement, and grievance resolution.

Employees in offices in Jakarta and Ternate work 5-day weeks with 2-day weekends and public holidays off. For the key "Fly-in/Fly-out" employees, whether under Indefinite Employment Agreements or Fixed Term Employment Contracts, working periods are three, 7-day work weeks followed by one 7-day rest week; or alternatively, five consecutive 7-day work weeks followed by 2 weeks of rest. The policy allows 1 day for travel to or from the Halmahera Field Site up to a maximum of 2 days travel that are counted as working days.

Interviews with management indicate that, other than minor individual grievances and personality conflicts, labor issues do not arise with nonlocal permanent staff and fly in/fly out workers, whether based in Ternate, Jakarta, or elsewhere. Daily labor, hired from among the local villages, and the small number of locally-hired contract and permanent workers, have been the persons involved in most labor actions to date, and there are repeated issues between locals and the company with respect to labor utilization and working conditions. It was stated that WBN does not really have an HR policy with respect to daily labor, and information in the Company Regulation supports this view.

It should also be noted that there is recognition that this situation is unsustainable, and a comprehensive system for the labor force, including engaging of daily labor is being developed by the Engineering Procurement Construction (EPC) contractor in preparation for the Construction period.

Given the generally low levels of education and underdeveloped economy in Central Halmahera, existence of a *de facto* two-tier labor system is not surprising. No local hire has ever had more than a high school (SMA) education, and a great many daily laborers never finished elementary school. From 1996 to the present, only two locals (Weda Bay residents) have reached the Supervisor level. . WBN has hired 194 locals as permanent employee and another 406 locals (daily labor and sub contractor).

Ring-Rotation System. Casual local labor, which does not include people from Ternate and distant areas of the Province, has been organized on a "Ring Rotation" system WBN devised in 2006. The radial Ring is a simple graphic showing radial circles around the Tanjung Ulie exploration and development headquarters camp. Villages' positions in the radial zones determine their transport mode to the camp; workers from Weda are transported by boat to the camp, other villages mostly by vehicle. More importantly, distance from the camp determines the allocation of labor slots. The innermost rings, the villages of Lilielef Webulen, Lilielef Sawai, and Gemaf, provide the largest percentages of laborers within the Rotation system.

Under the current system, the department or contractor needing labor fills out a request form; the Tanjung Ulie Administration office sends a letter to the KADES (Village Head) whose village is next in the rotation. The KADES (Village Head) provides a list of nominated workers and the WBN department selects the ones it wants. Under the Ring System, the casual labor pool is locals 18 to 45 years of age (mostly male), as shown on ID Card/KTP, who are physically qualified. Casual labor is generally hired on 21-day contracts.

There are repeated complaints with this system, the most common being that the KADESs' decisions are generally nepotistic and favor his clique or cronies. Sometimes the KADESs appoint workers who are actually in-migrants (WBN policy is that a local casual hire must be a person who has lived in the village for 6 months, or "is recommended by the KADES.") The Grievance Mechanism applicable to this system is to complain to the KADES. This system of course makes it difficult for the Company to ensure employment decisions are not made based on personal characteristics unrelated to job requirements as required by PS2.

Focus Group Discussions (FGDs) by the ERM social team have confirmed that these complaints are widely supported. Focus Group members have stated that all Village Heads tend to favor their cliques of supporters or their own extended families. The most common request from the FGDs has been to take employment recruitment decisions away from the Village Heads and allow WBN to make them.

WBN keeps records on the performance of the day laborers, and has employed skilled workers outside the Rotation system on annual contracts. Cooks are particularly valued because they reduce the catering contractor's labor overhead. After two 1-year contracts, the choices are to cut the employee from the work force, make him/her permanent staff, or lay the person off for a month, then sign another 1-year contract. Some workers have been sent to Ternate for training then put on another 1-year contract.

The Ring Rotation system has been at least partly successful in spreading training and experience to the project region. WBN has added permanent staff from local villages while drilling contractors have used laborers from the Weda region at other project sites on Halmahera and other islands. The Ring-Rotation System will end with the start of construction. The EPC (Technip) is working with WBN Jakarta on the system for casual hires during the construction period. A Strategic HR person has just been hired in support of this and other personnel management efforts.

2.2 *WORKER'S ORGANIZATION AND LABOR ACTIONS*

There is no labor union in the Company, however WBN have employee representative.

The Employee Representative system was changed substantially with the first election of the Representatives on 8 June 2009 at Tanjung Ulie. The seven departments each have Representatives, and there has not been another strike since, though there have been actions by disgruntled former employees. Employee representatives were elected by WBN employee themselves. Each department is being represented by two representatives.

The Eramet Group's Sustainability Development Policy strengthens the grievance mechanism by introducing a policy, the goal of which was "To protect and develop Eramet's employees by involving them in its actions." Eramet would foster professional development and industrial dialogue. The ERAMET Group strives to keep up constructive dialogue with personnel representatives, who are essential partners in the implementation and rollout of Sustainable Development policy.

There have been issues with grievance handling; the grievance handling procedure in WBN's Company Regulation is in fact a reinforcement of line management authority, though it states an objective to "resolve and settle any complaint, dispute, or difference (in each case, a "Grievance") of an Employee justly, fairly and promptly."

Under the Regulation, an employee may notify his/her immediate Supervisor of dissatisfaction with work assignments, salary, working hours, working conditions, management treatment, or other work-related issue. If the Supervisor cannot resolve the Grievance to the Employee's satisfaction within 10 (ten) working days, the matter will be referred to and if possible settled by consultation and mediation by a manager of the Company with responsibility for settlement of grievances pursuant to a Company Directive on Grievances. If the Grievance is not settled within 30 (thirty) days, it is referred to the President Director of the Company for resolution and decision. An affected Employee dissatisfied with such decisions may then take the steps available under applicable laws and procedures.

Interviews indicate that WBN's system of Employee Representatives is considered the Grievance Mechanism. Complaints by or about employees are handled in monthly meetings of Employee Representatives with management. The longstanding complaint about the Employee Representative system was that the Representatives were appointed by management, and did not represent workers. Management interviews have indicated that the real Grievance Mechanism has been strikes. There had been at least one strike a year, with the last one in April 2009.

Because all strikes have been initiated by local employees, the strikes have characteristics beyond simple labor actions, appearing as local reactions to the mining operations. It should be noted that WBN's period of tenure in Halmahera corresponds to the end of Indonesia's New Order Regime and the entire Reform (Reformasi) Era, in which labor militancy, demonstrations, and "people power" have been frequent channels for grievances. Strikes have been triggered by objectively minor disputes, and illustrate that Indonesians in general have a highly refined sense of fairness and justice, as well as a preference for collective action. Local employees receive lunch; there have been strikes to get breakfast and even demands from villagers to stay at the camp while working so as to get 3 meals a day.

More ominous have been the strikes in reaction to the regional government's issuance of KP (mining licenses) for laterite ore mines. Ore export mines have gone immediately into production, with minimal planning and infrastructure required (and effectively no environmental management), and these operations have provided locals (including many trained by WBN) with what appeared to be permanent jobs. The reaction of course was to question why WBN has been in exploration for more than a decade and still provides only temporary jobs. When the high-grade nickel ore has been exhausted, or prices fall, the KP operations have closed up and the "permanent" jobs have disappeared, so the situation is somewhat self-correcting. But this illustrates that the strikes have often been something other than conventional labor disputes.

At every strike, Police from the Weda district (POLRES) and Keamanan Sipil (unarmed security functionaries) arrive at the Camp immediately and at times actually prior to the start of the action. The authorities have always been very restrained, and no information has indicated that violence or rights violations occurred.

2.3 RETRENCHMENT

The WBN Company Regulation addresses retrenchment in Article 42, entitled Rationalization, which is defined as the termination of 10 or more employees, and states that the Company endeavors to prevent this occurring. Article 42 makes reference to prevailing laws and regulations, and does not indicate that a plan for "Rationalization" will be prepared to mitigate adverse impacts based on non-discriminatory principles as required by PS2. Interestingly, the Regulation notes that if Force Majeure requires retrenchment, the Company will "meet with affected Employees to determine collectively, if possible, how best to deal with necessary reductions in the total number of Employees."

The minimal preparation for retrenchment is understandable, given that WBN is a project company that is expanding as it moves into the construction phase. The last major retrenchment was apparently in 2002, when Forestry issues forced suspension of operations. WBN management is aware that it will need to be prepared for the numerous layoffs that will occur at the end of the Construction period.

Prior to the each stage of development (Pre-Construction, Construction, and Operation) WBN reports the Company's manpower plan in compliance with applicable regulations and procedures. WBN has outlined and described the Manpower Plan for Exploration and further stages in Chapter VII of the Feasibility Study (Organization and Manpower), and also in the Prefeasibility Study Chapter 4 Human Resources. The Feasibility Study has been approved by Department of Energy and Mineral Resources in July 2009.

2.4 *PROHIBITION OF CHILD AND FORCED LABOR –*

In the Company Regulation there is no mention of a policy regarding employment of persons under 18, however, WBN already follows Law No. 20 of 1999 regarding ratification of ILO Convention No, 138 Concerning Minimum Age for Admission to employment. Interviews with management indicate the Company does require employees be at least 18 years of age, and checks age against the Government-issued Identify Card (KTP). Issues of forced labor do not arise, as there is generally active competition for all work positions at WBN while prison labor in the mining sector doesn't exist in Indonesia. These issues are covered in the Eramet Group Charter of Ethics, described below.

2.5 *OCCUPATIONAL HEALTH AND SAFETY –*

WBN has for some years been actively working to institute a culture of safety in its Halmahera operations, and claims some successes. WBN reports that is in compliance with safety regulations, trains its workers in occupational health and safety, provides and enforces use of personal protective equipment (PPE) and documents and reports occupational accidents, injuries, and illnesses. WBN employees had no Lost Time Injuries (LTI) in 2009, while contractors reported some LTI. Indonesia has a long-established workplace health and safety regulatory system, and its enforcement has been a major priority in mining and other industries over the past decade.

All workers participate in morning "tool box" safety meetings prior to starting work each day. There were no serious accidents in the WBN operations last year, while the most common that did occur were parang injuries (a parang is a long bush knife, an essential tool for working in tropical forests and farms). The Safety Supervisor has issued a safety guideline procedure for parang use, and is researching the possibility of a more "ergonomic" parang.

Occupational Health and Safety (OHS) is an independent department, distinct from Environment. In addition to the supervisor, the unit has nine safety officers and seven trained paramedics. This is supplemented by a physician and 2 paramedics, who split their time between Tanjung Ulie and the Northern Province. The medical personnel are from SOS, a highly-respected medical services company/contractor. SOS personnel train WBN's paramedics to the Red Cross Class III level.

Emergency preparedness, prevention, and response planning is under active development. Risk studies have indicated earthquake and tsunami are the biggest hazards to be expected, and major tsunamis are likely to be very low frequency. All operations in the future are to be sited 10 meters above the high water line (though Tanjung Ulie Camp itself is less than 1 meter above high water). There have been training drills for disasters.

2.6 CHARTER OF ETHICS

In the middle of 2009, the concept of a Charter of Ethics was introduced by Eramet. In order to better respond to global challenges, the Group wished to adopt a Charter of Ethics based on responsibility, citizenship, integrity, and respect for the individual. The Group requires that the behavior of each of its members is exemplary in all circumstances, from the directors to all business partners of the Group.

This Charter aims at formalizing a set of general essential principles to ensure that everyone in the Group can refer to and comply with it in any situation. These rules are not exhaustive, but allied to the sense of responsibilities of each member; they are useful benchmarks for all members of the Group and all its partners. These principles apply first to the Group, but the Group intends that each of its suppliers, subcontractors, co-contractors, co-investors, sales agents, and resellers share these rules.

The Charter has two main purposes; 1) protecting the integrity of the group and; 2) promoting profitable, sustainable and harmonious growth. With regard to respecting and protecting occupational health and safety, the Group is committed to compliance with international standards of the International Labor Organization, and with the rules applicable in countries where it is present and more generally to comply with the principles of international law relating to human rights. Particularly, the Group is prohibited from using any form of forced labor or child labor, either directly or through its suppliers or partners.

CHAPTER III
POLLUTION PREVENTION AND ABATEMENT (IFC PS3)

The objectives of IFC PS 3 are:

- Avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities
- Promote the reduction of emissions that contribute to climate change.

During the future Construction and Operation phases of the Weda Bay Nickel Project, WBN will comply with the requirements of PS3 through extensive and state-of-the-art pollution prevention and abatement measures comparable to those detailed in the IFC Environmental Health and Safety Guidelines. During Construction, provisions of the General Environmental Health and Safety Guidelines will be of particular importance. In the Operational period, the Project will ensure compliance with the IFC Environmental Health and Safety Guidelines for Mining.

During the Exploration and Development period assessed in this document, the PS3 requirements are fairly minimal. Throughout the long Exploration period, WBN maintained a consciousness of environmental impacts, appointing the first Environmental Manager at Tanjung Ulie in 2001.

3.1 POLLUTION PREVENTION, RESOURCE CONSERVATION & ENERGY EFFICIENCY

IFC standards require that the project sponsor reduce the impacts of activities on ambient conditions. The guidelines underline that for small- and medium-sized projects with "limited potential emissions" it is sufficient to ensure compliance with emissions and effluent standards, as well as the application, as appropriate, of pollution prevention and control.

ERAMET has recently adopted a Sustainable Development policy and has had an Environmental Charter since 2002. The Weda Bay Project is required to comply with this policy and charter. PT WBN adopted an environmental and a safety policy in 2009. ERAMET's exploration policies and practices define how exploratory field work should be undertaken and typically address respect for the rights of others, safe operations, and care to minimize disturbances or harm caused to wildlife, vegetation, soil, and water. Measures often mentioned, all of which were applied by WBN in its exploratory program, include:

- Careful planning of temporary roads or paths used to reach drilling or test pit sites

- Use of mufflers and other noise reduction measures with respect to helicopters, planes, and vehicles
- Proper disposal of drilling wastes
- Appropriate storage of fuels
- Proper disposal of human wastes
- Management of suspended particulates in air and water.

Environmental impacts of WBN's nickel-cobalt exploration, as outlined in the Environmental Impact Assessment (Section I), have been relatively minor and minimal pollution prevention and abatement measures have been necessary. Drilling fluids other than water have generally not been used. Fuels and lubricants have been used in small quantities and often at widely dispersed locations. Generators are small and, as with vehicles and aircraft, maintained in good operating condition to minimize gas, particle, and noise emissions. Tanjung Ulie Camp's Waste Management Flowchart (Figure 3-1) outlines the key pollution control steps applied by WBN, and indicates functioning of the Company's environmental management system.

3.2 *HAZARDOUS MATERIALS*

There are very few hazardous materials used during the exploratory drilling. Tanjung Ulie Camp's Waste Management Flowchart outlines the key pollution control steps applied by WBN, which include:

- Solid wastes are separated at source into organics (which are composted for use in nursery operations) and paper, glass, and plastics that are generally sold for recycling.
- Valuable scrap metals are similarly sold for recycling.
- Waste oils and fuels are stored as hazardous wastes and sent to a licensed disposal facility.
- Waste batteries and electronic wastes are similarly handled and disposed as hazardous wastes.
- Medical wastes are incinerated in a licensed unit.
- Nonhazardous wastes that cannot be recycled are disposed in separate organic and inorganic landfill pits.

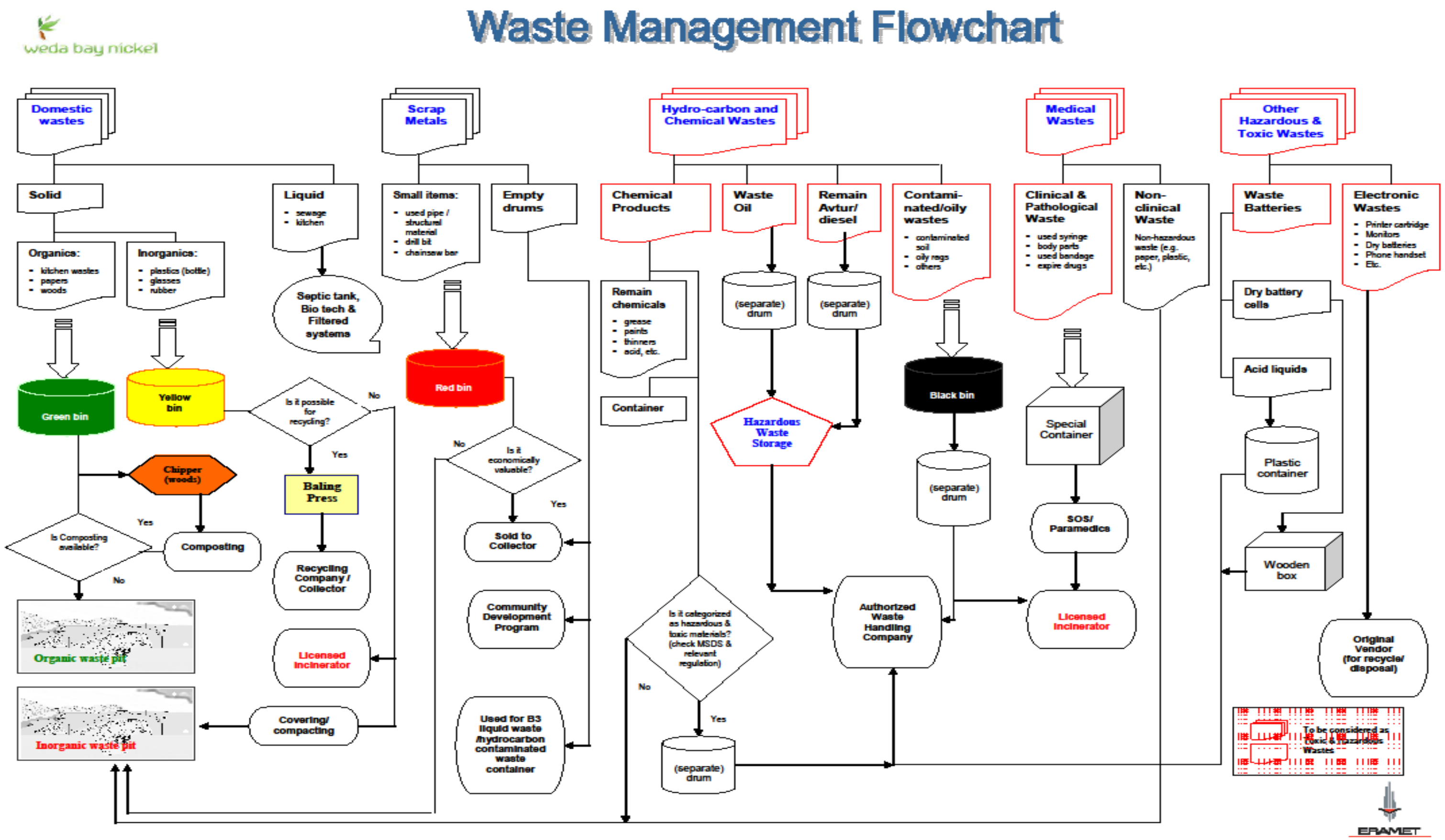

Figure III-1 Waste management flowchart

Pesticides. The nature of the Exploration and Development operations has not created a need for an integrated pest management strategy. Insecticides, herbicides, and rodenticides are used only as needed for very specific purpose. The two most important pesticides in use are:

- Herbicide--Roundup (glyphosate) used to control vegetation at the airfield
- Pyrethrin compounds used for cold fogging in the camps to control malaria vectors.

In both cases, hand-pumped backpack sprayers are used for precise application. Personnel wear appropriate personal protective equipment and are trained in proper application and made aware of the hazards of the substances.

A potential safety hazard specific to this project site is related to a suspected asbestos-containing geologic unit at the bedrock surface below the saprolite in the ore bodies. Risk analysis is in process, as there is believed to be a chance this material has been or will be incorporated into building materials used in local residences. Samples were taken in late December 2009 and sent to France for analysis, but no reports have been received as yet.

The tank farm at the west end of Tanjung Ulie Camp isolates each above-ground storage tank in its own secondary containment berm. Procedures for managing this fuel storage facility are still in development, as construction was just completed in late 2009 and the tanks are actually not in use at the time this document is being prepared.

3.3 EMERGENCY PREPAREDNESS AND RESPONSE

Emergency preparedness, prevention, and response planning is under active development in the preparation for Construction, including spill prevention, control, and countermeasures plans for petroleum products and other hazardous materials. Risk studies have indicated earthquake and tsunami are the biggest natural hazards to be expected, and major tsunamis are likely to be very low frequency. All operations in the future are to be sited 10 meters above the high water line (though Tanjung Ulie Camp itself is less than 1 meter above high water). There have been training drills for disasters.

CHAPTER IV
COMMUNITY HEALTH, SAFETY AND SECURITY
(IFC PS4)

The objectives of IFC PS 4 are:

- Avoid or minimize risks to and impacts on the health and safety of the local community during the project life cycle from both routine and non-routine circumstances
- Ensure that the safeguarding of personnel and property is carried out in a legitimate manner that avoids or minimizes risks to the community's safety and security

In general, Weda Bay Nickel does not believe that the Project has adversely impacted community health, safety, and security in its operational area to date. In contrast, by providing paid, formal sector (if temporary) employment to more than 1,000 local workers each year, it has been instrumental in the village populations benefiting from improved diet, health care, and housing conditions. WBN management in the Project area believes the Company has or is working toward Broad Community Support. There are security issues associated with the Project, which maintains a private security force and works closely with the local units of the National Police, there has been no history of excessive application of force or human rights violations in responding to and resolving numerous demonstrations and strikes at the Project.

4.1 COMMUNITY HEALTH AND SAFETY

The key provisions of PS 4 give the proponent responsibility, during design and construction, operations, and decommissioning and closure, to evaluate the potential for community impacts associated with the project considering infrastructure, equipment, and hazardous materials safety, natural resource issues, and exposure to disease. Most of these issues will arise with the Construction and Operation phases, and as appropriate these were addressed in the AMDAL process. As the project proceeds through detailed design, technological risks of the mining and processing infrastructure and equipment will be subject to the types of hazard and risk assessments that have become standard in modern engineering, in terms of risks to both the labor force and the neighboring communities.

During the Exploration and Development period, perhaps the most probable risks are from the Project's aviation assets. However, even in a worst case aircraft accident, the area's extremely low population density reduces the probability of community casualties to a very low level.

A key tool for managing community risks from Project's future equipment and infrastructure is the simple planning step of ensuring adequate separation of local residential settlements from the mineral processing and support facilities. As the Project is currently planned, no industrial facilities are immediately adjacent to villages. An important cautionary note is appropriate in this respect, however. As detailed in the environmental assessment above, and again below in the discussion of land acquisition, in 2009 and early 2010 local residents have been establishing compensation claims by clearing and planting land on and near future project sites that have been identified for them by the geotechnical drilling program. It can reasonably be expected that this phenomenon will continue through the remaining period prior to Construction.

As the land acquisition proceeds with respect to Project sites, lands adjacent to, nearby, and between Project sites will also become targets of local interest, and local residents (and particularly in-migrants) may actually establish residential and/or business structures within the Project area. As noted in Chapter V, WBN has obtained a quite large Site Permit (Izin Lokasi) that includes planned process plant, accommodation, infrastructure, and some of the coastal mining sites. As recommended below, it is in WBN's interest to work closely with the local government and communities in establishing and enforcing a detailed land use plan for the entire Site Permit area. If carried out properly, this will forestall the types of uncontrolled and incompatible developments that could increase the community's health, safety, and security risks.

Public Health Conditions and Risks. The social-public health baseline studies documented in Appendix C clearly indicate that the residents of villages in the Project region suffer from many of the diseases and medical conditions commonplace in underdeveloped rural areas of Southeast Asia and the Southwest Pacific. Sanitation is fairly primitive and the medical infrastructure quite limited. While the Construction period will likely produce risks of in-migrating labor carrying communicable diseases, there is almost an equal threat of the region's poor health conditions posing serious risks to the present and future labor force.

During the current Exploration and Development period, WBN has responded to these challenges by implementing locally significant medical civic action programs as part of its Local Development Support (LDS) program. Rather than use the Project's clinical facilities to treat non-employee local residents, the Company incurs significant costs stationing SOS contract medical professionals in the area. These include physicians, paramedics, and midwives, who move on scheduled circuits among the villages and greatly supplement the limited Government public health facilities. While this has increased the local dependence and feelings of entitlement, an interview with one of these doctors clearly indicates this program is making a difference in health conditions in the Project region.

In 2009, as part of the Local Development Support (LDS) program, WBN signed an agreement with the Health Agency of East and Central Halmahera Regencies to station a doctor in South Wasile for improving access to professional medical services for residents of Waijoi, Saolat, and Minamin villages, and to provide general community health support. WBN also conducts campaigns on Health Education such as Influenza H1N1 and coordinates with Local Government Health Offices in 15 villages in the two Regencies.

Community Outreach and Grievance Mechanism. WBN has what it considers a "conceptual" Grievance Mechanism. The Community Liaison Officers (CLOs) are considered the key to handling grievances from the communities. The CLOs spend 2 days a week in the Camp and 3 days in their assigned villages. There are 10 CLOs assigned to the 10 villages in the operational area. Some are new, since Weda was split into four villages in 2009. Most are permanent staff, while some are on annual contracts. Several have been with WBN as long as 5 years.

The Focus Group Discussions, recent demonstrations, and intelligence reports have all indicated the same message however—the effectiveness of the CLOs could be greater. Feedback also indicates they spend too much time with the KADESs and not enough with the people. Shortcomings have been noted in the limited criteria applied in selecting CLOs; most are high school educated, and a few did not complete high school. The Company response has been to add training for the CLOs and to add another layer of management, the Community Relations Officers (CROs), of which there will be three for the three kecamatans (sub districts). The CROs will need to demonstrate "significant community support."

4.2 *EMERGENCY PREPAREDNESS AND RESPONSE*

PS 4 requires, where emergency preparedness and response requires participation of the community, that WBN collaborate with and assist government agencies and the community to establish and maintain preparedness for emergencies. If in gauging government capacity, shortcomings are noted, the Company should compensate for these to adequately aid the community in emergency response.

WBN has developed Corporate Evacuation Guidelines and Emergency Evacuation Plans for Jakarta and Halmahera. WBN provides practical training on site. At present, coordination of emergency planning with the local villages has not progressed to a detailed level. As noted above, current operations involve very limited technological hazards that could affect local communities except possibly a helicopter or fixed-wing aircraft accident. A tsunami drill conducted onsite at Tanjung Ulie was complicated by text messages sent by local employees to the villages, which led to some misunderstanding about whether a real tsunami was imminent.

4.3 SECURITY PERSONNEL

PS4 security personnel requirements mandate that if a project proponent retains security services, it will:

- Perform due diligence of the proposed security services provider
- Incorporate specific requirements of PS4 into security services contract specifications
- Establish a grievance mechanism allowing affected communities to present and obtain a response to express issues with security arrangements
- Investigate allegations of unlawful and/or abusive acts of security providers.

Private Security. Most of the following information was obtained from an interview with the Risk Assessment Manager at Tanjung Ulie, who has considerable experience in security services provision at mining sites in Indonesia, and who has been working at WBN since June 2009. WBN's security services provider is PT. Secom Indrapratama (part of the Japanese firm Secom). PT. Secom has provided security services to other mining companies in Indonesia.

As of the end of January 2010, there are 26 security staff at Tanjung Ulie camp including 23 local staff (from Central and North Halmahera regencies), the site risk manager, and 2 assistants i.e. one policeman and one former TNI (Indonesian national armed forces) member. Few guards are needed at the smaller camps, which are in wilderness locations remote from residential settlements. The key due diligence in hiring security personnel is a police record check that is initially performed on all security staff applicants. Only individuals with no criminal record are employed as security staff. There is no Security Grievance Mechanism, but one is being developed in conjunction with the Bankable Feasibility Study.

At Tanjung Ulie camp, a three-shift system (i.e., day, night, and off) is applied with eight to nine local staff per shift. Guards are stationed at the front gate (four during day time and three at night), jetty (three during day time and two at night), and on patrol (one during day time and two at night). There is one supervisor for each shift.

The emphasis of WBN's security system is prevention, through providing information to the community and employees on company activities, and also collecting information from the villages on matters relevant to WBN's security. Thus, the site risk manager works closely with Local Development Support (LDS) Staff and will be involved in community engagement activities planned by the Visitor Information Center. Security expects to be involved in the land acquisition activities that are starting up.

The current security system makes use of multiple sources of intelligence, i.e., police intelligence and intelligence sources within the communities and among employees. Intelligence from the Territorial Army's network at the village level is apparently also available to WBN security. A risk assessor from Control Risk spends 1 week every month on site to assess the security and update the security plan with the site Risk Manager.

Public Security. WBN security also works together with the local Police at Weda in accordance with a Memorandum of Understanding between WBN and the District Police at Weda and the Regional Police Command in Ternate. A small number of Police personnel are stationed at Tanjung Ulie, and also at the Ake Jira Camp, paid by the Company on agreed daily rates. These and other arrangements with the Police are covered by a memorandum of understanding with the District and Regional Police Headquarters in Weda and Ternate.

The Police and HANSIP (unarmed civil security personnel) always arrive onsite in force during (and apparently usually slightly prior to) demonstrations and strikes. WBN prohibits firearms within the Camp, and the police apparently cooperate with this. Police have not been actively involved in these situations, simply maintaining overwatch while the contract security handles the situation. Police prefer not to directly intervene in civil disorder "short of anarchy." While the New Order pattern was to react fast with overwhelming force, now the police are much more conscious of human rights issues.

Security Upgrades. WBN conducted a Strategic Risk Study to address security issues in each stage of development and developing further programs for Construction stage. The front gate in its current configuration is one of several security measures that were instituted in October 2008. WBN management had already decided to install the gate but implementation was accelerated by a demonstration in May 2008. Since the current security measures were instituted in October 2008, there is said to have been no complaints or tensions from the community or employees from any of the measures. As the project progresses and more security measures are put in place, the local community potentially will be affected. PS4 requirements indicate WBN must establish a grievance mechanism to allow affected communities to present their concerns about security arrangements and to obtain a response from the company.

In the near-term future, additional security plans may include:

1. Six more staff
2. Security training
3. Razorwire concertina coils atop the existing fence
4. More lighting
5. CCTVs at the main gate and jetty by the end of 2010
6. More distance between helipad and main gate as practical
7. A “sterile” area between main gate and visitor entrance to hold vehicles and visitors for inspection
8. Control room (with operators who understand safety and security issues)
9. Emergency response team (currently 75% formed).

The above measures to improve security at Tanjung Ulie camp have been approved and supported by WBN management.

Security Training. There is a screening process and test in the Security Hiring Process. Secom also sets yearly training programs; for 2010, security staff will have basic training and additional specific security training at the Secom training centre in Bogor run by Yayasan Bhayangkara (Indonesian Police Foundation). As of January 2010, security staff had only been provided with basic training (three times a year and a monthly refresher class). In addition to such measures, an evacuation procedure has been prepared considering evacuation routes from every camp site.

Feedback from Community Social Assessment on Security. The experience of other projects in the country highlights the importance of security issues, particularly as the Project moves to construction. Staff and others acknowledge a lingering tendency for some on the contracted security force to operate under the New Order paradigm, that is, to very quickly resort to violence to suppress or contain civil disorder or demonstrations. Although major incidents have been avoided so far, the danger remains that significant blow-ups could occur, particularly as the numbers at the Tanjung Ulie Camp continue to rise. Specific concerns arising in discussions include:

- Human rights violations, including potential for on-site security to deploy violence against protestors or local people thought to be “encroaching” on Project lands
- Security forces incorrectly interpreting the will of the Company when performing their duties, and the potential for heightened community distrust of the project as a result
- If WBN’s on-site security force cannot effectively manage and contain problematic situations, external and conceivably aggressively over-militant security forces will be invited or invite themselves to stay to “oversee” security issues.

Recent Experience. The security manager gave the example of the December 2009 student demonstration. The 30-plus students from Weda arrived by sea at the Camp jetty. The security force approach was to take control and "reduce their confidence." The demonstrators were not allowed to enter the jetty gate, and were directed to enter the front gate to be processed as all other Camp visitors. Only a portion of the group was let in at a time. Very few of the demonstrators were really aggressive, and experience has shown the importance of limiting the numbers inside the perimeter at one time.

Historical Context. Discussions with management on the period of civil conflict in Maluku and North Maluku Provinces in the period 1999-2002 indicate the fear of conflict breaking out again drives a lot of peoples' perception of the trauma from that period. The current feeling is generally one of relative safety, however. Documentation from the period of the 1999-2001 conflict is lacking, but most local residents remember it quite clearly. The operating mine of Nusa Halmahera Mineral site at Gosowong to the north on Halmahera was evacuated and local employees terminated. Even today many NHM trained local employees have never returned to work.

CHAPTER V
LAND ACQUISITION AND INVOLUNTARY RESETTLEMENT (IFC PS5)

The objectives of IFC PS 5 are as follows:

- Avoid or minimize involuntary resettlement.
- Mitigate adverse social and economic impacts from resettlement by paying compensation for assets at replacement cost, and ensuring proper consultation, disclosure, and informed participation.
- Improve or at least restore livelihoods and living standards of displaced persons.
- Improve living standards of displaced persons by provision of adequate housing with security of tenure.

5.1 PS 5 APPLICABILITY AND REQUIREMENTS

The challenges of WBN's land acquisition and compensation program are significant, but no physical displacement of families from their homes is expected (thus eliminating the need for a Resettlement Action Plan, or RAP), and in only a very few cases will land acquisition cause serious economic displacement or loss of livelihood.[3] WBN's land acquisition process, which of necessity must take place during the pre-construction period of the project, mainly concerns the facilities associated with the Main Industrial Complex (MIC) and the port site. Because the land is classified as State land, the land acquisition will be involuntary with respect to current occupants.[4] Leileilef Sawai, Leileilef Webulen, and Gemaf are the villages primarily affected by the Project's estimated land take of approximately 424 hectares for the plant site, construction camp and permanent accommodation area. This is a reduction in size, as some documents indicate a land take of 530 hectares. WBN has taken a negotiated settlement approach to this process, and only applies land acquisition where it is unavoidable, as per IFC guidelines.

PS5 holds that "economically displaced persons who are without legally recognizable claims to land … for lost assets (such as crops, irrigation infrastructure and other improvements made to the land) other than land, at

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[3] Economic displacement is, by IFC definition, "loss of assets or access to assets that leads to loss of income sources or means of livelihood."

[4] IFC Guidance Note 5 states that "Resettlement is considered involuntary when affected individuals or communities do not have the right to refuse land acquisition that results in displacement. This occurs in cases of: (i) lawful expropriation or restrictions on land use based on eminent domain; and (ii) negotiated settlements in which the buyer can resort to expropriation or impose legal restrictions on land use if negotiations with the seller fail."

full replacement cost. The client is not required to compensate or assist opportunistic settlers who encroach on the project area after the cut-off date."

In cases where project-related land acquisition results in loss of livelihoods or income of those without any legal title or legally recognized or recognizable claim to land, they are normally entitled to a range of assistance, including compensation for lost assets and any structures on land as well as targeted assistance and transitional support.

PS5 specifies that "[i]n cases of land acquisition based on negotiated settlement that does not result in the physical displacement of people, the client should provide the affected people with information on current property values and methods of value appraisal, whether for physical or economic resettlement. PS 5 further requires that a grievance mechanism must be established to manage any concerns raised subsequent to land acquisition. As noted below, values and appraisal methods have been in negotiation at public meetings; WBN does not appear to have completed development of a Grievance Mechanism as yet. However, Central Halmahera Bupati Decree No. 130.05/KEP/21/2008 concerning Appointment of Team 9, contains an implicit Grievance Mechanism. In this ruling, WBN is guided in complying with land acquisition regulations, and the government team in turn also act to assist WBN by facilitating the acquisition. All land acquisition related issues and complaints should be addressed to Team 9 before being brought to WBN.

5.2 *LAND ACQUISITION GENERAL SITUATION*

Land acquisition during the Exploration and Development stage has included rather minor amounts of land for the exploration camp, airstrip, and a few other infrastructure and monitoring facilities. To date, most roads used by WBN have been existing logging tracks upgraded for exploration purposes.

Land acquisition will be an important activity in the remaining Exploration and Development period. Land areas to be utilized for the proposed mine and associated facilities are expected to amount to about 2,000 ha for the first 30 years of the project life. Additional areas will be required for the limestone quarry and plant, permanent accommodations, a dedicated port, an enlarged airstrip, roads, tracks, and pipelines. When the project exceeds 30 years, mining activities (and associated haulage and access roads) will require additional areas to be acquired, although other facilities will not need to be extended. In general, the mining areas throughout the project development will be Forest land obtained through the borrow-to-use mechanism. It is believed these lands will in no cases involve negotiating with individual land claimants.

WBN received its *Ijin Lokasi* (Site Permit) in November 2009, for 1,430 ha, covering both the sites to be developed (Process Plant/Port and Construction

Camp/Permanent Accommodation) as well as some of the Coastal Deposits of nickel laterite. The rectangular site delineated also includes significant areas of land around these parcels.

Approximately 424 hectares will be acquired by the Company under *Hak Guna Bangunan* (HGB), or "Right to Build" certification, as a pre-requisite for the construction of the major facilities, including the process plant, port and permanent accommodation facilities. While the facilities themselves will not occupy the total area to be acquired, consideration has been made to create a corridor between and surrounding the major facilities to ensure access can be maintained unencumbered by any residual local land holdings, and to facilitate possible future expansions of the project.

Private land ownership in the area falls into two broad categories: (1) traditionally-owned, which is based on traditional claims, and (2) land acquired through legal purchase, which requires a certification process sanctioned by a government body, the National Land Board (BPN). Whether privately-owned or traditionally-owned land is to be acquired, the acquisition process is transparent and will follow relevant Indonesian practice and regulations. It will involve consultation with villagers. WBN, in conjunction with the local authorities, will strive to acquire the land at a fair price, with minimal impact on the value of other nearby land.

Land acquisition will initially be required for the hydrometalurgical plant geotechnical studies. Subsequent locations, such as the permanent accommodation facility location, will then be required prior to commencement of construction activities.

5.2.1 Management and Staffing

The land acquisition process is under the responsibility of a Special Project Manager and supported by External Relations on site and at the corporate management level in Jakarta. In addition support also received from the Security manager on site, who indicated his section is preparing to support the land acquisition effort. Security works with Community Liaison Officers (CLOs) to collect and compile village situation intelligence, public opinions, and analysis of their implications for security.

5.2.2 Land Status under Indonesian Law

Effectively all the area of interest for project development was classified as Conversion (or Convertible) Production Forest (HPK) in 1999. WBN sees a need both to complete the Conversion process with the Ministry of Forestry and also to respect the customary rights of the local residents. Lelilef Woibulen, Lelilef Sawai, and Gemaf are the only villages being dealt with at this stage.

The Tanjung Ulie Camp had been on a temporary certificate but is now classified *Hak Guna Bangunan* (HGB) or right to use and build/develop. Otherwise, all land within the Site/Location Permit is State land, mostly HPK. On such land, cultivation of annual crops is in fact permitted, but cutting trees without a specific permit is not. Under the Forest Law, land classified as Forest cannot be a subject of transactions. The Agrarian Law, however, recognizes settlers' rights.

5.2.3 *Land Prices*

WBN started negotiations with the Assessed Tax Value of land, or NIOP, which in Central Halmahera is Rp 2,200. A Central Halmahera Bupati (Regent) Decree set the price at Rp 3,500/m^2. The market price, as set by a licensed appraiser, was considered in 2008-2009 to be Rp 7,300/m^2. As stated, the price offered in late January 2010 is close to the market price, and may be accepted.[5]

5.3 *STATUS OF LAND ACQUISITION PROCESS*

WBN's effort to secure title to the land for the processing facilities follows a number of sometimes overlapping steps:

1. Conversion of forestry land status
2. Survey of land claim boundaries
3. Verification of land claims
4. Survey of assets on the claimed land parcel
5. Negotiation of price for assets
6. "Sosialisasi" or consultation with the affected communities [continuing throughout the process]

The necessity for WBN to change the legal status of the land targeted for acquisition complicates the process. Aside from needs of the land acquisition process, WBN also needs this conversion to secure the targeted land under legal title to provide warranties to banks. All land targeted for acquisition is classified as State Forest Land (i.e. designated as "Forest Areas" under the Decree of the Minister of Forestry No. 415/Kpts-II/1999 regarding Stipulation of Forest Areas in Maluku Province). Since legal title to Forest Areas cannot be secured by private companies, land must be released

[5] PS5 specifies full replacement cost (market value plus transaction costs) for acquired land.

("converted") by a Decree of the Minister of Forestry to non-Forest status. WBN formally applied for land to be so converted during 2009.

The process of Forest conversion to "Other Uses" has thus been initiated and is proceeding in parallel with the land acquisition. WBN in early 2009 requested the Bupati (Regent of Central Halmahera Regency) to apply for conversion. The Bupati sent a letter to the Minister of Forestry in July 2009. The outcome was that the regional government needs a solid program plan and budget (in the APBD). By September 2009, WBN realized the Kabupaten (Central Halmahera Regency) does not have the money, and that the Company will need to facilitate it.

Recent regulatory changes (January 2010) mean that private companies can apply for conversion for Other Uses, specifically for industrial development. A Minister of Forestry Decree implementing this regulation is being prepared.

Each land claim must also be individually addressed by a government team (Team 9, frequently the designation for interagency teams for land acquisition programs), accompanied by WBN and village representatives. The survey maps out the claimed land boundaries and records the assets on the claim.

In addition to the asset-value of a given piece of land, IFC requires some measure of the potential economic effects of the loss—referred to as "economic displacement". For this level of assessment, an additional follow-up census is necessary. Toward fulfilling this requirement, an ERM team will need to visit all claimant households in the course of an involuntary resettlement census to gather household baseline data as well as take a full inventory of affected assets.[6]

As of January 2010, the government/WBN team had mapped out claimed boundaries and recorded land assets (standing trees) for 214 of the 530 hectares. The completion of this process for an additional 210 hectares is planned to begin in May 2010. As part of the BFS ESHIA studies ERM plans to complete two separate surveys: one in tandem with the second phase of the 210-hectare government/WBN/villagers survey, and the other will be conducted separately by ERM on the initial 214 hectares. This will supplement the gathering of IFC-required data on economic displacement,

For WBN, the next step after mapping and assets surveying is the verification of land claims. This step has occasioned much dissatisfaction among the local communities, as it questions the appropriateness of the claims made and, in the claimants' minds, inordinately delays compensation disbursements.

[6] This activity relates to the BFS ESHIA, currently under way.

As of January 2010, Team 9 had not concluded the verification process for the first phase of the land and inventory plant survey. The demand from some members of the community is to dispense with the verification process and proceed with price negotiations and payment. Contention over this demand itself contributed to a delay in the verification process as it necessitated additional rounds of consultations with the local communities to inform people in more detail about both the lengthy process requirements and the need to convert the land status.

Early in the process WBN sent a letter to the Bupati requesting government assistance in the land acquisition process. The Kabupaten (Regency of) Halmahera Tengah (Central Halmahera) is newly formed, and its only experience in land acquisition has been in the new capital Weda for local government offices. WBN reports that the Kabupaten Government has been very supportive in the process. However, it is noted the government prefers to issue relatively short-term permits, so that the Company must repeatedly go back for extensions.

The results of land surveys are given to BPN, the National Land Agency, and the map the agency produces is disclosed to the Village Head and residents. The map for the Process Plant Site has been completed, showing all the claims, and Team 9 will rely on it.

The chronology of land acquisition is presented in Table V-1 .

Table V-1 Chronology of Land Acquisition

Date	Chronology of Land Acquisition Activity
Q1 2009	*WBN started land and asset surveys for the Processing Plant and Port Site, a total of 214 hectares. The survey was to be conducted west to east, but was stopped by L. Sawai residents, who started cutting trees to establish land rights. After much of the site was cleared of trees, they allowed the survey to continue.*
June 2009	*Leileilef Sawai residents blockaded the Process Plant site to prevent the geotechnical investigation for a time.*
27Oct 2009	*There was a major meeting to "socialize" the land acquisition process. The Provincial and Kabupaten governments were present, as were the Police. It was made clear at the meeting the need to recognize most of the coastal land of interest is HPK, or Conversion Forest. Local inhabitants may plant annual crops on this land but cannot cut trees. WBN tried to get across the point that there is no need to cut trees, as the Company intends to deal honestly with all claims. There was a positive response and eventually some acknowledgement it was a mistake to do all the cutting.*
November 2009	*WBN received its Ijin Lokasi (Site Permit) in November 2009, for 1,430 ha, covering both the sites to be developed (Process Plant/Port and Construction Camp/Permanent Accommodation) as well as some of the Coastal Deposits of nickel laterite. The rectangular site delineated also includes significant areas of land*

Date	*Chronology of Land Acquisition Activity*
	around these parcels.
December 2009	*Of the 424 hectares to be acquired prior to Construction, WBN has surveyed 214 hectares, and considers surveying more than 50% complete, and verification by Team 9 is under way. Results of the survey are posted on the Leilielef villages' Notice Boards, with a note that the boundaries are not yet verified. In the Process Plant area, the assets (plants and structures) survey has not been carried out; it is unclear when this will be done, and no cutoff date has been established as yet.*
Q1 2010	*Survey of land and assets is scheduled to be conducted for the Permanent Accommodation and Construction Camp Sites, covering 210 hectares.*
11 January 2010	*Land acquisition negotiations began with a public meeting.*
26 January 2010	*A meeting was held to set land prices. The price WBN is now offering is not far from the market price, and the villagers are said to be close to accepting it.*
February 2010	*Geotechnical investigations move to the Phase 2, the area designated for Construction Camp and Permanent Accommodations*
February/March 2010	*Socialization of the land acquisition will be carried out in Gemaf.*
Q2 2010	*ERM's Social Team proposed the survey for the LARAP in this period, and the BPN survey has been postponed to coordinate with ERM; now it should be completed in May.*
Q2 or Q3 2010	*Lists of claimants specific to each of the villages will be prepared after the Accommodation area is surveyed.*
May 2010	*WBN expects negotiations to agreement on compensation will all be completed*
November 2010	*WBN will need to finish the Conversion of Forest land and obtain their HGB (Development Permit) within a year of the issuance of the Site Permit, or to have it extended.*
Late 2010 or Q1 of 2011	*Full completion of compensation payments and certification of land plots are expected to be completed.*
2012 onward	*The Coastal Deposits of nickel laterite are adjacent to and near the development sites, but will be alienated for mining via Pinjam Pakai agreements with Forestry. WBN expects to pay compensation for crops and trees in this area, even though this is not required, as contributions to the villages. The Bukit Limber and other main deposits are in Production Forest or Protection Forest, and such contributions should not be necessary.*

5.4 *WHAT IS NOT KNOWN*

Although the Eramet/WBN Project Team has been quite forthcoming with information about the land acquisition process for the plant facilities and port site, we are lacking data on the procedures followed and experience engendered when land was acquired for the airport, and other exploration activities including the current base camp at Tanjung Ulie.[7] These acquisitions did not involve physical displacement.

Although discussed with the Project Team, an update of their plans for announcement of a "cut-off date" for land claims was not available. For the second area of 210 hectares, it is claimed that a cut-off date will be set the week before the survey begins.

Finally, a precise understanding of the customary land claims of the most relevant villages in the land acquisitions process is necessary.

5.5 KEY ISSUES-- CLAIMS CONCERNING CUSTOMARY LAND

Key issues for PS 5 application include the status of communal lands, the determination of entitlements, the viability of the land-for-land option, the setting of a cut-off date, and the determination of what sorts of income restitution options are available. Most critical is consideration of the claims based on communal land status and the feelings engendered in the communities about this customary relationship to the land.

Completing the land acquisition process for the Project will be complex and difficult. Only part of the story is the need to convert the current classification of State forest land to a status under which the Project can then purchase and use it. The other critical part is resolving the issue of customary land claims. This is perhaps the more complex issue, one with its roots in the region's historical experience, namely the often competing authorities of the Dutch and the sultanates.

Since colonial times, State claims to land have competed against customary land claims, a pattern mimicked in the current discussion of State vs. village land claims. The State usually has dominated in the struggle, and this domination has continued into the current period, for, as one observer put it:

Past procedures have greatly favoured mining operations with COWs authorised by the state. The legislation relevant to mineral development in Indonesia is underpinned by the 1945 Constitution, Article 33 of which states that the nation's natural resources are to be exploited under state control for the maximum benefit of the people of Indonesia. The Basic Agrarian Law (BAL) of 1960 was intended originally to redress the excesses of individual land parcelling under the colonial Dutch administration. In its conception, the BAL was 'not primarily aimed at economic development', but the fact that the BAL overruled traditional (adat) land rights permitted successive governments to interpret the law to the considerable advantage of the state's industrial contractors.

[7] Acquisition of land for the mine test pits was not necessary.

In the absence of the BAL, however, when this basic law does not apply to an issue, *adat* (community or customary) law then applies.

Under Indonesian Customary Land Law (*hukum tanah adat*), individual land rights are a type of personal rights that simultaneously allows the community to assert its own communal rights over the individual. The individual land holder thus has his own "social function" and obligations within and to his community. Thus discussions of land "ownership" and "rights" must recognise this Indonesian cultural context.

Although a community's perception of customary land is different in each village, there is a common understanding concerning the utilization of such land. Customary land can be cultivated and utilized but never owned, sold or purchased. In several of the villages, cultural land is located in a lowland area (swamp) and planted with sago trees. In the old days, customary land was the source of subsistence for the local community. Crops from this land may be collected by anyone with permission from the Village Head or community elders. It is often difficult to measure the boundaries of this land in a legal formal way since the land area boundary is based on the knowledge of the community elders (*tetua adat*).

Land ownership in the Project-affected villages may be granted in a number of ways, some not congruent with Western legal norms of purchase and inheritance. Local customary land approaches also recognise the land ownership process to be initiated with the clearing of the land's 'virginal', previously unclaimed, forest. The land clearing is conducted by cutting down trees with simple tools such as the machete (*parang or peda*), axe (*tamako*) or with more modern tools such as the *sensor* (diesel-powered chain saw). Land clearing is an activity commonly performed by any household that requires new land for settlement and/or cultivation or that needs to expand its landholdings. Even though land clearing is a recognized way to acquire land, the process usually begins with a request for permission of the Village Head to so clear a plot. These approaches reportedly have been followed with at least some of the land claims on the 424 hectares.

Data collected from our Community Social Assessments show that communities often lack knowledge and understanding of the importance of the State's process for certifying their land claims, relying instead on customary land law (*hukum tanah adat*) and oftentimes apply customary usage alone to press their claim to land ownership. They also lack knowledge of the legal process required to obtain such State certification. People in several communities said that they believed their annual payment receipts for the Building and Land Tax (*Pajak Bumi dan Bangunan – PBB*) were sufficient proof of ownership, even though they also reported that only about 10-20% of households in their villages paid the tax. Many communities also asserted their belief that, in addition to tax receipts, acknowledgement and recognition from other communities could be used as valid proof of land ownership—in effect relying on neighboring communities' tacit recognition of their *tanah adat* claims.

Data show that the State land ownership certificates that villagers do possess are mostly found in settled village areas; possession of certificates for plantation or cultivated land areas is very uncommon. This is the general situation in almost all of the villages except for the Transmigration villages where the migrants, participants in a Government-sponsored resettlement program, are required to possess land ownership certificates.

Resolving the State vs. Village Land Competition. From the above discussion, one conclusion is that in Indonesia, two sometimes competing and sometimes complementary legal systems have evolved to regulate land ownership and use. The current tussle between State ownership in the guise of the Ministry of Forestry and counter-claims by the villagers based on *hukum tanah adat* – or just plain "custom" – can be seen in this light.

The Project reports that villagers have yielded their claims to the land in exchange for registering a claim for assets compensation. Information gathered during the Community Social Assessments suggests a possibility that true *hukum tanah adat* jurisdiction may only be claimed over a small proportion of the cultivated or plantation lands (particularly those with sago—a particularly culturally and spiritually important plant). This may also apply to the parcels comprising the 424 hectares currently slated for land acquisition. In sum, the Project may be able to argue that customary land law should not be applied to these particular 424 hectares and thus should be excluded from compensation requirements (or even the application of PS 5). As it is, the Project does not view *adat* law claims as critical to adjudicating this land acquisition process.

Yet it may be worthwhile for the Project to consider some mechanism for recognition of the customary land claims of land-acquisition affected villages, particularly if PS 7 (Indigenous Peoples) is also applied to these villages. Under PS 7, customary land claims need to receive special recognition by the Project and the Project's facilitation of the regularization or recognition of such claims is encouraged. Such recognition early in the Project life, prior to construction, might prevent the issue from festering below the surface only to re-emerge during later project stages.

5.6 DOCUMENTS TO BE COMPLETED

The Project Sponsor must prepare the following documents:

- Census Report;
- Land Acquisition and Resettlement Plan (LARAP);
- Resettlement Framework (RF).

WBN has committed to the preparation of these documents, which will form part of the BFS ESHIA.

The Census Report will include ERM's survey of all 424 hectares of assets and land claims. This Census Report will be separate from documentation gathered by TEAM 9.

The LARAP will be an Action Plan that will detail compensation entitlements and include any necessary income restitution actions, including in response to data on non-land-acquisition economic displacement effects from the Community Social Assessment Report

The Resettlement Framework will focus on the requirements of Indonesian laws/regulations as well as IFC requirements for involuntary resettlement including those specifying the process to be undertaken when new land acquisition activities take place.

5.7 TREE CLEARANCE

An unpredicted impact of land acquisition with which WBN has been dealing is that of tree felling for speculation on land compensation, on the plant site and on a large area north of the road and east of the plant site that WBN does not actually intend to acquire. This began at the beginning of 2009, when Lilielef Sawai residents started cutting trees to establish land rights, blocking the land survey until they believed a sufficient area of land was cleared. Village residents claimed that BPN asked or recommended they cut the trees; this has not been verified. One person interviewed indicated that trees in the areas not scheduled to be acquired were cut down by in-migrants, obviously hoping to establish land claims; this has also not been verified.

WBN has reached an agreement that it believes will stop villagers from cutting trees except for specific wood needs. The Company is hoping to prevent tree cutting on the Accommodation Area and Construction Camp land plot to the east. WBN is also conscious of the need to prevent a repeat of this speculative cutting on the mining lands, and has reported all events to the Central Forestry Department. Signage for the land was to have been in preparation by Forestry since the end of October. WBN is now having the signs prepared itself.

Land Use. The land use for mining and other areas is not specified in the initial project plans to date, though both WBN and the villages may have uses for much of the land in the Site Permit (*Izin Lokasi)* not allocated to the Process Plant and Accommodation sites. The IL assumes 88% open/cleared area or *semak* (bush), with 12% to stay forest.

5.8 NOTE ON CULTURAL HERITAGE

Tied to the application of PS 5, PS7, and PS8 is the risk that a community may feel that the Project is disturbing or harming sacred sites, and customary lands. The information above gives the context for this concern. The Company needs to display respect for customary land and *adat* institutions (including practices for managing and cultivating communal lands). This can take the form of special recognition of customary land claims or by devising an *adat* strengthening program as part of the Community and Indigenous Peoples Development Plan (CIPDP).

For *ada*t to be recognized by the Government, it needs to exist as a comprehensive adat system, it should be implemented in daily life, and it should be *masyarakat adat*, meaning based among the society as a whole. In fact, adat fell into disuse in the area in the 1990s. Issues with re-establishing adat are that there has been extensive assimilation of outsiders in the past decade in the area, starting with the logging concessions in 1999-2000, with the base camp near Tanjung Ulie.

5.9 COMMUNITY BASELINE INCOME

The land acquisition for the Project will result in a short term increase in community income. AMDAL baseline data show average household income for five villages near the Project was Rp 984,000 in 2006, as shown in the **Table V-2** below. The table shows three villages in the Project area--Lilielef Sawai, Gemaf, and Kobe Kulo Transmigration Unit--all fall below the poverty line. Land Acquisition is likely to affect the community income of Lelilef Sawai, Lelilef Waibulen and Gemaf, but not Kobe Kulo Transmigration.

Table V-2 Average Monthly Household Income and Expenditure (IDR) in 2006

Village	Average Income	Average Expenditure	Variance	Average Expenditure per Capita*
L. Waibulen	1,410,000	1,405,000	5,000	281,000
L. Sawai	933,000	711,000	223,000	142,000
Gemaf	670,000	444,000	226,000	89,000
Sagea	902,000	776,000	126,000	155,000
Kobe Kulo Transmigration Unit	1,006,000	733,000	273,000	147,000
Average	**984,000**	**813,000**	**171,000**	

Village	*Average Income*	*Average Expenditure*	*Variance*	*Average Expenditure per Capita**
Per capita*	**197,000**	**163,000**	**34,000**	

Source: Primary Data, 2006

- * assumed average family consist of 5 persons

5.10 LAND OWNERSHIP

A majority of land owned by people in the local communities is in the Coastal area. Changes in land ownership will occur due to the land acquisition process, with the most likely affected villages being Lelilef Sawai, Lelilef Waibulen and Gemaf. The **Table V-3** below provides a breakdown of the type of Land Ownership in the affected villages. High proportion of the land is inherited land, particularly in those villages directly affected by land acquisition.

Table V-3 Land Ownership in 2006

Village	*% Purchased from other people*	*% Inherited land*	*% State owned land*	*% Other*
Lelilef Waibulen	23	57	17	3
Lelilef Sawai	13	73	3	10
Gemaf	20	30	35	15
Sagea	13	70	7	10
Kobe Kulo Transmigration Unit	0	0	100	0
Average	**14**	**46**	**32**	**8**

Source: Primary Data, 2006
Note: Based on 138 respondents (Lelilef Waibulen 30, Lelilef Sawai 30, Gemaf 20, Sagea 30, and Kobe Kulo Transmigration Unit 28)

5.11 LIVELIHOOD PATTERNS

- Changes in livelihood are a likely consequence of changes in land ownership. The table below shows a breakdown of livelihoods of the people in the affected villages. The **Table V-4** shows the high percentage of respondents as farmers, especially in those villages directly affected by the land acquisition scheme. Income received from the land compensation will possibly be reinvested to create an opportunity for an alternative livelihood. However there is a risk that this income will be spent in manner that does not create a new and sustainable livelihood.

Table V-4 Main Livelihoods of the respondents in field survey conducted in 2006

Village	Livelihood (%)					
	Government employee	Private business	Farmer	Fisherman	Construction Labor	Other
Lelielef Waibulen	7	7	67	3	17	0
Lelielef Sawai	7	17	63	0	13	0
Gemaf	5	0	91	0	0	5
Sagea	21	10	66	3	0	0
Kobe Kulo Transmigration Unit	3	7	83	0	0	7
Average	**9**	**8**	**74**	**1**	**6**	**2**

Note: Other livelihood activities include: Honorary teachers (non Civil Servant Officer), members of the Clergy, and saw operators. At Kobe Kulo Transmigration Unit, several individuals are employed in the saw mill and do not grow crops.

5.12 *COMMUNITY UNREST*

Many factors may contribute to community unrest resulting from the Land Acquisition process, including:

- Perceived inequalities in compensation for land;
- Expectations that WBN will acquire their land;
- Poorly managed income as a result of land compensation;
- Unexpected disruption to lifestyles;
- Perceived lack of transparency in the land compensation process.
- During the 2006 "local perceptions to mining" survey, less than half of the respondents were aware of the adverse impacts of mining. Of those respondents, none identified land acquisition as a potentially significant impact. This lack of awareness/understanding, which often leads to unmet expectations, can contribute to community unrest resulting from land acquisition.

CHAPTER VI
BIODIVERSITY CONSERVATION AND SUSTAINABLE NATURAL RESOURCE MANAGEMENT (IFC PS6)

The objectives of IFC PS 6 are:

- Protect and conserve biodiversity
- Promote sustainable management and use of natural resources through adoption of practices that integrate conservation needs and development priorities.

A review of the available information on the biodiversity baseline in the WBN project region, in the context of project activities now in progress on the ground, indicates that the construction and operation of the planned nickel-cobalt mining-processing project will have scheduled, quantifiable impacts on forests and other habitats. Practices and procedures for mitigating these impacts and restoring habitats are being developed and monitored onsite, most notably in connection with the bulk sample "test pit" operation of 2007. This site is still active with vegetation trials and sediment controls being monitored. The unsurprising lesson of the test pit was that clearing forest is in and of itself a serious impact. While the test pit is about one hectare in size, the access road to the site involved much more land being deforested, which was the source of most erosion impacts.

Conclusion on Biodiversity. A logical conclusion from onsite observations and review of the project is that the greatest threats to biodiversity resources in the WBN area are not from the planned sequences of clearing, construction, mining, and rehabilitation, but from unplanned land clearing associated with the very real potential for uncontrolled development within and around the *Izin Lokasi* (Site Permit) lands. Of most concern is the forest clearing for land speculation, where people attempting to establish compensation claims, including many that will not be upheld, cut trees in large numbers. There may be no compensating planting or other development of such lands, nor replanting and site restoration, so the impacts are serious. The only obvious approach to this is for WBN to work closely with the regional government in instituting strict land controls in the Contract of Work area, and particularly within the *Izin Lokasi* area.

Technical Memorandum 01 (TM01). Currently under preparation for WBN by ERM is an assessment of the potential impacts of the proposed development of the WBN project on terrestrial biodiversity resources, conducted for the Bankable Feasibility Study (BFS) in compliance with IFC Performance Standard 6 requirements. In recent years several terrestrial flora studies were conducted for WBN, while fauna biodiversity coverage has been limited. Given the extensive data and information already gathered on vegetation resources, the Terrestrial Biodiversity field surveys focus on gathering primary data on fauna diversity (covering: insects, herpetofauna, mammals, birds, freshwater fish and mollusks) in and around the WBN Contract of Work area, and on preparing detailed habitat maps. To account for seasonal variations due to climatic conditions, field surveys are being undertaken during both wet and dry seasons. The first round of field surveys began on January 22nd 2010.

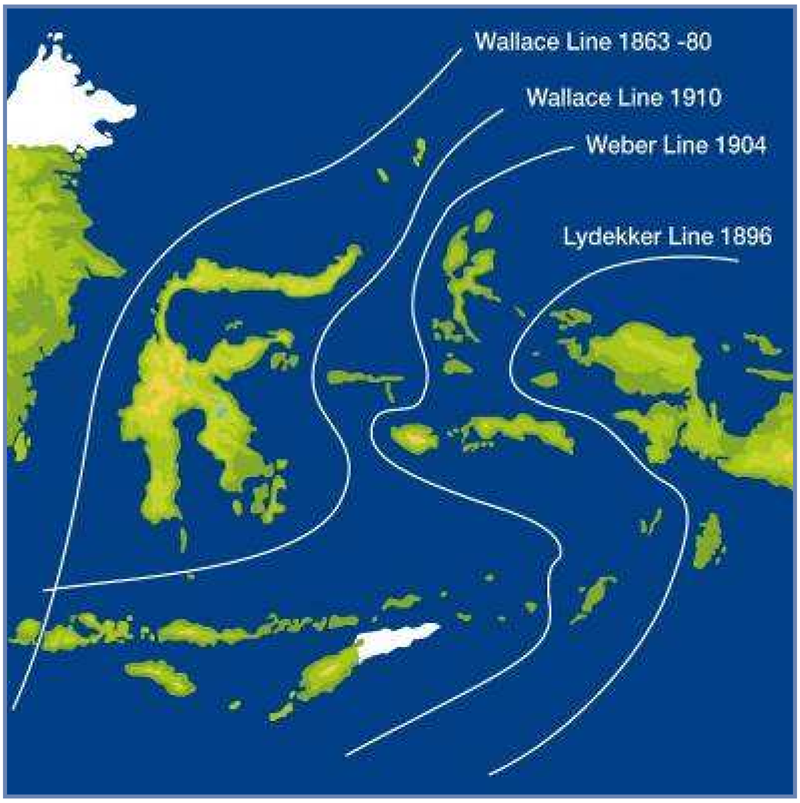
TM2 Marine Biodiversity. WBN also commissioned TM2 Marine Biodiversity, in March 2009. This included collecting baseline data on marine ecosystems including coral reefs, intertidal zones, mangroves, in addition to recording of oceanographic data and sediment and seawater quality. However as the impacts associated with marine ecosystems are not likely to be significant in the period prior to construction, the baseline data is addressed in this report only in Appendix C.

6.1 PROTECTION AND CONSERVATION OF BIODIVERSITY

Halmahera Island is biogeographically unique, with floristic and fauna compositions that are of great interest to biologists because of the island's proximity to the three ecological boundaries: Wallace line, Weber line and Lydekker line (as shown in Figure VI-1). Halmahera displays complex vegetation patterns and habitat diversity. It is mostly covered by evergreen tropical forests dominated by flora of Malesian origin (Whitmore 1981). However, as Halmahera consists of remnants of outer arc of Melanesia, inner volcanic arc islands, raised coral reefs and the Pacific plate in the south, its vegetation is a mixture of Asian and Papuan (New Guinea) taxa.

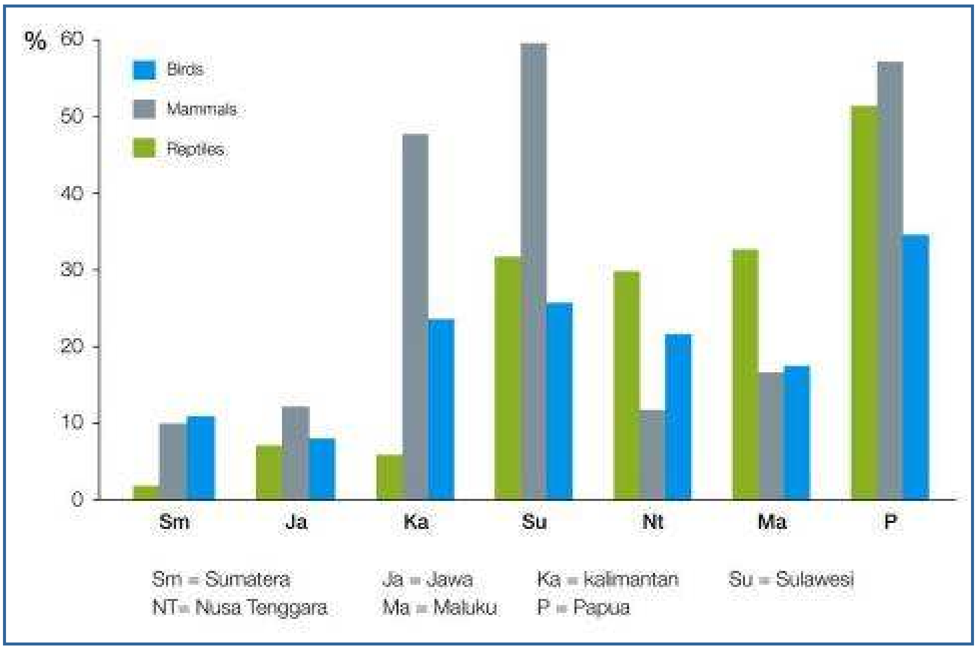
Research indicates that the islands of Maluku's location far from other main islands reduces the distribution of flora and fauna from other islands. Maluku has never been linked to the main islands of Indonesia or with Asia or Australia, with the exception of the Island of Aru. The Maluku region has the characteristics of high endemism for species and subspecies levels (Monk et al 2000) and low endemism for family.

Many of the Northern Maluku islands, including the larger islands, were formed by the contact zone between the Indo-Australian Plate and the westward movement of the Pacific Plate during the Miocene (Hamilton 1979). Fauna diversity on the island is considered poor (Monk *et al*, 2000) with respect to other equatorial rainforests on the larger islands within the Indonesian Archipelago (i.e. Sumatra, Borneo, Papua). In general, Maluku has a low number of endemic species, particularly when compared to other eastern or central parts of Indonesia (i.e., Papua and Sulawesi). However, Maluku displays high endemism for birds and mammals when compared to Java and Sumatra (as shown in Figure VI-2).



Source: Monk *et al*. (2000)

Figure VI-1 Biogeography lines passing through Indonesia



Source: Monk *et al* (2000)

Figure VI-2 Percentage of islands' species endemic to Indonesia

6.2 *FOREST CLASSIFICATIONS*

Under the Forestry Law No. 41 of 1999, forests in Indonesia are classified as:

a. **Conservation Forest**: an area established and directly managed by the Directorate General for Forest Protection and Nature Conservation (PHKA). This type of forest is set aside for conserving flora and fauna species and their ecosystem. Conservation forest is classified into two major categories: (i) sanctuary reserves (i.e., nature reserve and wildlife sanctuary) where no human activity is allowed; (ii) nature conservation areas (national park, forest park, nature recreation park, and hunting reserve) where limited human activity is permitted.

b. **Protection Forest** is a forest area designated to serve a life support role, as seen in its role and impact on hydrological system maintenance, flood prevention, erosion control, seawater intrusion avoidance, and soil fertility. Protection forest is managed by the local government and supervised by the Department of Forestry.

c. **Production forest** is an area designated to promote sustainable forest production. This type of forest is classified as permanent production forest, limited production forest, and convertible production forest. Production forest is managed by the Directorate General for Forest Production Development (BPK).

In addition, to meet hydro-orologic concerns (flood prevention, erosion control), a forest determination also takes into account the interests of the public, which include socio-economic development, education, religion and culture.

The Ministry of Forestry is responsible for land under Permanent Forest Status – e.g. all land that has been allocated for use as conservation forest, protection forest, and production forest. Virtually all forests in Indonesia are State-owned, and administratively defined forest lands are mapped by the government in terms of their intended function and use. Government forest lands in the WBN project area include:

(i) protection forest;

(ii) production forest;

(iii) limited production forest;

(iv) convertible production forest; and

(v) other usage.

According to forestry data, WBN project area included forests with various status: protection forest (HL); other use (APL); production forest (HP); limited production forest (HPT); and convertible production forest (HPK). Based on coordination between the Governor and the Forestry Department, forest areas in Sake were originally conversion production forests has been converted into 'Other Use (APL) area'. In general, transmigration and plantation areas in WBN project are still in convertible production forest status. The details of forest classification in the project area are presented in Table VI-1 and Figure VI-3. The project area is dominated by protection forest (46.9%) and limited production forest (24.3%).

Table VI-1 Area of Forest at COW

No	Forest Area	Area (Hectares)	Percentage (%)
1	Conversion Production Forest	8,650	16.1
2	Production Forest	6,807	12.7
3	Protection Forest	25,118	46.9
4	Limited Production Forest	13,026	24.3
	Total	**53,601**	**100.0**

Source: Forestry Department, (P.48/Menhut-II/2008 dated 10 July 2008)

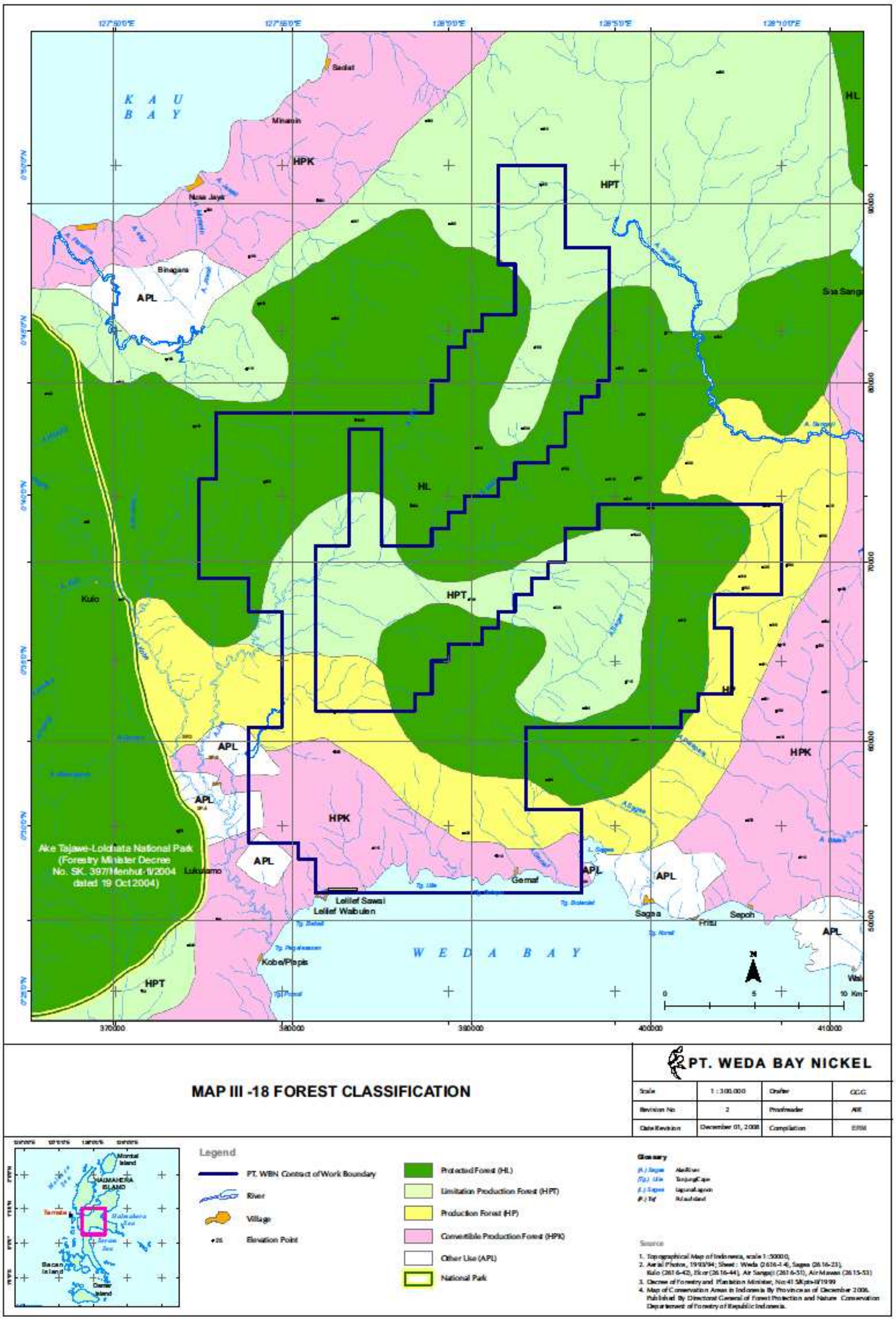


Figure VI-3 Forest classifications in the Project Area

6.3 FLORA BIODIVERSITY

Poulsen *et al* (1999) classified 10 main habitat types and 21 vegetation types on the island of Halmahera. This classification is based on several factors including: the geology, elevation, rainfall, and the use of spatial data and satellite imaging. Using the Poulsen classification, the WBN COW contains the following habitat types:

- Mangrove and freshwater swamps forest;
- Lowland forest on Ultra Basic Soils;
- Lowland forest on Alluvial Soils;
- Lower montane forest; and
- Lowland forest on limestone (i.e. Karst).

6.3.1 Lowland Forest

Lowland flora in the project area represent forest ecosystems at elevations from 0 and 500 meters above sea level. The survey collected flora data from the following habitat types:

- Mangrove and Freshwater Swamp Forests;
- Lowland Forests on Alluvial Soil; and
- Lowland Forests on Ultra Basic Soil.

Floristic richness and diversity values in the lowland forests were high, as seen from the Margalef richness index (R ranging 0-36-1.89 in mangroves to 8.51-11 in ultra-basic soils) and the Shannon-Wiener diversity index (H' ranging 0.96-1.08 in mangroves to 3.15-3.68 in ultra-basic soils). In the lowland forests 530 plant species from 311 genera and 117 families were recorded. The floristic composition varied significantly across and even within the forest types, which indicates the influence of micro-habitat characteristics.

The number of species per hectare ranged from 3 to 269 species, averaging 186 species per ha. There were common species with relatively even distribution (*Vatica rassak)*, abundant species with limited distribution (*Melochia umbellate*), not abundant but had wide distributions (*Kejilbergiodendron hylogeiton*). Some species were new records for North Maluku. Species richness and composition varied significantly, influenced by forest type, geology, topography, micro habitat conditions and level of human disturbance. Primary forests on ultra basic soils were the most diverse and species rich.

6.3.2 *Lower Montane Forest*

The lower montane flora represents forest ecosystem between elevation 700 m and 1,200 m above sea level. Based on the analysis of a remote sensing data and site observation, the Lower Montane forest was dense, relatively species rich and diverse, with intact structure and healthy dynamics. Compared to lowland forest in, species richness, which is a function of the number of species recorded in a given transect, was significantly lower in the lower montane forest due to its altitude. However, given that diversity is determined by species richness and pattern of distribution, the range of H' indexes for the Lower Montane (2.83-4.91) is higher than the range of H' indexes found in the Lowland forest (0.96-3.68).

Species diversity in the lower montane is lightly higher than those found in the Lowland Forest, indicating a well-balanced spatial distribution of various species. In the lower montane forest 231 species from 129 genera and 53 families, including two species suspected to be new discoveries were recorded.

6.3.3 *Karst Forest*

Literature reviews suggest that not many studies on karst flora have been conducted in Indonesia, including no recent publications on karst vegetation in Halmahera. Plants growing on limestone face many limitations such as shallow soils with high calcium and magnesium content, free draining rock substrate, exposure to full sunlight, severe water stress and high temperatures during dry periods. Such conditions have the potential to create unique vegetation communities.

In the project area, a karst flora survey was conducted in the Zohra Mountain region between the elevations 50 m to 175 m above sea level. Zohra Mountain is located in the karst formation directly west of Sagea Lagoon and in the area identified as a limestone resource. The survey investigated flora composition in the east and the west portions of the karst. The karst forest is dominated by small diameter trees. This implies a condition of normal habitat, meaning that regeneration is well taking place.

The Shannon Diversity Index (H') for the Eastern Karst is 3.03 and for the Western Karst, H' is 2.64. These values indicate medium level of flora diversity. Furthermore, The East karst had a species richness value (Margalef Index) of 7.50 and the West Karst of 5.36. This indicates that the eastern part of Gunung Zohra is relatively richer in species than the western part.

6.3.4 *Significant Plant Species*

Significant or important plant species in the Weda Bay Nickel CoW are classified as those that have economic or ecological significance. This includes species which are covered directly by the Indonesian Government laws and regulations, species which have been identified in international treaties signed by the Indonesian Government and species which provide a special function for the local people (i.e. economic, medicinal, cultural etc).

In total 17 species found in the WBN COW have been identified which are either controlled by Indonesian Law or governed by the *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Appendix B-1* or the *International Union for Conservation of Nature's (IUCN) Red List*, as shown in **TableVI-2**.

Table VI-2 Protection status of Flora Species found in WBN COW

Species	*Common/local name*	*Protection status*
Lowland Forest		
Aquilaria filarial	Gaharu	CITES Appendix II
Gonystylus macrophyllus	Ramin Bukit	CITES Appendix II
Intsia bijuga	Kayu Besi	Vulnerable (IUCN Red List), Proposed for CITES Appendix III
Intsia palembanica	Merbau	Proposed for CITES Appendix III
Hopea gregaria		Endangered (IUCN Red List)
Duabanga moluccana	Benuang laki	SK. Mentan No. 54/Kpts/Um/2/ 1972 (not allowed to cut trees under 60 cm diameter)
Nepenthes mirabilis	Pitcher Plant	CITES Appendix II
Dendrobium lancifolium	Orchid species	CITES Appendix II
Liparis odorata	Orchid species	CITES Appendix II
Vanilla albida	Orchid species	CITES Appendix II
Lower Montane Forest		
Agathis celebica	Damar	IUCN Red List: Lower Risk
Aquilaria filaria	Gaharu	CITES Appendix II
Dacrycarpus imbricatus	-	IUCN Red List: Lower Risk
Dacrydium nidulum	Jewenikolano	IUCN Red List: Lower Risk
Dacrydium novo-guineense	Jewenikolano	IUCN Red List: Lower Risk
Nepenthes papuana	Pitcher plant	CITES Appendix II
Agrostophyllum sp.	Epiphytic orchid	CITES Appendix II
Apostasia sp.	Apostasia orchid	CITES Appendix II
Spathoglottis plicata	Ground Orchid	CITES Appendix II
Agalmyla sp.	-	Liana suspected to be new species
Karst Ecology Forest		
Alstonia Scholaris	Pulai	IUCN Red List: Lower Risk
Arenga pinnata	Aren	Ministry of Agricultural Decree No.54/Kpts/Um/2/1972

Important Plant Species in Lowland Forests Among the species recorded during surveys, three species were found as protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II, namely gaharu (*Aquilaria filarial* and *A. parvifolia*) and ramin (*Gonystylus macrophyllus*). Both species were scattered across the study area in low densities (*Aquilaria* in forests on ultra basic soils and *Gonystylus* in alluvial forests), mostly as saplings or seedlings. *Aquilaria parvifolia* and *Diospyros lolin* were among the 55 tree species represented by only one individual. *Aquilaria* yields the highly valuable agarwood. Large *Aquilaria* trees are now difficult to find as evidenced in this survey. *Gonystylus macrophyllus* is a globally-recognized luxury timber species which has been over-exploited and are now rare in its native range.

Intsia spp. (trade name: merbau) are among the most valuable timber species produced in Maluku and Papua region. Due to heavy domestic and international demand, *Intsia* population in natural forest is under threat. *Instia* has been proposed to be included under Appendix III of CITES.

Trees species in the family Dipterocarpacea are known to provide high-quality timber. The family has been overexploited in much of its natural range. Several species of Dipterocarps were recorded during the survey. Of these, *Vatica rasak* was abundant and well distributed. Others (*Hopea gregaria*, *H. papuana*, *H. dryobalanoides* and *Anisoptera thurifera*) were found in low density and frequency. Of the Dipterocarp species recorded, *Hopea gregaria* is an endangered species under IUCN's Red List. Dispersal range of Dipterocarps is generally limited due to their heavy seeds and they do not regenerate well in secondary forests. As such, intervention may be necessary to ensure their survival in mining-impacted forests.

Important Plant Species in Lower Montane Forests Among the species recorded during survey, there were several species with significant economic and ecological importance. *Aquilaria filaria* (gaharu), which is protected under CITES Appendix II, yields the highly valuable agarwood. Large *Aquilaria* trees are now difficult to find as evidenced in recent biodiversity surveys in which only saplings were recorded.

Agathis celebica (Damar) (dominant canopy species at one study site), is a tree species that can attain a large diameter and has a cylindrical log with high free bole. The wood is categorized as medium quality wood. Lately, this species has been highly exploited to be processed as furniture material. Beside its timber, *Agathis* produces resin with economic value, which contributes to the livelihoods of some local people. This multi-function species, which is categorized as Lower Risk on IUCN Red List, has not been stipulated as a protected species by the Government of Indonesia.

Conifers of Podocarpaceae family characterize lower montane forest in Halmahera. *Dacrydium novo-guineense* and *Dacrydium nidulum* are listed on IUCN Red List as low risk species. However, their limited range and usefulness as timber may threaten them in the near future.

The forest is abundant in epiphytes, many of which were out of reach and not included in the survey. One of the common epiphytes in the lower montane forest, *Hydnophytum formicarum* (Rubiaceae), is a medicinal plant whose tubers possesses cardiovascular, anti-inflammatory and antiparasitic effects and has been used for the treatment of hepatitis, rheumatism and diarrhea. *Nepenthes papuana* and wild orchids were abundant and widely distributed. All species of *Nepenthes* and Orchidaceae (orchid) family are protected under CITES Appendix A2. *Agalmyla* sp., a liana in Gesnariaceae family, is probably a new species in one of survey site. *Calophyllum* sp. which remains unidentified could be a new discovery as well.

Important Plant Species in Karst Areas. Two species found during the Karst survey have protection status. *Arenga pinnata* (Aren), found on the eastern part of Gunung Zohra Karst was the only species protected by the Indonesian Government (Ministry of Agricultural Decree No.54/Kpts/Um/2/1972), due to its multipurpose function. This species is distributed in other parts of Indonesia and is typically found in the poorly drained soils. It is widespread throughout the swamps of the CoW.

Alstonia Scholaris (Pulai), observed in Karst forest, is registered on the ICUN Red List as lower risk. This tree species is widely spread throughout the major islands of Indonesia, including Sumatra, Kalimantan, Sulawesi and Papua. This species was not wide spread within the Karst forest. Macaranga involucrate was the only species found in the Karst forest that is endemic to Maluku. This species is a pioneer species found in open areas. It is likely that this species is found in other forest types.

6.1 FAUNA BIODIVERSITY

Monk *et al* (2000) stated that biologically, Maluku can be considered poor in terms of its biodiversity, because Maluku has never been linked to the main islands of Indonesia, Asia or Australia. An additional reason for the relatively poor diversity of both flora and fauna is the very low nutritional status of the lateritic soils, in contrast to the young volcanic soils that occur in most Indonesian areas of high bio-diversity. Forests provide the main habitat for most fauna, providing shelter, cover and food. Ecological restoration of the disturbed land cover on mined areas is essential if pre-existing fauna are to re-colonize these areas.

6.4.1 Birds

Previous studies on Halmahera (cf. that of BirdLife) and the surrounding islands of North Maluku have identified 232 bird species, including 28 endemic and 72 protected species (Coates & Bishop, 2000; Noerdjito & Maryanto, 2007). The bird survey in WBN CoW has recorded 130 species from 50 families as shown the **Table VI-3**. Of the total number of species, 48 are protected under Indonesian Law, 24 species are protected under the CITES Appendix II, 27 species are registered under IUCN Red List. The bird survey also found 27 species endemic to either Halmahera or North Maluku.

Table VI-3 Number of Birds Species Found for Each Ecosystem Type in WBN

Forest Ecosystem Type	Number of Species	Protected species	Endemicity
Karst Forest	43	23	15
Lowland Forest	99	47	22
Lower Montane Forest	83	35	16

Note: Protected species include those species classified under Indonesian Law, CITES and IUCN
Endemicity refers to North Maluku or Halmahera.

Table VI-3 summarizes the bird diversity, protected status and endemicity in relation to the forest ecosystem types. Data in the table clearly show the lowland forest have not only the greatest diversity but also the highest number of protected species. The most likely reason for this is that the lowland forest covers a broad range of habitats including mangrove, freshwater swamp, plantations, primary and secondary forest on alluvial and ultra-basic soils.

A number of species occurring in the study area are significant due to their protected status, rarity, specialized habits, restricted range, or potential for exploitation. According to the IUCN Red List, there are currently no species which are classified in the highest category of Critically Endangered and one species, the Chattering Lory (as shown in Figure VI-4) classified as Endangered. There are four species (Drummer Rail, White Cockatoo, Sombre Kingfisher and Dusky Friarbird) classified as Vulnerable and four species classified as Lower Risk (near threatened).

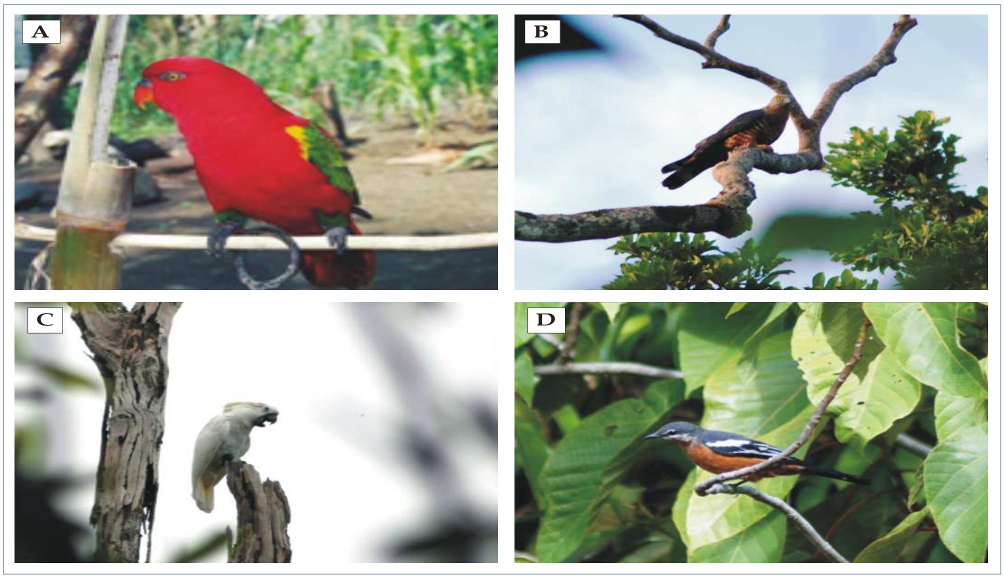


Figure VI-4 ***(A) The Chattering Lory, an Endangered Species, is a highly valued commodity in the Indonesian domestic bird trade, (B)*** *Moluccan Goshawk (Accipiter henicogramus) in limestone, (C) White Cockatoo (Cacatua alba) observed on the edge of secondary forest, (D) (Rufous-bellied Triller) one of endemic birds in Wallacean area*

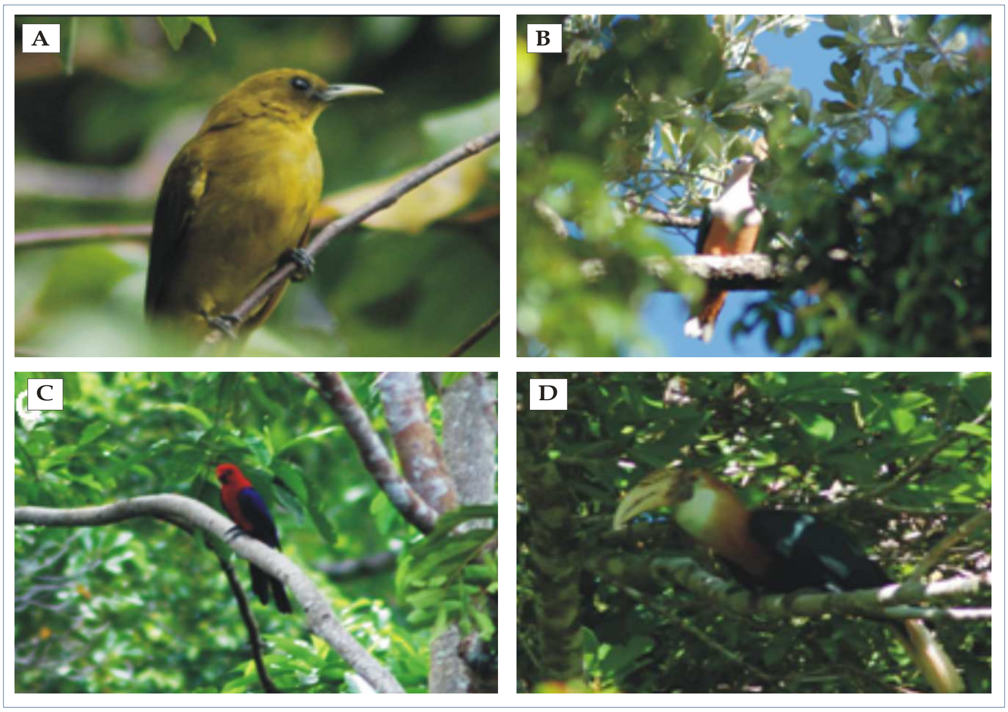


Figure VI-5 (A) *Thapsinillas affinis* (Golden Bulbul), endemic bird in Wallacean area, (B) Cinnamon-bellied Imperial Pigeon (*Ducula basilica*) common species found in study area, (C) Moluccan King Parrot (*Alisterus amboinensis*) one of rare species, (D) Blyth's Hornbill (*Rhyticeros plicatus*)

6.4.2 *Significant Herpetofauna*

McGuire et al (2000) recorded 53 species of herpetofauna (i.e. reptiles) on Halmahera, with 5 species considered endemic to the island and 5 protected species. The various surveys conducted in the WBN COW recorded a total of 16 amphibian species and 33 reptile species.

A greater number amphibian species were recorded in the lower montane forest (9 species) as compare to karst and lowland (6 species each). Given the wet and humid climate of all forest types and subsequent microclimates, it is unlikely that this difference in amphibian diversity is significant.

Reptile in lowland forest had greater species (23) than karst (7 species) and lower montane (14 species). Reptile, being cold blooded species, will be more likely to occur in the warmer climate of the karst and lowland forest. Skinks and lizards appear to be more adapted to the colder temperature of the lowland montane forest than snakes.

The dominant reptile species in all forest types were either skinks or geckos. In the Karst forest, *Emoia kuekenthali* (a species of skink) seems to dominate, however, this species was mainly recorded in disturbed areas. The most dominant reptile for both the lowland forest and the lower montane forest were found to be *Emoia cf. baudini* (a species of skink) and *Hemidactylus frenatus* (house gecko).

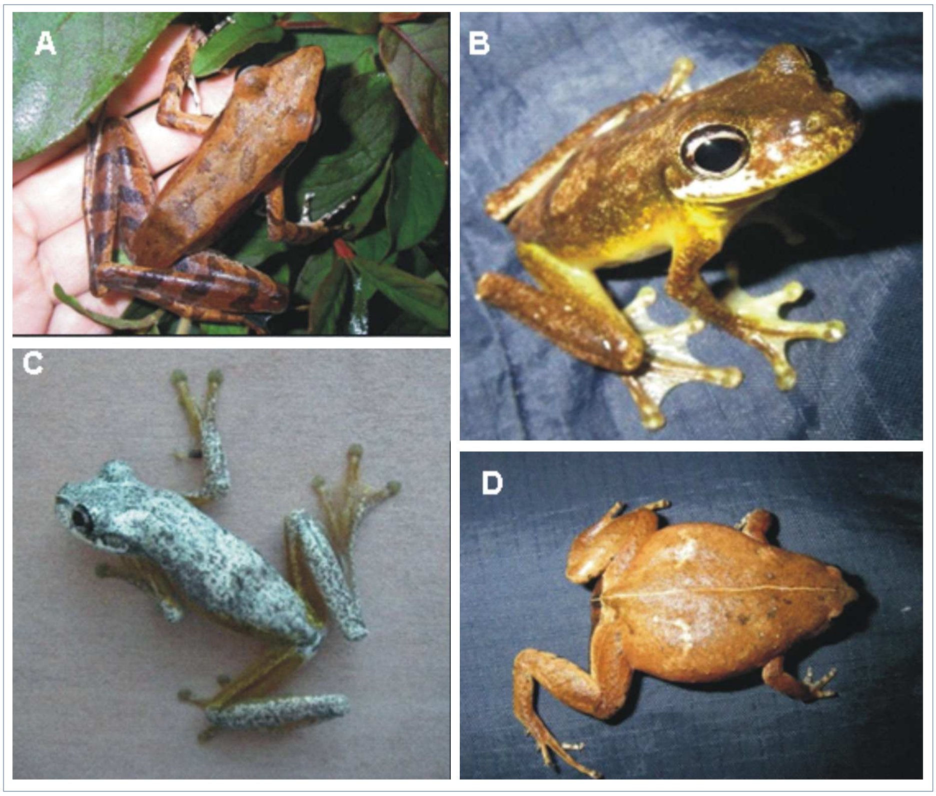


Figure VI-6 **Examples of amphibians found during survey***: (a) Rana grisea, (d) Litoria amboinensis* **during night time** *(b) Platymantis papuensis, (c) Litoria amboinensis* **during daytime, and** *(e) Oreophryne senckenbergiana,*

A number of species occurring in the study area are significant due to their protected status, rarity, specialized habits, restricted range, or potential for exploitation. Nine species of amphibian were registered under IUCN Red List. One species, *Nyctimystes rueppelli,* is classified as vulnerable and was found in the lowland forest. According to the IUCN Red List, there is only one species classified as vulnerable, the Asian Box Turtle (*Cuora amboinensis*). This species is threatened throughout Asia through habitat loss, and through collection for the pet trade. It is very common on Halmahera, and was reported to be common in the streams and swamps of the project area (**Figure VI-7 A**).

The Sailfin Lizard *(Hydrosaurus amboinensis)* has been protected under Indonesian law since 1973 (as shown in **Figure VI-7 B**). The species remain popular the international reptile trade due to the decreasing population due to habitat destruction or illegal hunting as well as collection of their eggs.

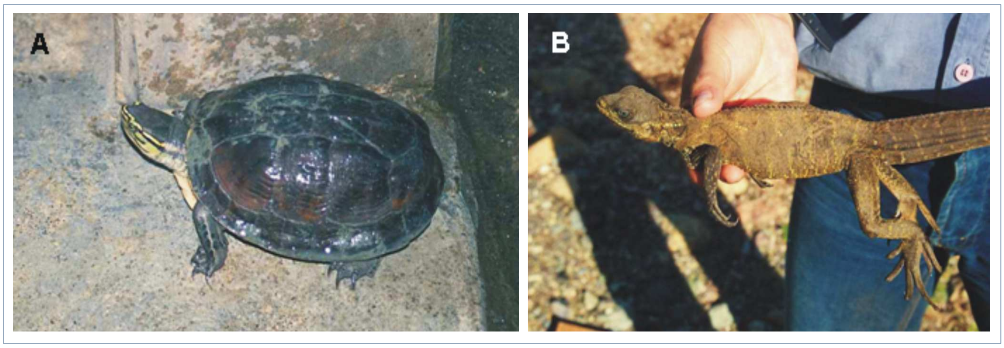


Figure VI-7 ***Protected reptiles found in the study area (A)*** *Asian Box Turtle* ***(Cuora amboinensis****)* ***kept as p****et at Gemaf Village*, ***(B) A Female Sail-Fin Lizard (Hydrosaurus amboinensis)***

6.4.3 Mammals

Previous studies of mammals in the Maluku region have recorded 120 species of which 28 species are endemic and 14 species protected. Studies on Halmahera Island have recorded only 44 mammal species (Suyanto et al., 2002, Noerdjito & Maryanto, 2007) suggesting a poor diversity of mammal species in relation to the surrounding islands.

Bats are the most common mammals encountered in Maluku but there appears to be no endemic genera there, although there are a few endemic species (Corbet and Hill 1992).

A total of 22 species bat have been recorded on Halmahera including three full species and two sub-species which are endemic to North Maluku and two endemic sub-species of Horseshoe-bat.

The various surveys conducted in the WBN COW recorded a total of 10 non-flying and 12 flying mammal species. In the karst, there were no dominant non-flying mammals recorded. Due to the availability of caves in the karst, two species of bats were found to be dominant i.e. Raffrays Sheath tail-Bat (*Emballonura raffrayana) and* Fawn Horseshoe-Bat (*Hipposideros cervinus).* In both the lowland and lower montane forest, the dominant species recorded were Wild Boar *(Sus scrofa)* and Wild Rat *(Rattus sp.).* Both species are not native to Halmahera. Of the 10 species of fruit bats (Pteropodidae family) identified on Halmahera (Dames and Moore 2001), nine species were recorded in the lower montane forest (**Figure VI-8**).

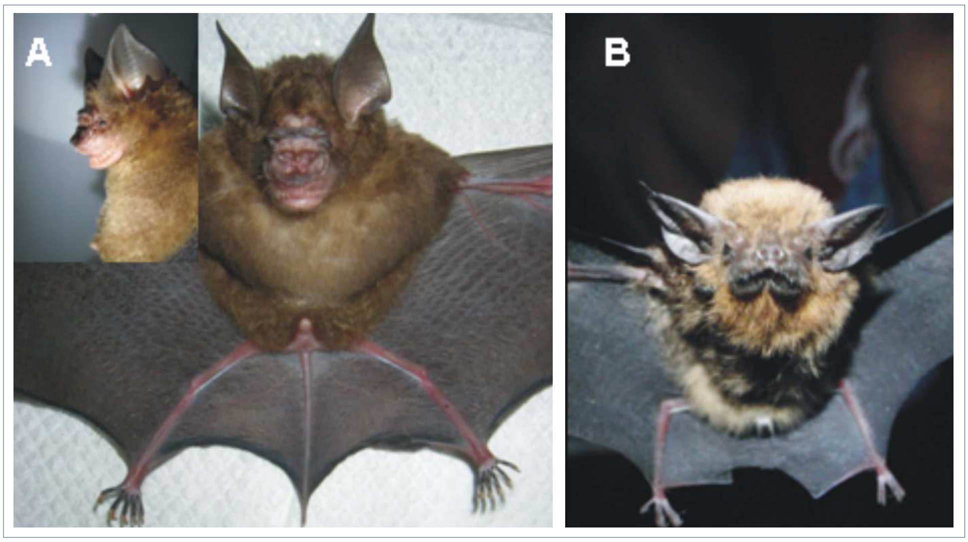


Figure VI-8 ***Two dominant bat species found in caves. (A) Fawn Horseshoe-Bat (Hipposideros cervinus Gould, 1854), (B) Raffray's Sheathtail-Bat (Emballonura raffrayana Dobson, 1876)***

The Ornate Cuscus (*Phalanger ornatus)* was the only mammal, native to the island, recorded in the survey that protected under Indonesian Law. The Timor Deer (*Cervus timorensis*), which was recorded as widespread but in low density in all forest type, is also protected under Indonesian Law. Of the 10 mammal species register on the ICUN Red List, only the Lesser Tube-nosed Bat (*Nyctimene minutus*) is vulnerable.

Two species of mammals recorded in the survey are endemic to the region. The Moluccan Prehensile-tailed Rat (*Rattus morotaiensis)* is endemic to North Maluku. The Brown Eyed form of the Ornate Cuscus (as shown in **Figure VI-9)** which is only found in Halmahera and Bacan is a subspecies of the Ornate Cuscus of North Maluku.

Figure VI-9 ***Ornate Cuscus (Phalanger ornatus) subspecies endemic to Halmahera and Bacan***

6.4.4 *Insects (Butterfly)*

Little is known regarding butterfly species of Halmahera. Previous studies on butterflies by Sutrisno (1995) in North Halmahera resulted in 20 species from 7 families. A total of 46 species of Butterfly were recorded during the fauna survey in WBN COW area, from 6 families. Thus, the fauna survey of Weda Bay Nickel's Contract of Work identifies a significant increase in the butterfly species diversity than previously published surveys.

The Karst forest had the greatest diversity, with 37 species identified, whilst the lowland and Lower Montane forest recording 13 species each. Six butterfly species were most dominant in the Karst: *Jamides* sp., *Vagrans* sp., *Andaus* sp., *Andis* sp., *Terias* sp. and *Papilio* sp. Four butterfly species were the most dominant in the lowland forest: *Idea* sp.; *Ideopsis* sp.; *Zizina* sp.; *Papilio* sp.; and *Catopsilia* sp. Seven butterfly species were commonly observed in the Lower Montane forest: *Euchrysops* sp., *Eurema* sp., *Hypolimnas* sp., *Jamides* sp., *Junonia* sp., *Mycalesis* sp. and *Zizina* sp

A review of the CITES and IUCN Red List database found that none of the butterfly species recorded in the Weda Bay Nickel Contract of Work were protected under international treaty. No butterfly species recorded during the fauna survey are protected under Indonesian Law (Government Regulation No 7 of 1999 regarding Preservation of Plants and Animals).

6.4 *CURRENT BIODIVERSITY INITIATIVES*

In addition to the complementary surveys associated with TM01 Terrestrial Biodiversity, WBN has committed to initiatives related to Biodiversity that focus on restoration of disturbed forest vegetation and habitats.

Permanent Plots. In 2009, two out of a proposed number of six permanent plots were established in the WBN CoW. The objective of the Permanent Plots is to monitor impacts from the mining operation on the surrounding environment. Other benefits of permanent plots include providing a source of seedlings and a seed bank for rehabilitation activities, generate growth rate data for rehabilitation purposes, improving accuracy on carbon sequestration and as a fauna refuge.

The establishment of plots in the Lower Montane and Mangrove forests was completed, along with the initial round of monitoring and identification. Additional plots in the various lowland forests are planned for 2010.

Figure VI-10 Bukit Limber Test Plot

Nursery Trials. Nursery and propagation trials at WBN commenced as early as 2001; however greater focus was put on these trials during the Trial Mine Test Pit operations in 2007. Two nurseries have now been established, in the Lower Montane habitat and the Lowland habitat. The total number of local species successful propagated in the lowland nursery was 52, and in the lower montane nursery it was 31[8]. The most successful form of propagation has been through the farming of seedlings from the forest.

Figure VI-11 Bukit Limber Nursery

[8] These totals include tree and non-tree species.

CHAPTER VII
INDIGENOUS PEOPLES (IFC PS7)

The objectives of IFC PS 7 are:

- Ensure that the development process fosters full respect for the dignity, human rights, aspirations, cultures and natural resource-based livelihoods of Indigenous People.
- Avoid adverse impacts of projects on communities of Indigenous People, or when avoidance is not feasible, to minimize, mitigate, or compensate for such impacts, and provide opportunities for development benefits, in a culturally appropriate manner.
- Establish and maintain an ongoing relationship with the Indigenous People affected by a project throughout the life of the project.
- Foster good faith negotiation with and informed participation of Indigenous Peoples when projects are to be located on traditional or customary lands under use by the Indigenous People.
- Respect and preserve the culture, knowledge and practices of Indigenous People.

7.1 *ISSUE OF APPLICABILITY*

PS7 addresses the potential vulnerability of Indigenous People "if their lands and resources are transformed, encroached upon by outsiders, or significantly degraded" as a consequence of the proposed project. Indigenous People are social groups with "identities that are distinct from dominant groups in national societies." The IFC addresses in PS7 the need to "defend their interests in, and rights to, lands and natural and cultural resources" and to determine whether their status may restrict their ability to participate in and benefit from the project.

IFC's PS7, as well as the World Bank's OP 4.10, applies a global definition to varied national contexts concerning Indigenous People. In Indonesia, the effort to address concerns with respect to Indigenous People has been checkered. For this MIGA-oriented review of the WBN Project, three questions arise in the context of PS7 within the framework of pre-construction activities:

- Does PS7 apply from a technical point of view?
- What is the significance to the Project of applying PS7?
- What are the risks of not applying PS7?

These issues are addressed in the following subsections.

7.1.1 *Does PS 7 Apply?*

PS 7 certainly applies to the Project, but a key question is whether or not it should be applied to the majority populations of project-affected peoples (the Sawai and Forest Tobelo) or only to the small group of forest dwellers, the Forest Tobelo. Of the multiple ethnic groups in Central and Eastern Halmahera Regencies, those living in central Halmahera include the Sawai, Forest Tobelo (Tugutil), and Gorap. In the province of North Maluku one group is clearly recognised by all as "indigenous": the Forest Tobelo (also known as the Tugutil). ERM has recommended the Project refer to these people as the Forest Tobelo, as "Tugutil" is reportedly considered by the group themselves as a derogatory label, while "Tobelo" refers as well to a larger group of primarily coastal-living communities, with "Forest Tobelo" approximating a name they prefer for themselves.

Yet the majority population to the south of the COW in the Weda Bay area—the Sawai, a people dwelling on the coastal strip—also display characteristics commonly attributed to indigenous populations under the IFC's IP policy: self-identification, cultural distinctiveness, unique language, and collective attachment to traditional lands. Likewise, the Tobelo people who comprise the majority of the people in the South Wasile and Maba districts to the north and east of the COW in Eastern Halmahera Regency can also be seen to display such characteristics.

7.1.2 *What is the significance to the Project of applying PS7 to the Sawai?*

If PS 7 applies to a group of people, then certain requirements need to be met:

- ***Compensation.*** Indigenous Peoples status entitles a group to compensation for lands and resources even when they lack formal title but can show customary use. This can affect pay-out amounts for land acquisition.
- ***Consultations***. If a group is considered indigenous, then consultations held with them are required to be at a higher standard. This entails not just "free, prior, and informed consultations" but also good faith negotiations in the context of *land acquisition* involving commercial exploitation of natural resources and *physical displacement*, if land is communally held.
- ***Benefit-sharing.*** When PS 7 applies the Project needs to include benefits-sharing measures along with mitigation measures in a community development plan.
- ***Land claims***. When PS 7 applies the Project is also encouraged to support or facilitate efforts to regularize customary land claims, as appropriate.

7.1.3 *What are the risks of not applying PS7 to the Sawai?*

Not declaring the Sawai as indigenous (i.e., not applying PS7 to the Project as a whole) is likely to invite future problems. The IFC or another financial institution might decide the project should have recognised the Sawai as indigenous and accordingly require a new round of consultations be held with them to confirm previous agreements reached, but this time at the higher "good faith negotiations" level. They might also review land compensation agreements to make sure that the Sawai were properly compensated for lost customary land at the same standard as regular landowners. An added element of uncertainty regarding IFC's approach is the ongoing review of its Performance Standards (scheduled to be completed by October 2010) which might change IFC's approach to application of PS 7.

The Sawai communities might later register with AMAN (*Aliansi Masyarakat Adat Nusantara,* or Indigenous Peoples Alliance of the Archipelago), thus undermining part of the rationale for not having treated them as indigenous in the first place. Although AMAN's membership definition does not match the IFC/World Bank indigenous definition, AMAN membership would raise the national and international profile of this issue. Social tensions could rise, which might cause disruption to the project based on the Sawai feeling that their communal rights were not recognised fully—particularly their rights to land. Furthermore, NGOs might challenge the decision not to treat the Sawai as indigenous.

Given the Project's ongoing plans for a benefits-sharing arrangement such as envisioned in a Community and Indigenous Peoples Development Plan (CIPDP), for a robust consultation process, and for a high level of engagement, most requirements of PS 7 are already planned to be applied to the project. There are few risks, then, of applying the PS 7 to the project, other than a resistance among Indonesian staff and external parties to designating Halmahera mainstream groups (non-Forest Tobelo) as indigenous.

To avoid such a risk, it would be prudent for the Project to quietly apply PS 7 to the Project as a whole. As such it is also necessary to apply the PS' other requirements as well, including continuing with efforts to recognize communal land rights in some way. Applying PS7 to the entire Project also deprives external parties of a convenient stick by which to criticize the Project—as indigenous rights is an internationally prominent issue, particularly for extractive industries in eastern Indonesia. Also, this decision protects the Project against later changes in IFC policy (the Performance Standards revision expected later in 2010) and later demands by the Sawai themselves (with or without the urging of groups such as AMAN) to be treated as an Indigenous Peoples under the IFC policy.

7.2 *INDONESIA FRAMEWORK*

As per paragraph G1 of the PS7 Guidance Note, under international law, key UN human rights conventions form the core of international instruments that provide the rights framework for the world's indigenous peoples. Some countries have passed legislation or ratified other international or regional conventions for the protection of Indigenous People.

- Indonesia is one of the most ethnically and culturally diverse countries in the world. There is no definitive number of ethnic groups or languages spoken and no agreement on the use of the term "Indigenous Peoples." Conservative estimates list about 500 ethnic groups speaking as many languages, while other sources estimate up to 2,000 ethnic groups. This ethnic diversity is understood to be an asset-base of cultural resources supporting state unity, as is reflected in the national slogan: *Bhinneka Tunggal Ika* (Unity in Diversity). During the New Order period, *tunggal ika* (unity)—understood as implying a unified, standardized effort in contribution to economic growth—was more strongly emphasised than *bhinneka* (diversity). Since the end of the New Order period, public acceptance of diversity was reintroduced into social and cultural affairs.
- Traditionally the term associated with Indigenous Peoples in Indonesia is *masyarakat terasing* (isolated community), which refers to remote and vulnerable communities. This term was often used in a derogatory way, and government programs were designed to empower and "uplift" these communities from their isolation and "backward practices" with little respect for their cultural traditions and identity. To remove the negative connotations of *masyarakat terasing,* the Department of Social Affairs adopted a new term—*komunitas adat terpencil* (KAT), or remote *adat* (traditional) communities—that was defined by six characteristics: (i) small, closed homogenous groups; (ii) kinship-based social institutions; (iii) geographical remoteness, living in areas difficult for outsiders to access; (iv) use of simple technologies; (v) high dependence on the environment and natural resources; and (vi) limited access to social, economic and political services (Presidential Decree No. 111 of 1999). While difficult to estimate exactly, the number of people included under this category is likely around 1.5 million—mainly populations in Papua (formerly Irian Jaya), Kalimantan, Sulawesi, Sumatra, and the smaller outer islands such as Sumba, Sumbawa, and Maluku. The Sawai are not registered on the official Department KAT list.
- The term *komunitas adat terpencil* combines the previous *masyarakat terasing* with emerging legislation that recognises the more neutral and less exclusive term *masyarakat adat* ("customary law communities" or "legal communities")—referring to communities that establish their own

regulations and social control. This legislation recognises the status of *adat* communities and includes some provisions for their protection and rights, including over *ulayat* (communal) land—although this is open to multiple interpretations. Examples include the Human Rights Act (Act No. 36 of 1999) and the Local Government Act (Act No. 22 of 1999), as well as agrarian legislation (Regulation No. 5 of 1999: Guidance for Resolution of Problems of *Ulayat* Right of *Adat* Law Communities). The Forestry Law, however, does not provide the same level of protection of *adat* communities and *ulayat* land, which is classified as a sub-category of state forest.

- The majority of traditional communities in Indonesia are forest dwellers, and since State forest land covers some 70% of the country (with or without remaining forest), the legal framework that most affects Indigenous Peoples in Indonesia is this basic Forestry Law (Act 41 of 1999). The law states that the rights of traditional peoples can be recognized, as long as there is a regulation at District or Provincial level defining the community and territory concerned. In practice this has not happened and recognition of the rights of traditional communities remains the political aspiration of civil society groups such as AMAN, the Traditional Communities Alliance of the Archipelago.[9] There has been some progress in practical adaptation of forestry policy to accommodate local needs, though this stops short of acknowledging rights.

7.3 *PROJECT PRECEDENTS*

The IFC, as the private sector arm of the World Bank Group, directly relies on the experience and advice of the World Bank. A search of the World Bank data base revealed over two dozen projects where Indigenous People were recognised as project-affected peoples somewhere in the country.[10] Three Halmahera-focused projects and one national project located on Halmahera were also found (listed below):

- Partnerships for Conservation Management of Aketajawe-Lolobata National Park, North Maluku

[9] AMAN defines *masyarakat adat* as communities of people who: have lived from their ancestors' time in a specific geographic area; have a system of values and a culture that is unique to them; have sovereignty over the land and natural resources, and manage their existence with the use of customary laws and institutions. Members of AMAN are not tribal groups but are communities who live in a traditional way. AMAN's approach to working with *masyarakat adat* communities points to the fact that some people from the same tribal group may not be considered *masyarakat adat*.

- Maluku Regional Development Project
- Maluku Conservation and Natural Resources Project
- Third Kecamatan Development Project.

Of the four Halmahera projects, none addressed the status of the Sawai or Tobelo specifically. Apart from the first project in the National Park, however, the other three covered peoples ethnically and socially similar to the Sawai; these groups were recognized as Indigenous Peoples. Yet since the Indigenous Peoples were the majorities of the project-affected peoples, for two of the projects they chose to design the project to meet all Indigenous Peoples policy requirements and not create a stand-alone Indigenous Peoples plan. As for the IFC, it has not yet applied PS 7 to Halmahera nor financed a project in this region of Halmahera.

As noted earlier, the World Bank is currently reviewing its approach to determining which groups should be considered indigenous in terms of policy application, while the IFC is undergoing its own review of its Performance Standards, including PS 7. Direct consultation with those responsible for these processes revealed that they believed that in the coming years, Indigenous Peoples designations will probably be applied more often in WB projects and that Indonesian civil society groups such as AMAN will pursue plans to promote *masyarkat adat* registrations, particularly for groups living in areas which will receive project investments, thus raising the profile of project treatment of such issues.

Preceding studies relevant to the current effort are described in the following textbox.

7.4 IDENTIFICATION PROCESS

Resolving whether to categorize ethnic groups as Indigenous People usually involves a careful interpretation of the IFC policy on Indigenous People.[11] The policy definition focuses on four distinct characteristics (possessed "in varying degrees"):

1. self-identification as indigenous
2. collective attachment to ancestral territories and resources
3. unique social, economic, cultural, and political institutions
4. distinct language

11

PARTNERSHIPS FOR CONSERVATION MANAGEMENT OF AKETAJAWE-LOLOBATA NATIONAL PARK, NORTH MALUKU

An IP Plan was prepared for the Partnerships for Conservation management of Aketajawe-Lolobata National Park Project. The project IPP considered whether to include communities living in settlements outside the Aketajawe—Lolobata National Park, and in seminomadic groups within the park—within the definition of Indigenous People.

The project social assessment findings indicated that no permanent settlements were located inside the National Park. Three villages (comprising nine sub-villages) and three transmigration settlements were close to the boundary of the National Park, however only a small proportion of the people in these settlements are indigenous in the sense of the Bank's criteria. The majority of the affected people derived from ethnic groups traditionally comprising farmers and fishermen living in coastal settlements (the Tobelo, Maba, and Bicoli) or originating from outside Halmahera.

Within some villages there was a minority of people who self-identify as members of the Forest Tobelo ethnic group. The Forest Tobelo's distinct language, culture, and attachment to particular forest areas within the project area qualified them as Indigenous People under OP 4.10. There were several small hamlets where the residents appear to be virtually all Forest Tobelo, and are in varying stages of adopting a sedentary lifestyle. There is also a small population of Forest Tobelo people still living semi-nomadic lives within the forests covered by the National Park and surrounding logging concessions. These people qualified as Indigenous Peoples and are the focus of the project's safeguards work.

MALUKU REGIONAL DEVELOPMENT PROJECT

The Maluku Regional Development Project recognized that there were a number of Indigenous Peoples in the area (not the Sawai, but coastal groups similar to them), but decided that since the whole project basically supported indigenous and other groups, the project as a whole conformed with Indigenous Peoples Development Plan requirements and no special stand-alone plan was necessary.

MALUKU CONSERVATION AND NATURAL RESOURCES PROJECT

The Maluku Conservation and Natural Resources Project was not financed, but nevertheless employed an anthropologist to make an initial assessment of the Indigenous Peoples situation in the area. In the Project Appraisal Document, Indigenous Peoples are recognized to inhabit Central Halmahera and Maluku, but the report also concluded that an IPP would not be necessary since most beneficiaries are Indigenous Peoples. Instead, the project as a whole would be designed to meet the requirements of the Indigenous Peoples policy.

IFC's Guidance Note on its Indigenous Policy (PS 7) is clear: "…the applicability of Performance Standard 7 is determined on the basis of the four characteristics presented in paragraph 5 of Performance Standard 7," which are those listed above. In addition, "each characteristic is evaluated independently, and no characteristic weighs more than the others." In addition, the IFC recognizes that indigenous groups comprise a socially vulnerable section of society, but does not explicitly use vulnerability in the identification process.

7.5 *ASSESSMENT*

7.5.1 *Forest Tobelo*

A number of small groups each based around a single family are known to inhabit the inland forests of Halmahera. Collectively known as the Forest Tobelo, these groups are nomadic, depending on hunting and gathering for subsistence, and occasionally visiting lower elevations to harvest sago.

Members of the groups avoid contact with other inhabitants of Halmahera, except if they are trying to exchange goods for tobacco, salt, and rice. It can be expected that they will largely avoid contact with project operations.

Preliminary anthropological studies (URS/Dames & Moore, 2001), along with site experience, suggest that the Forest Tobelo are present in the Jira River valley (proposed location of the RSF) and in East Halmahera, close to the Tofu Bleuwen deposit. Reference studies have also indicated that they are also known to range widely throughout other parts of the island.

The extent to which the Forest Tobelo depends on resources within or close to areas to be mined is not known. However, ERM has conducted studies of the Forest Tobelo in January and February 2010 to look into such questions, with a report expected by late March 2010. It is possible that Project activities may hamper their movements and cause changes to livelihood patterns and distress.

7.5.2 *Are the Sawai Indigenous?*

The Project Sponsor can argue that to the degree the IFC Indigenous People Policy (although not its definition of Indigenous People) mentions vulnerability as a general characteristic of Indigenous Peoples, the Sawai in their Halmahera social context do not display classic vulnerability, especially as compared to groups like the Forest Tobelo. Furthermore, in the Indonesian context, the Sawai are not in the remote or isolated status of the Forest Tobelo and are full participants in the regional mainstream. Although individuals claim *adat* (communal) rights, AMAN, the national association of adat communities, has not registered the Sawai as a *masyarakat adat* (customary community) group, and thus arguably they have not self-declared as an "indigenous" group.

However, a good case can also be made that the Sawai nevertheless fit the four identifying characteristics for Indigenous Peoples used by IFC and that they by and large demonstrate the Indonesian concept of *masyarakat adat* as well. IFC and World Bank staff, when apprised of the general project and Sawai context, recommend that the Project proceed with IFC PS 7 applying to the Project as a whole, to include groups like the Sawai and Tobelo. Academic and civil society predilections also clearly lean toward designating these groups as Indigenous People. One could also argue that their lack of formal land title also renders them economically vulnerable, as does their poverty.

Fuller exploration of the degree to which the local Sawai and Tobelo communities meet the four characteristics is needed to provide a more definitive answer to this question. Fortunately, the Community Social Assessment Study carried out by ERM in November and December 2009 aimed at collecting information regarding customary land use and similar information and can hopefully add to this discussion.

7.6 BROAD ACTIONS REQUIRED BY PS 7

Following are broad approaches required by the IFC with respect to Indigenous Peoples:

- WBN and the affected communities of Indigenous Peoples should establish an ongoing relationship throughout the life of the project. The client is required to engage in a process of free, prior and informed consultation and informed participation (as per paragraph G3 of the PS7 Guidelines).
- PS7 Guidelines (paragraph G13) require that the CIPDP address broader community development issues "where communities of Indigenous Peoples exist in the same area with other similarly affected communities or where the Indigenous Peoples are integrated within a larger affected population." The CIPDP should detail actions to minimize, mitigate, or compensate for adverse social and economic impacts, and to identify "opportunities and actions to enhance positive impacts of the project on the Indigenous Peoples." The plan may also include measures to conserve and manage the natural resources on which they depend on a sustainable basis.

CHAPTER VIII
CULTURAL HERITAGE (IFC PS8)

The objectives of IFC PS 8 are as follows:

- To protect cultural heritage from the adverse impacts of project activities and support its preservation
- To promote the equitable sharing of benefits from the use of cultural heritage in business activities

WBN's AMDAL impact assessment baseline studies identified areas local residents considered culturally significant. These are being followed up as part of a broad scope of the Community Social Assessment (CSA) in Technical Memorandum 3 (TM03) of the BFS ESHIA. The objective of the CSA is to provide the Project with sufficient information to prepare well-formulated and integrated social planning frameworks. The CSA is the most critical exercise of the five social Technical Memoranda (TMs 03-07). A two-week on-site investigation has allowed the study teams—working in close coordination with on-site WBN staff—to gather directly the data needed for preparation of the Community and Indigenous Peoples' Development Plan (TM05), aspects of the Public Consultation and Disclosure Plan (TM04), and sections of the Cultural Heritage Assessment (TM06).

8.1 PROTECTION OF CULTURAL HERITAGE IN PROJECT DESIGN AND EXECUTION

TM06 will subject the project area to a scoping exercise to determine the presence of cultural heritage sites. It is widely recognized that the vicinity was home to the two early Muslim kingdoms of Ternate and Tidore. Vassal states in Papua paying tribute to the Sultan of Ternate transited the Weda area and seem to have established a presence there. It is therefore suspected that undisclosed sites from the two kingdoms or tribute states may exist in the COW. It may also be possible to discover heritage sites belonging to the local indigenous group, the Tugutil. Options for safeguarding physical/tangible Cultural Heritage in the project area are summarized below in 8.2, Chance Finds Protocol. There are however other considerations than potential to uncover artifacts, as summarized below.

8.1.1 Does the Project need anything other than a Chance Finds Protocol?

The CSA undertaken within the framework of the ongoing BFS ESHIA study revealed the presence of sacred sites claimed by villagers in the project area of impact. Other cultural heritage sites might also exist. In order to prevent disturbance of such sites, the Project will develop mechanisms for the identification of areas of potentially significant cultural heritage. Such mechanisms would likely be organized into two categories: those investigating and mapping oral accounts of sacred sites (a process to be conducted and completed before operations) and those designed to test and "clear" mining and construction sites prior to disturbing the land (an on-going process)

At the same time, it is important to take into consideration that a community's Cultural Heritage may also be understood to encompass a host of cultural practices and beliefs. IFC PS 8 covers intangible cultural heritage in the event the Project proposes to exploit that heritage commercially. Given the sensitivity of language and cultural institutions to the definition of Indigenous Peoples among international financial institutions, the Project team is proceeding carefully to insure that its operations do not adversely affect such aspects of customary community practices, representations, expressions, knowledge, and skills. The Community Social Assessment conducted in November and December 2009 gathered information on local heritage customs as part of a cultural baseline for the Project. Discussions were also held with local *adat* leaders to learn about efforts to promote and preserve local culture.

For example, one Sawai community member has been actively working with the Summer Institute of Linguistics International to preserve and promote the Sawai language through the development of educational materials. Concerns have been raised with respect to the future of both the Sawai language and *adat* institutions and general practices. There are well-founded fears that by bringing more 'outsiders' into the area, the Project might contribute to the erosion of customary beliefs and practices. Mechanisms to help preserve and promote local intangible cultural heritage is one area where the Project might be able to establish itself as an international "good practice" example.

8.1.2 *What is known of cultural heritage in the Project area*

Few specifics are known about potentially significant cultural heritage in the Project COW. The Project area has not yet been subjected to detailed scoping and appraisal for tangible cultural heritage, although initial cultural heritage survey questions were part of the Community Social Assessments in November-December 2009 and during the Forest Tobelo Project Impact Assessment held in January-February 2010. What is also known is that the region was home to two early Muslim kingdoms i.e. Ternate and Tidore. It is therefore suspected that undisclosed settlement (and possibly burial) sites from the two kingdoms or tribute states exist in the COW.

During the Community Social Assessment, attention was brought to one such potential site of archaeological significance not far from Tanjung Ulie base camp: a purported depository of human remains from a 17th century period of tribal warfare under the Ternate sultanate. A brief excursion to the area verified the presence of human remains, but not in a quantity or context that would corroborate the oral record. This is not to say that the oral record is inaccurate, but it does raise the question about the threshold of artifact density for determining a site of archaeological significance under national regulations as well as international financers—as well as what measures for testing undisturbed terrain ought to be followed to prevent potential disruption of prehistoric burial sites.

With regard to the Sawai people, historians of the area talk about a first wave of migrants arriving hundreds of years ago from Papua to plunder and eventually settle on the coast of a bay on the east coast of Halmahera. Later waves of Papuan migrants then waged wars with descendents of the first wave settlers for control of the island. All of this may have left physical sites within the COW.

Sacred sites have been claimed by several project-affected villages, and more may be claimed by the nomadic group living in the interior, the Forest Tobelo.

No Cultural Heritage finds were reported during construction of the Project airport, the base camp, the Mining Test Pit, or any other facilities. At the same time, the record of previous construction teams needs to be reviewed as part of the cultural heritage screening to be conducted in May 2010 for indications of past settlement areas, etc.

The previously-mentioned Community Social Assessment emphasised that Cultural Heritage claims ought to be explored through targeted questions on sacred areas and on local legends. Based on the CSA, first indications are that there are indeed some sacred areas within the COW that need mapping. One oft-repeated story was a Sawai legend of a highly respected and powerful man of wonders, Legae Cekel. He was a giant who walked across Halmahera in one day from the north to the south leaving huge footprints which can still be seen in the Weda region and whose reputed burial place is marked by huge stones and considered sacred by local residents. The alleged location of the grave is approximately 12 kilometres from Lelielef Woebulen Village in the Central Weda District of Central Halmahera Regency.

Evidence of Islamic influences in the Maba community is found in the form of two sacred graves (*ere*). The local community believes these to be the graves of the adat leaders, or *Bobato*— missionaries of the Islamic religion. The first is Jere Ujung, which is located at the edge (*ujung*) of the village and the second is Jere Mohon, located on the island opposite Maba.

A number of villagers also reported the existence of "*tanah mistik* (sacred land)" in Nusa Jaya on the South Wasile coast at Jere Sumaka (place where graves are) and admonished the research team to "Leave it undisturbed!"

Within the framework of the BFS ESHIA study,TM06 activities are under way to screen for the likelihood of cultural heritage sites or artefacts in different locations in the project area. This process will begin in May 2010 with an analysis of topographic data to identify natural features around which past settlements are likely to have formed. This will supplement a desk study of archaeological and archival information that will be undertaken during May and June 2010 that might indicate the presence of a potential archaeological sites (based on findings in nearby areas, where a high density of artefacts have been unearthed by previous studies, or anecdotal evidence from nearby residents of the presence of a past settlement).

The TM06 study also will include a review of national and international laws and regulations to ensure that all cultural resource management laws are acknowledged, and will include consultation with government, academic, and civil society experts for "good practice" recommendations. Local experts from the area, including a noted anthropologist from Khairun University in Ternate, will be carrying out such desk studies. Their work will be peer-reviewed by an international expert on cultural heritage preservation in marine environments and indigenous cultural resource management.

If the screening determines that more analysis is needed, then a Cultural Heritage Assessment (CHA) should be carried out in close collaboration with, and securing the permission of, local authorities. A CHA would involve a more rigorous appraisal of the potential heritage sites, such as shovel testing, either at random or in a grid pattern, to try to find evidence of artefact rich areas.

8.2 CHANCE FINDS PROTOCOL

Paragraph G13 of the PS8 Guidance Note define the chance find procedure as "a project-specific procedure that outlines what will happen if previously unknown heritage resources, particularly archaeological resources, are encountered during project construction or operation." The Guidance go on to note that these procedures include record keeping and expert verification procedures, chain of custody instructions for movable finds, and clear criteria for potential temporary work stoppages "that could be required for rapid disposition of issues related to the finds." The protocol would define the roles and responsibilities and the response times required on the part of project staff and any relevant heritage authority, as well as any agreed consultation procedures.

If a decision is taken to prepare a Cultural Heritage Preservation Plan, a Chance Finds Protocol will be included.

Appendix A

Description of Exploration Areas

A.1 Bukit Limber

The Bukit Limber deposits occur in the central region of the northeast oriented belt in the ultramafic rocks in the CoW's southern region. This belt also hosts the Coastal laterite resource to the southwest and towards to the Sagea to the East direction. Laterites are developed in four main zones, with three others where the resource has not been defined:

- **Bukit Limber Barat** (West). A broad, ENE-WSW trending dissected plateau occupying the south-western region of laterite development. This zone is approximately 4.1 km in length and 2.2 km at its widest point and contains a significant proportion of the currently defined laterite mineralization. BLB profiles contain the highest average grades at Bukit Limber and are of appreciable mineralized thickness (~ 15 m on average).
- **Bukit Limber Selatan** (South). Extending south-eastward of the central margin of BLB and occupies an area of approximately 1.8 km in length and 1.3 km at its widest point. BLS laterite profiles are thinner (averaging about 7.5 m) and of lower grade compare to BLB.
- **Bukit Limber Timur** (East). Oriented in a similar direction to BLS but extends from the eastern margin of BLB. It comprises two parallel lobes of mineralization of similar grade and thickness to the BLS. There is potential to extend known resources to the south-east of this zone.
- **Bukit Limber Timur Laut** (Northeast). An extensive area of laterite extending north-east from the north-eastern margin of BLB. Laterites have been mapped over a strike distance of 5.7 km and are 1.4 km at the widest point. BLTL contains the thickest average laterite profiles in the Bukit Limber region (18 m) albeit of lower average grade compare to the BLB profiles. BLTL profiles are geochemically distinct from laterites developed in the other three regions, containing higher levels of silica. There is additional potential to extend resources further to the north in this zone.
- **Boki Mekot.** This district lies to the north east of Bukit Limber Timur Laut at a great distance from the Plant Site, so the resource has not yet been properly defined.
- **Jiguru.** The Jiguru deposit extends to the southeast of Bukit Limber Timur Laut at a great distance from the Plant Site, so the resource has not yet been properly defined.

- **Ngowen.** The Ngowen deposit is located approximately 2 km due east of the Jiguru and Boki Mekot deposits at a great distance from the Plant Site, so the resource has not yet been properly defined.

A.2 Coastal Deposits

Coastal Deposits occur in the southernmost area of the Weda Bay COW and are developed over the south-western extent of the same ultramafic block that hosts both the Bukit Limber and Sagea laterites. However, the Coastal deposits are of much smaller extent and morphologically different from the larger plateau style deposits of Bukit Limber and the Sagea area. The nine (9) separate Coastal deposits are located within close proximity to the process plant location. Five of these (Nuspera, Karkar, Ake Sake, Uni-uni and Biri-Biri) are included in the first development stage of the project.

- **Nuspera.** Located immediately west of the process plant site, from which it is separated by the Wosia River, this deposit is situated on a broad, gently undulating hill at elevations of approximately 10 m ASL in the southeast to 80 m in the northwest.
- **Ake Sake**. Located approximately 4 km east of the process plant site, this deposit shows economic mineralization in three (3) separate zones (or lobes) of laterite development. Sake Selatan, a flat lying area on the coastal plain with two additional areas of laterite development on a horseshoe-shaped ridge to the north-west that rises to an elevation of 360 m.
- **Uni-uni.** A laterite body located north-northwest of the Nuspera deposit with its southern margin approximately 2 km northwest of the process plant site. Uni-Uni laterites occupy a broad SE-NW trending hill elevated 145 m in the SE to 250 m in the NW, access to which will be from the mine access road to the Bukit Limber region.
- **Biri-biri.** The three main lobes of mineralization are Biri-Biri Barat, Biri-Biri Timur and Biri-Biri Timur Laut). BBB and BBT occupy respectively the western and eastern limbs of a horse-shoe shaped N-S trending ridge system, while the BBTL deposits occupy a northeast trending ridge that extends toward the western margins of Bukit Limber. The southern margin of BBB is approximately 5 km northwest of the process plant along the alignment of the main mine access road to Bukit Limber, which traverses both the BBB and BBTL deposits.
- **Karkar.** Located at the process plant area on the southern edge of a N-S trending ridge, this orebody is extremely limited in size with a thickness generally less than 6m.
- **Ake Lipe. L**ocated to the west of Ake Sake, along the current Bukit Limber Access Road, this deposit has a southwest/northeast trend.

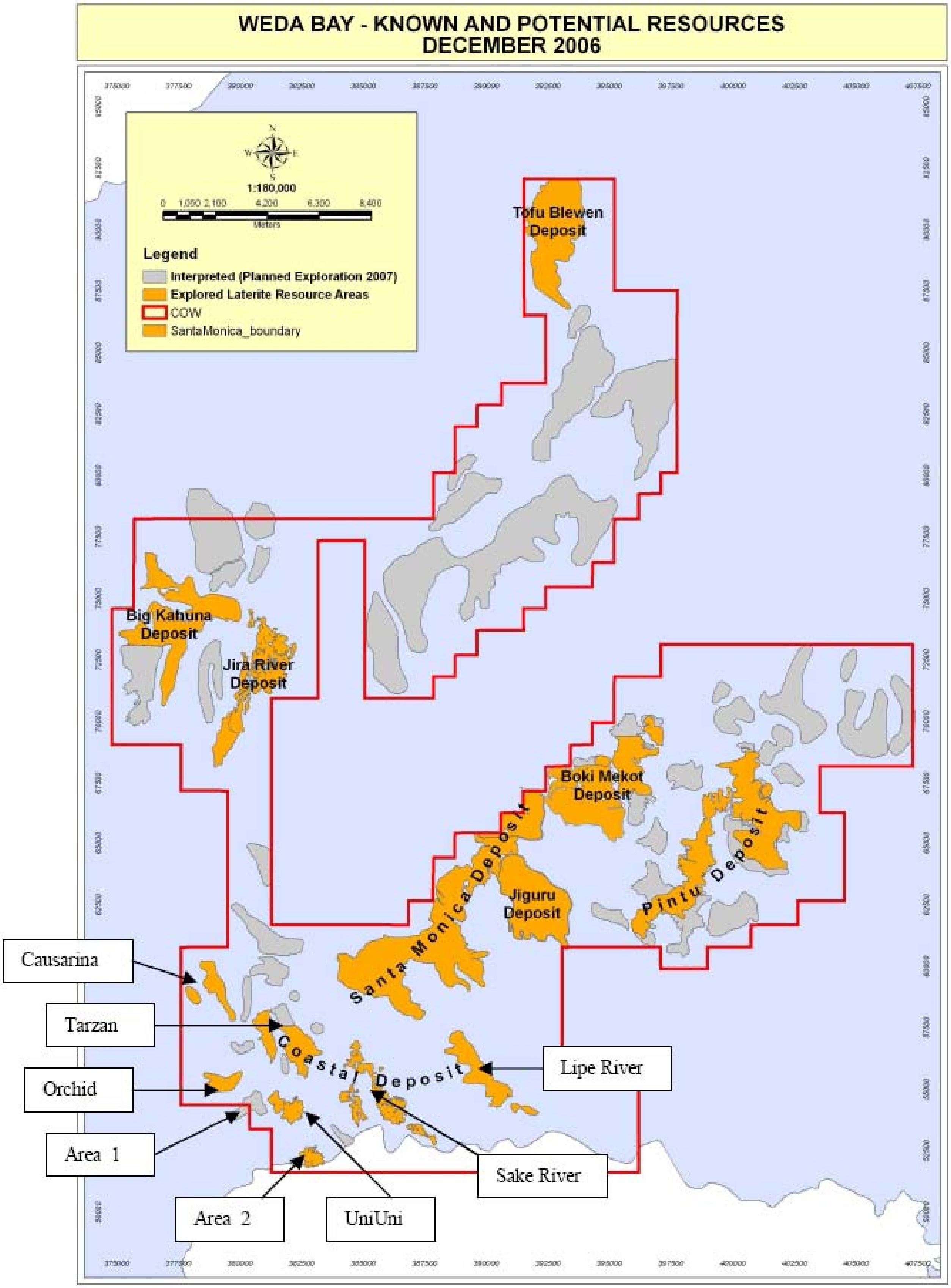
A.3 Ake Jira/Bongo Kfan

The Ake Jira River deposit is located approximately 20 km north of the Weda Bay coastal village of Lelilef and occupies an NNE-SSW trending region on the southeastern side of a more extensive lateritized ultramafic plateau (the Western Terrain) . This deposit is proximal to areas selected for solid residue stockpiling (process waste landfill) and will therefore be readily accessible via the residue placement infrastructure, in the generally subdued topography within the Ake Kobe - Ake Jira valley.

The Bongo Kfan laterite deposit is located in the northwestern region of the Western Ultramafic Terrain, west of the Ake Jira deposit, and is also relatively accessible. Laterite development has been mapped over an irregularly shaped area of approximately 11.7 km2 which comprises mainly a broad dissected plateau that increases in elevation from approximately 350 m ASL in the south to 600 m ASL in the north. Like Tofu Bleuwen, it is a relatively high grade deposit.

A.4 Northern Province

The Northern Province consists of the Tofu Bleuwen deposit, at the northern extremity of the Weda Bay COW in East Halmahera Regency. Laterite is developed over an elongated area with a strike extent of 5.3 km and a maximum width of approximately 2.7 km in the central part of the deposit. The western part of the deposit is characterized by ridge and plateau terrain, with the ridges trending toward the NW and NE with rugged and steep flanks, imparting a distinctive “herringbone” type morphology that reflects the dominant local structural trends.


WEDA BAY - KNOWN AND POTENTIAL RESOURCES
DECEMBER 2006
1:180,000
Legend
Interpreted (Planned Exploration 2007)
Explored Laterite Resource Areas
COW
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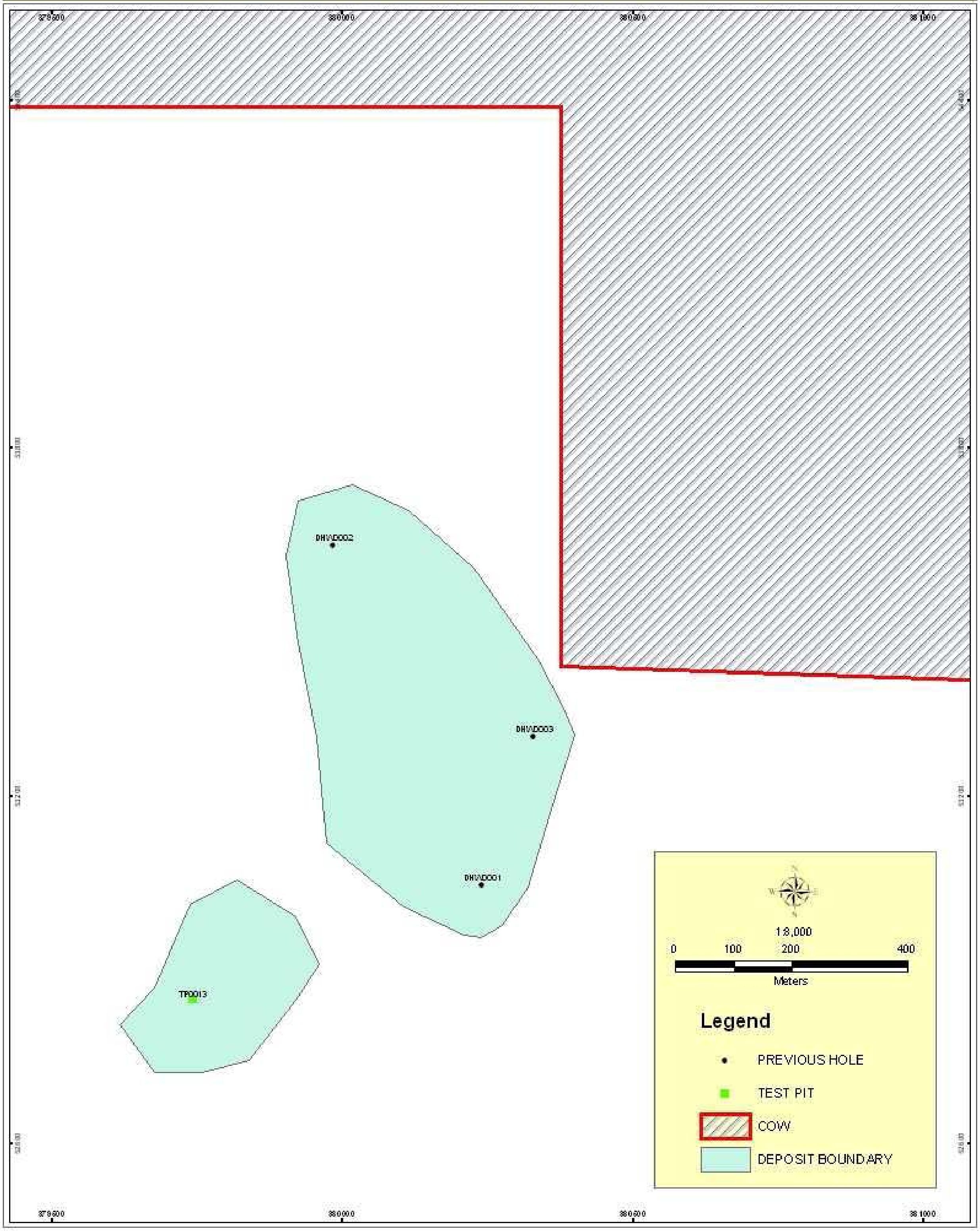
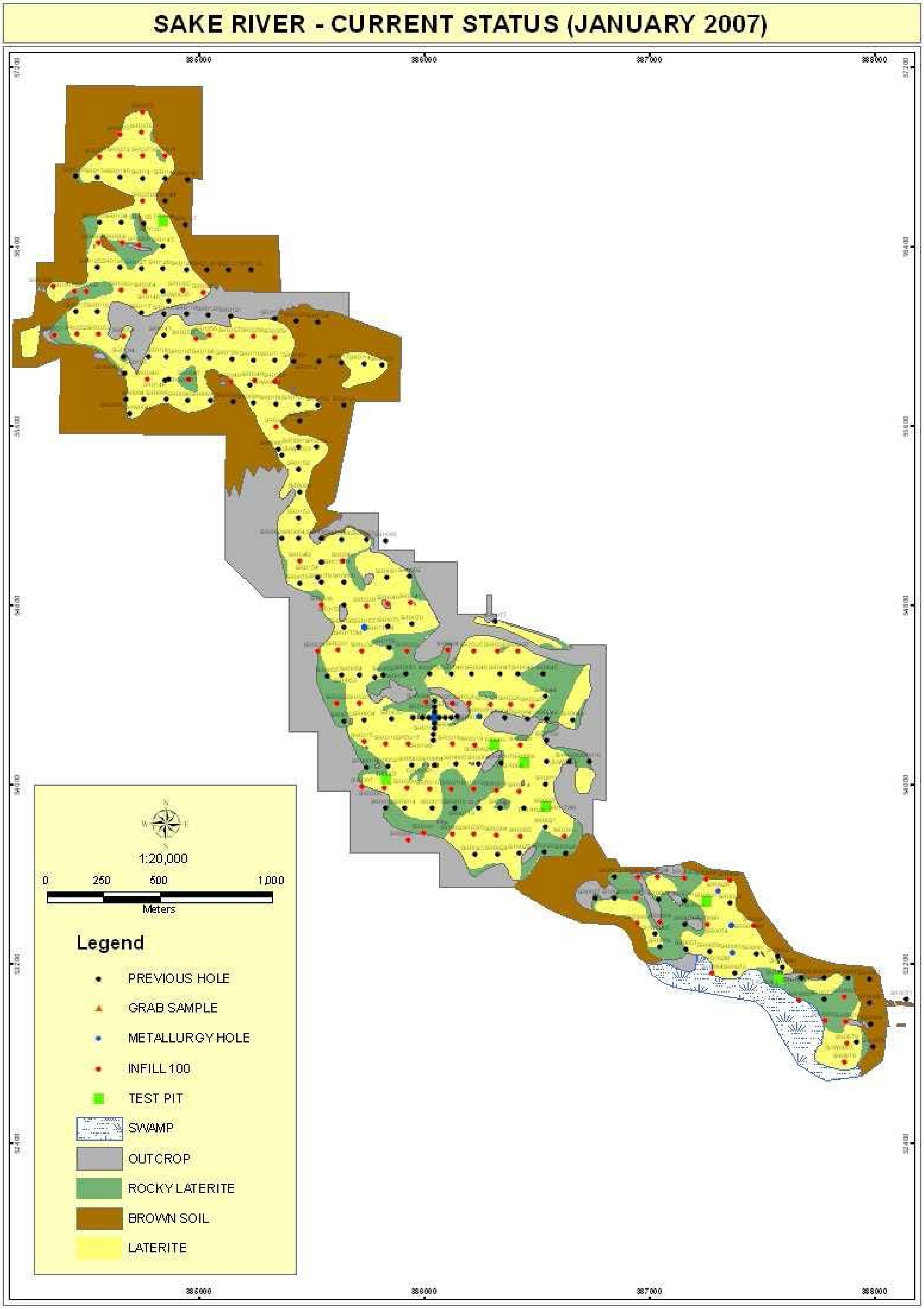
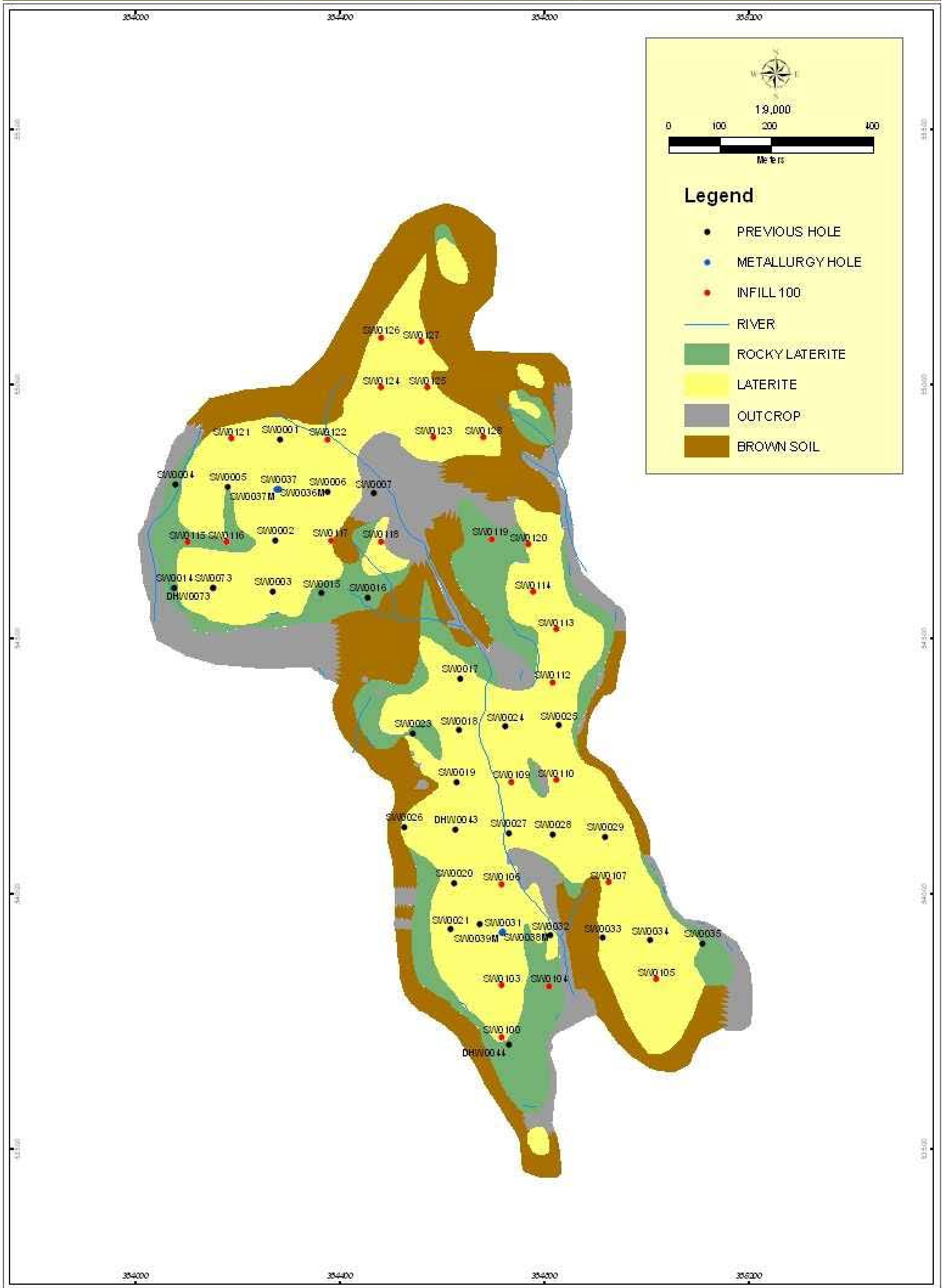
Tofu Blewen Deposit
Big Kahuna Deposit
Jira River Deposit
Boki Mekot Deposit
Santa Monica Deposit
Jiguru Deposit
Pintu Deposit
Coastal Deposit
Causarina
Tarzan
Orchid
Area 1
Area 2
UniUni
Sake River
Lipe River

AREA 1 - CURRENT STATUS (JANUARY 2007)

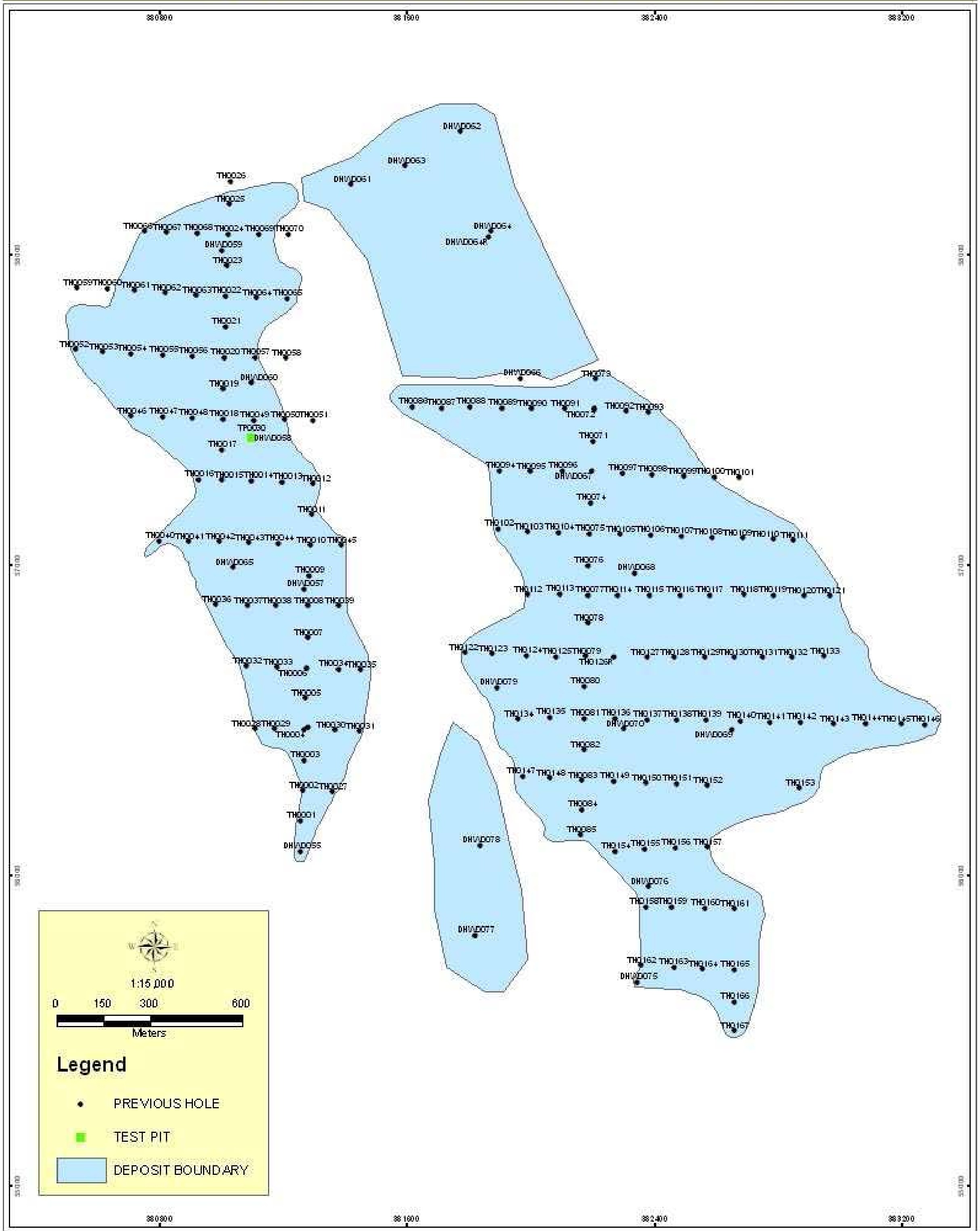



SAKE RIVER - CURRENT STATUS (JANUARY 2007)
1:20,000
0 250 500 1,000
Meters
Legend
PREVIOUS HOLE
GRAB SAMPLE
METALLURGY HOLE
INFILL 100
TEST PIT
SWAMP
OUTCROP
ROCKY LATERITE
BROWN SOIL
LATERITE

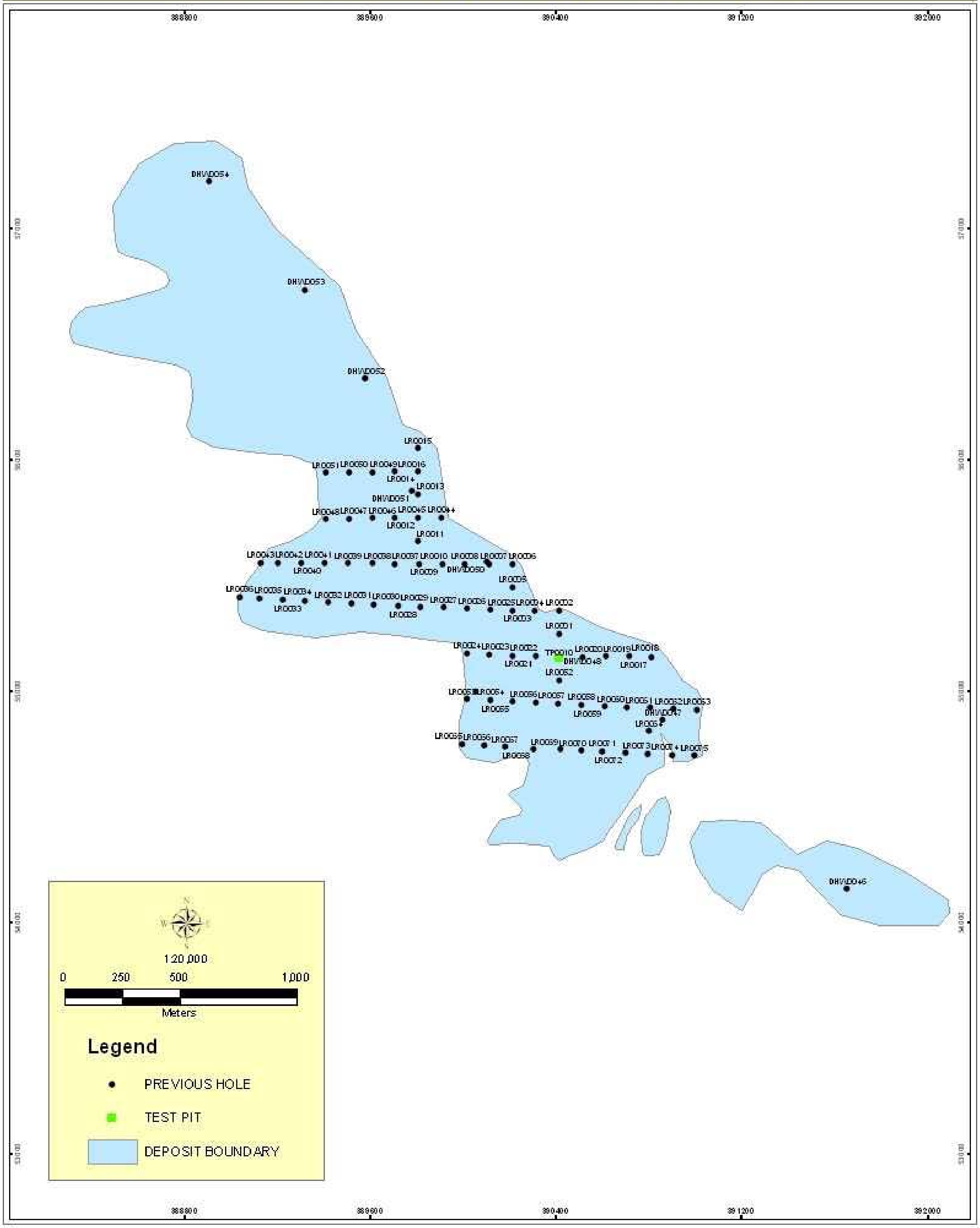
SAKE WEST - CURRENT STATUS (JANUARY 2007)



TARZAN - CURRENT STATUS (JANUARY 2007)



LIPE RIVER - CURRENT STATUS (JANUARY 2007)



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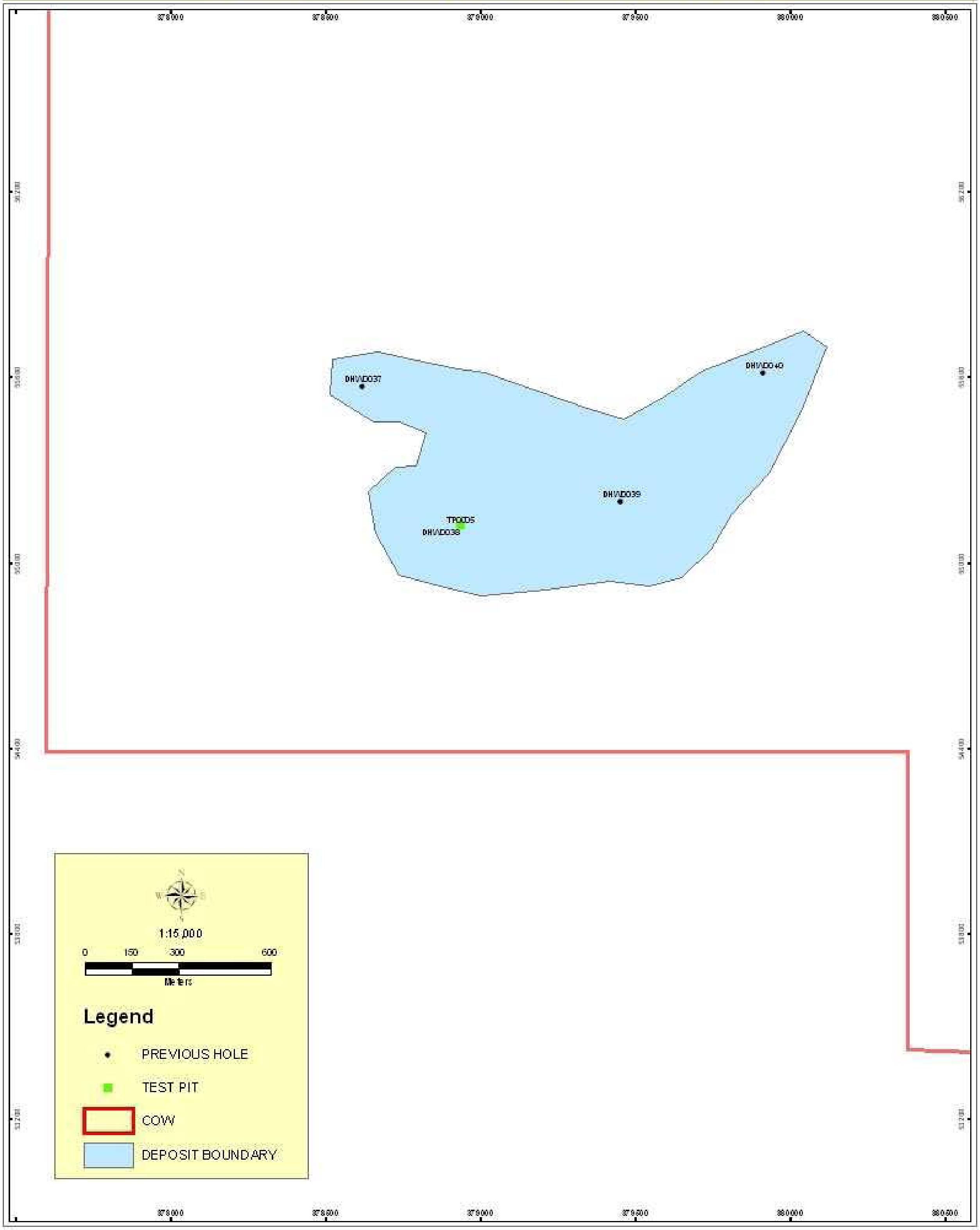
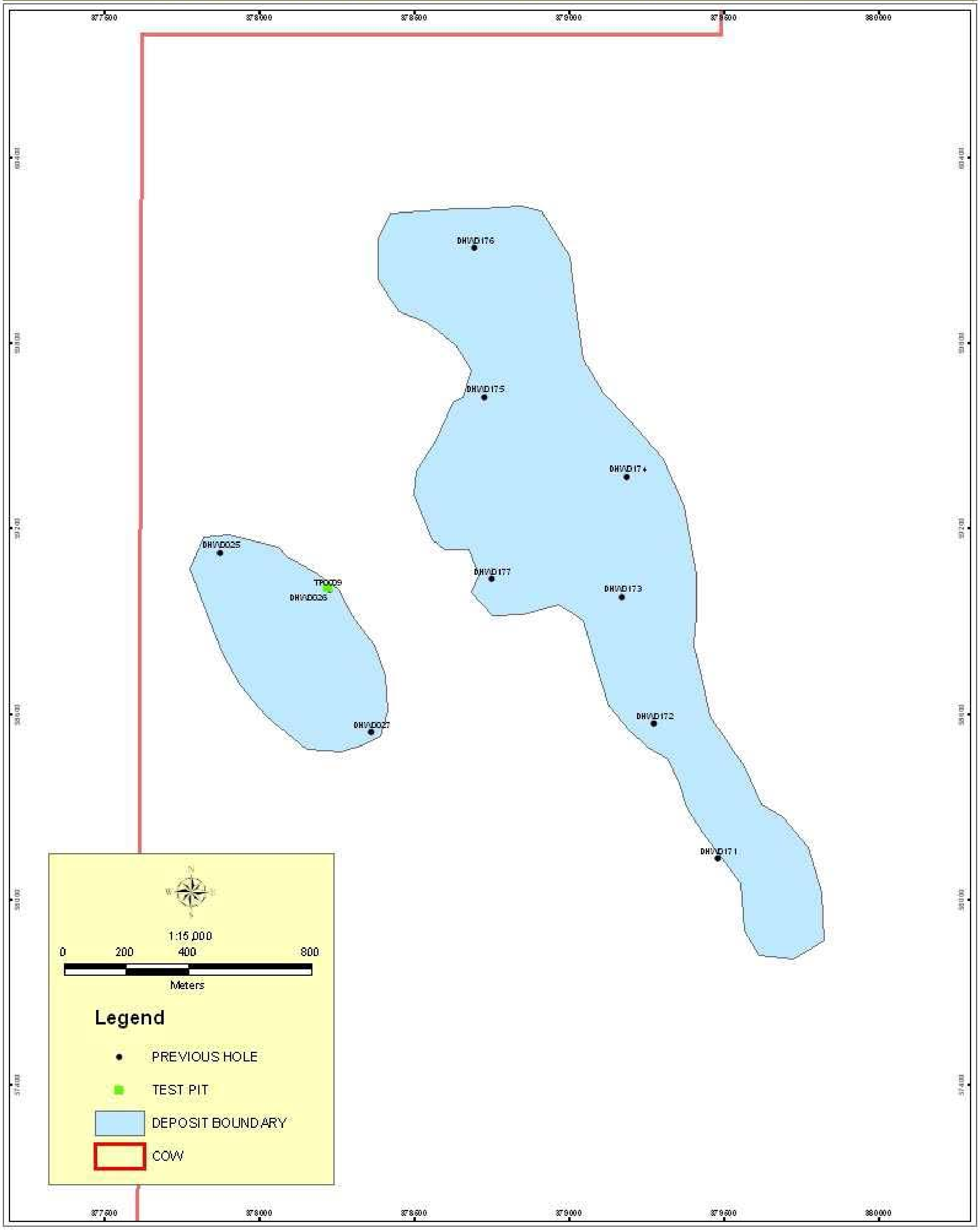
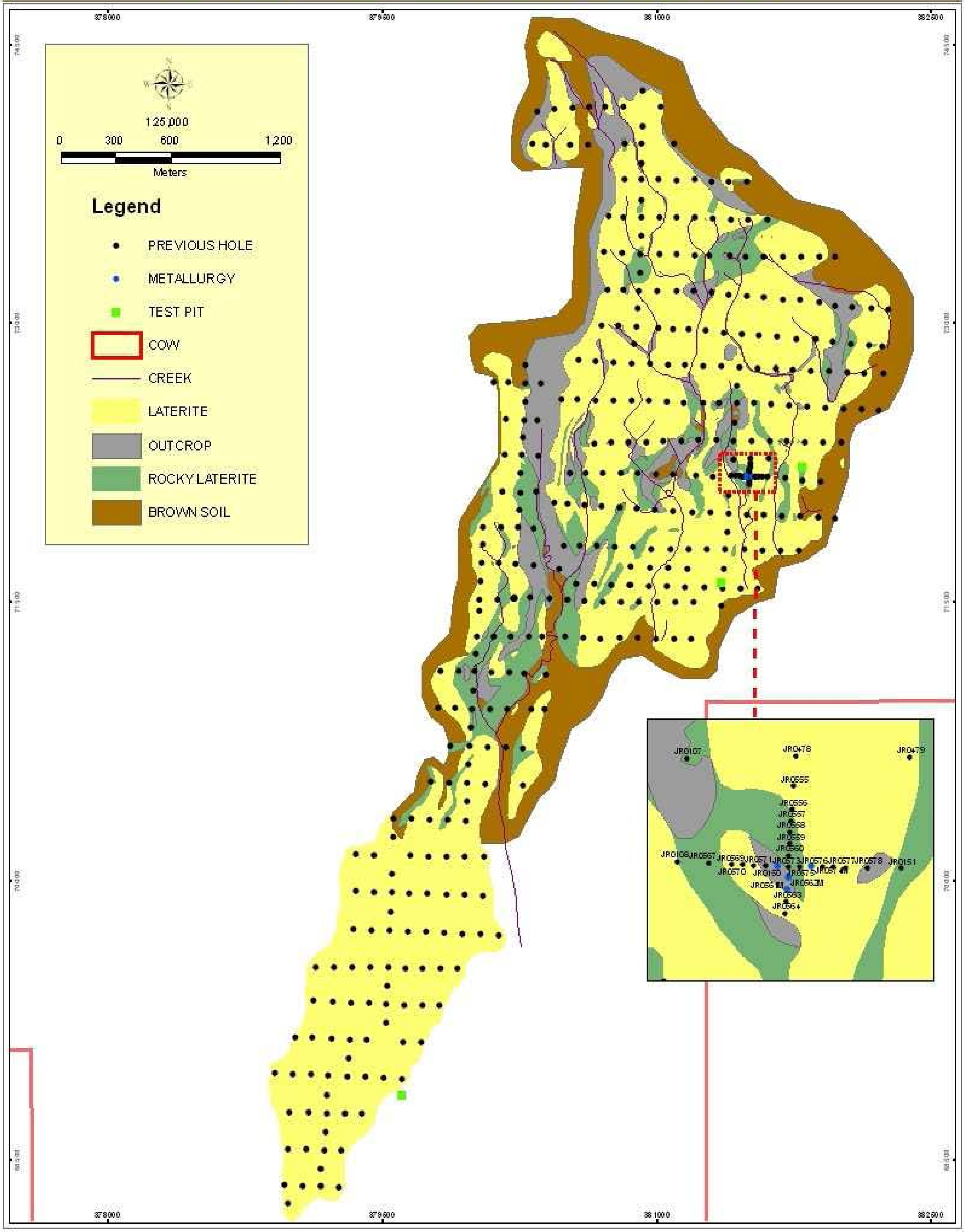


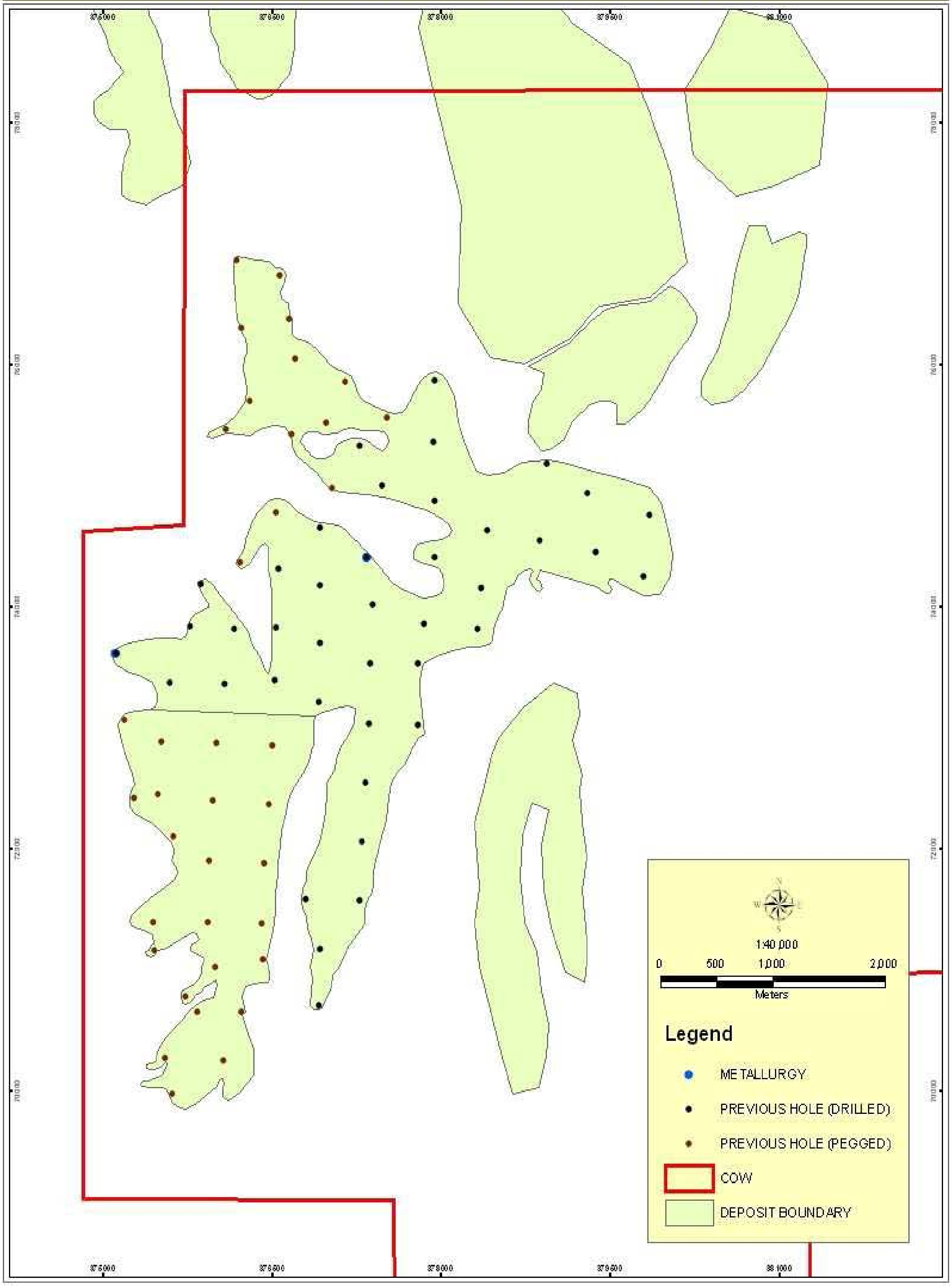
CASUARINA - CURRENT STATUS (JANUARY 2007)

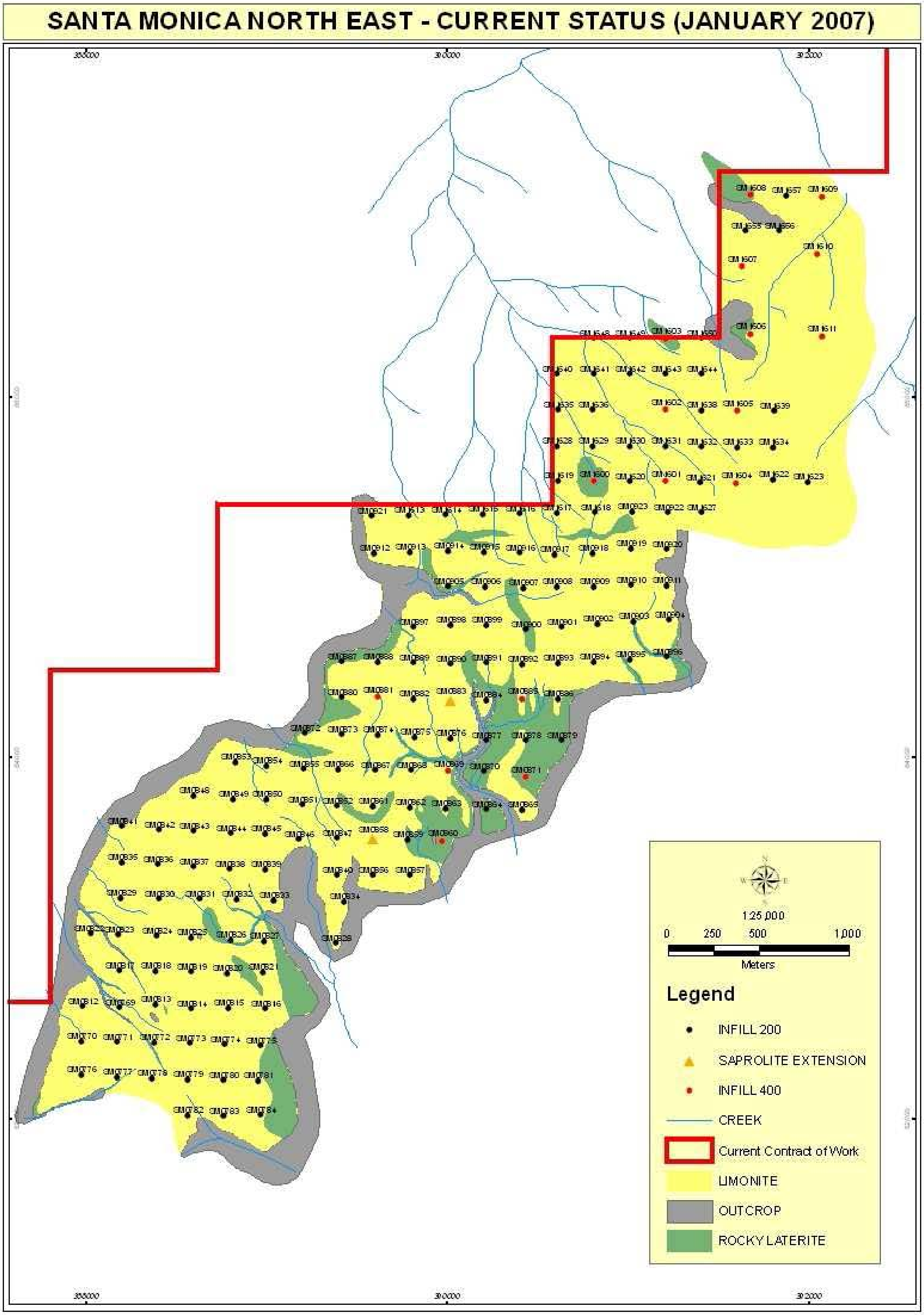


JIRA RIVER - CURRENT STATUS (JANUARY 2007)



BIG KAHUNA - CURRENT STATUS (JANUARY 2007)

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INFILL 400
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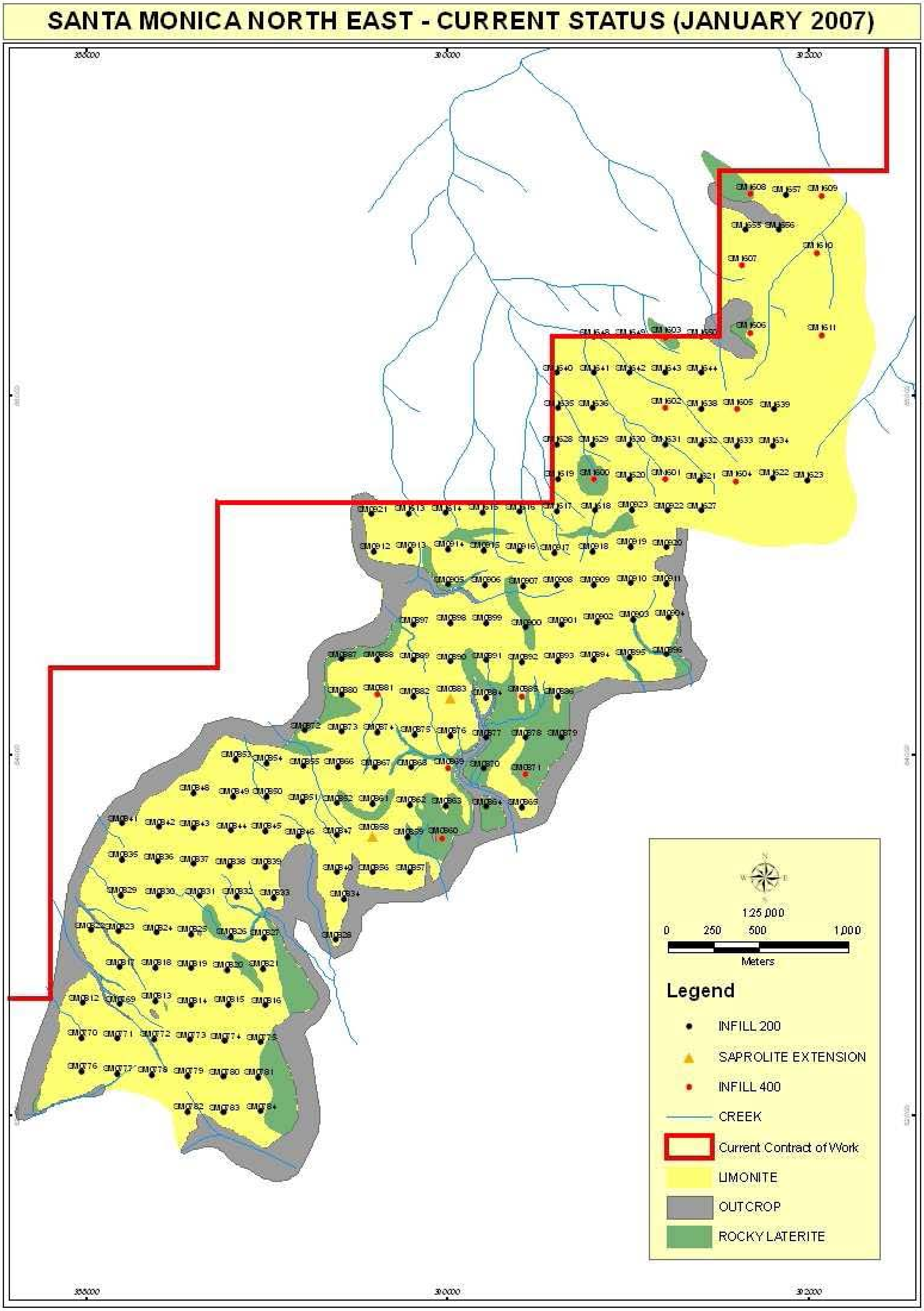
OUTCROP
ROCKY LATERITE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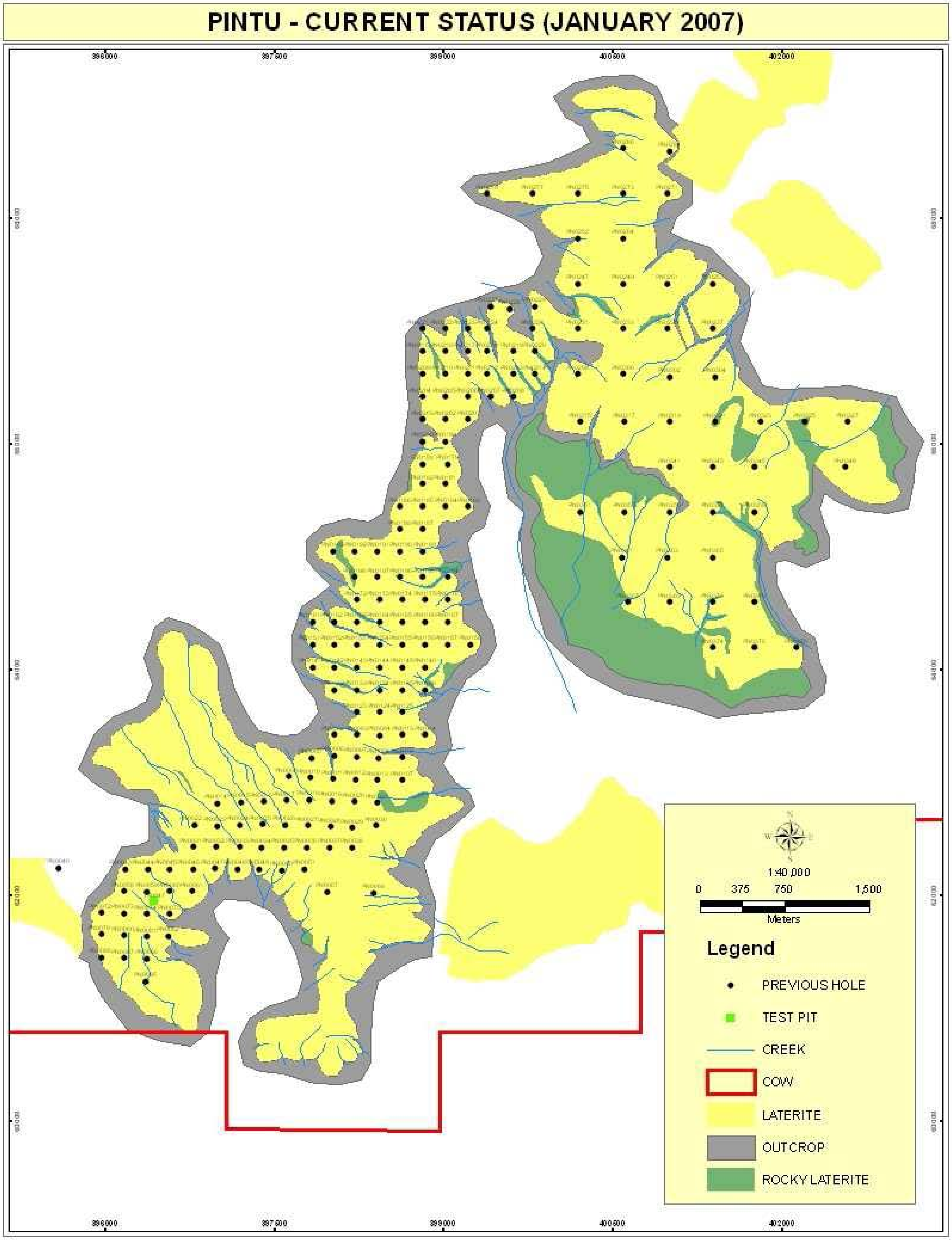
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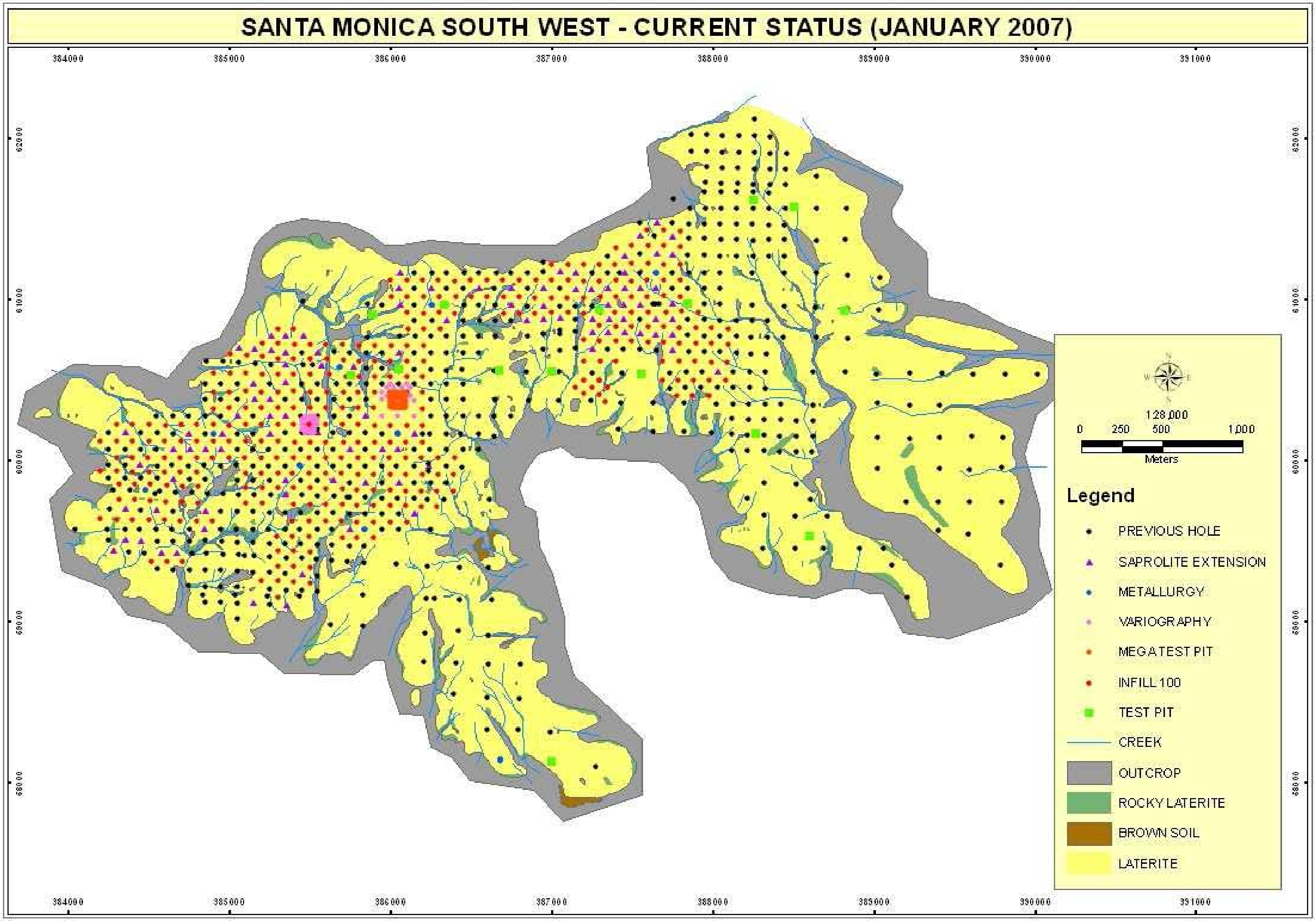
OUTCROP
ROCKY LATERITE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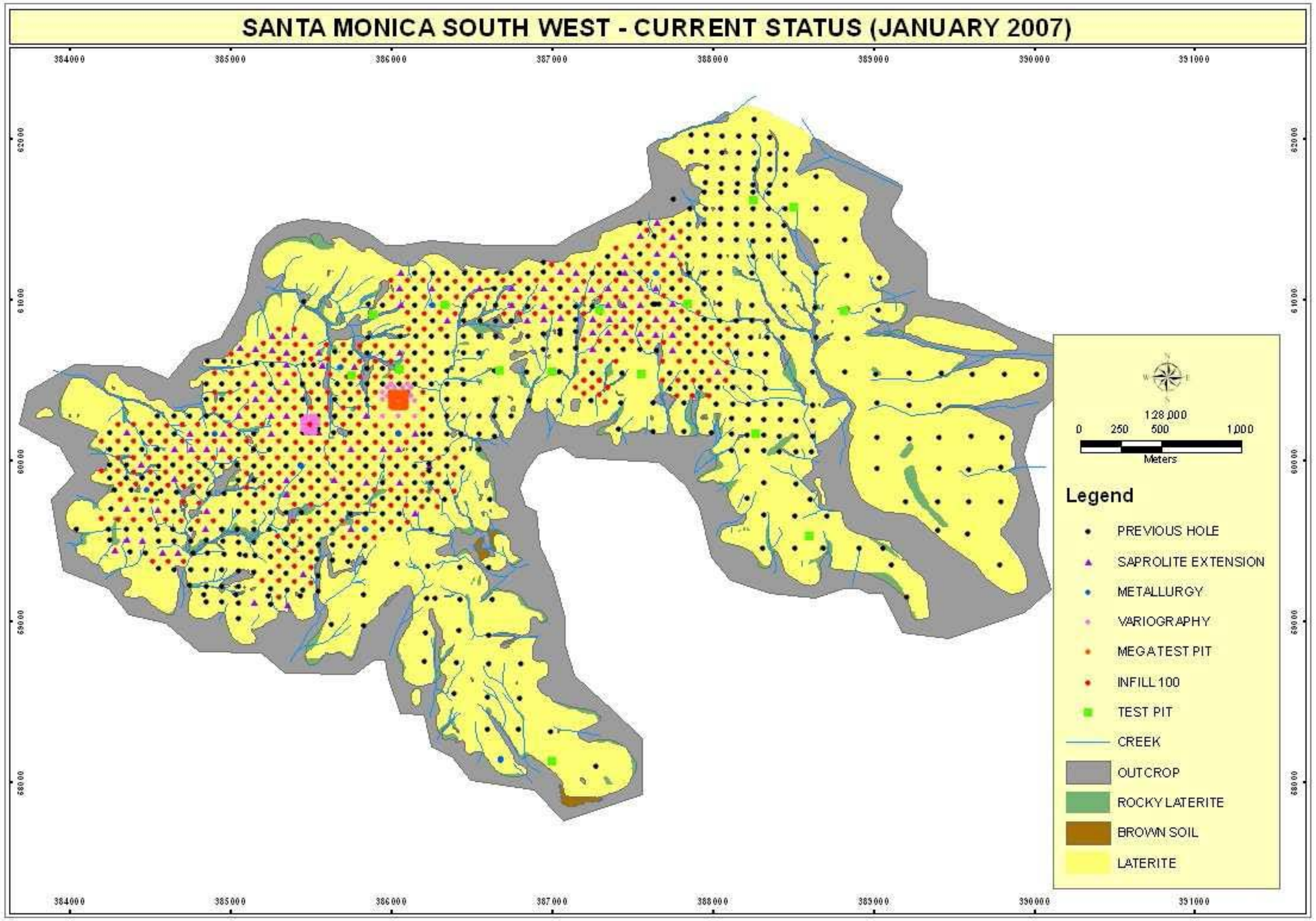
LATERITE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VARIOGRAPHY
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ROCKY LATERITE
BROWN SOIL
LATERITE

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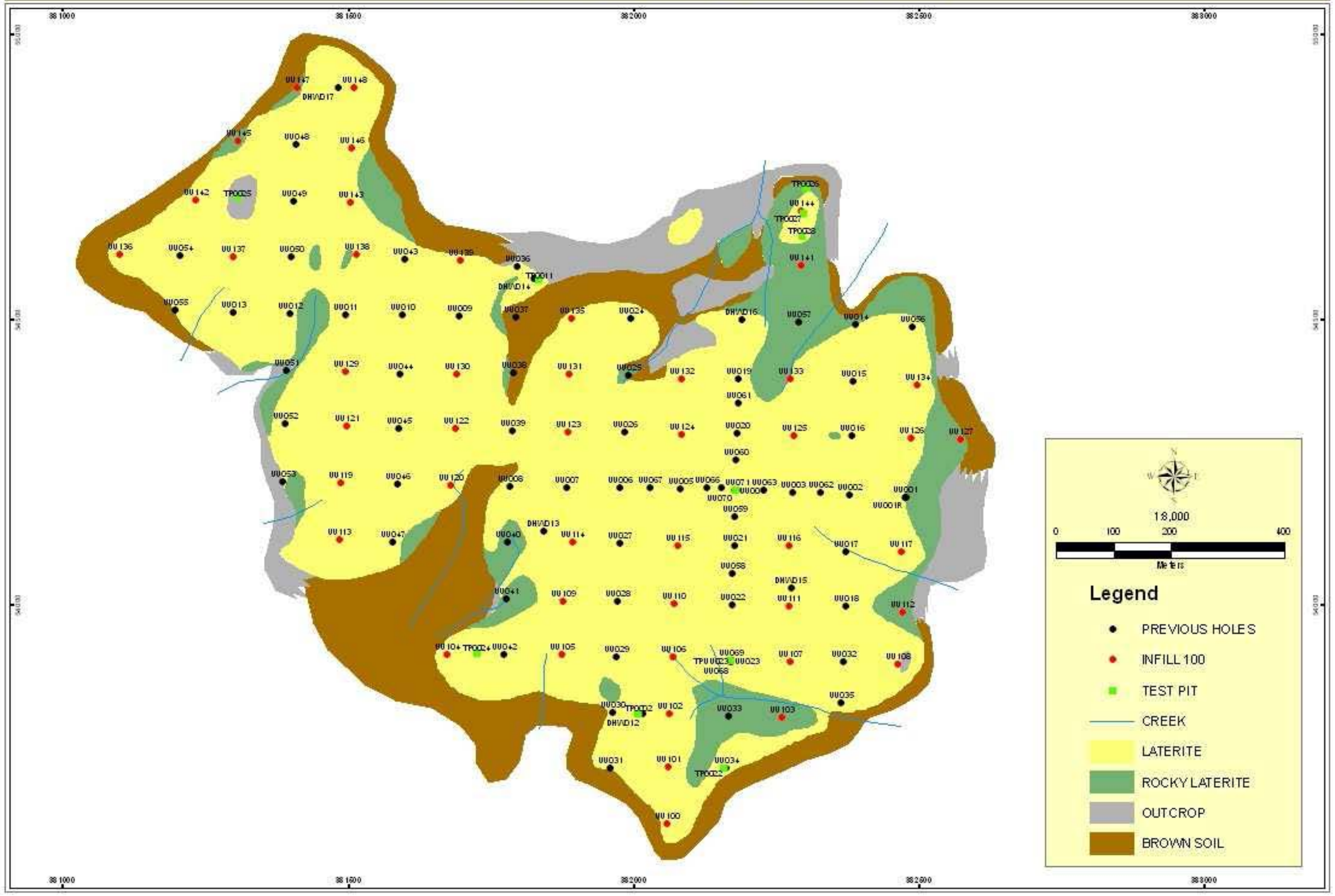

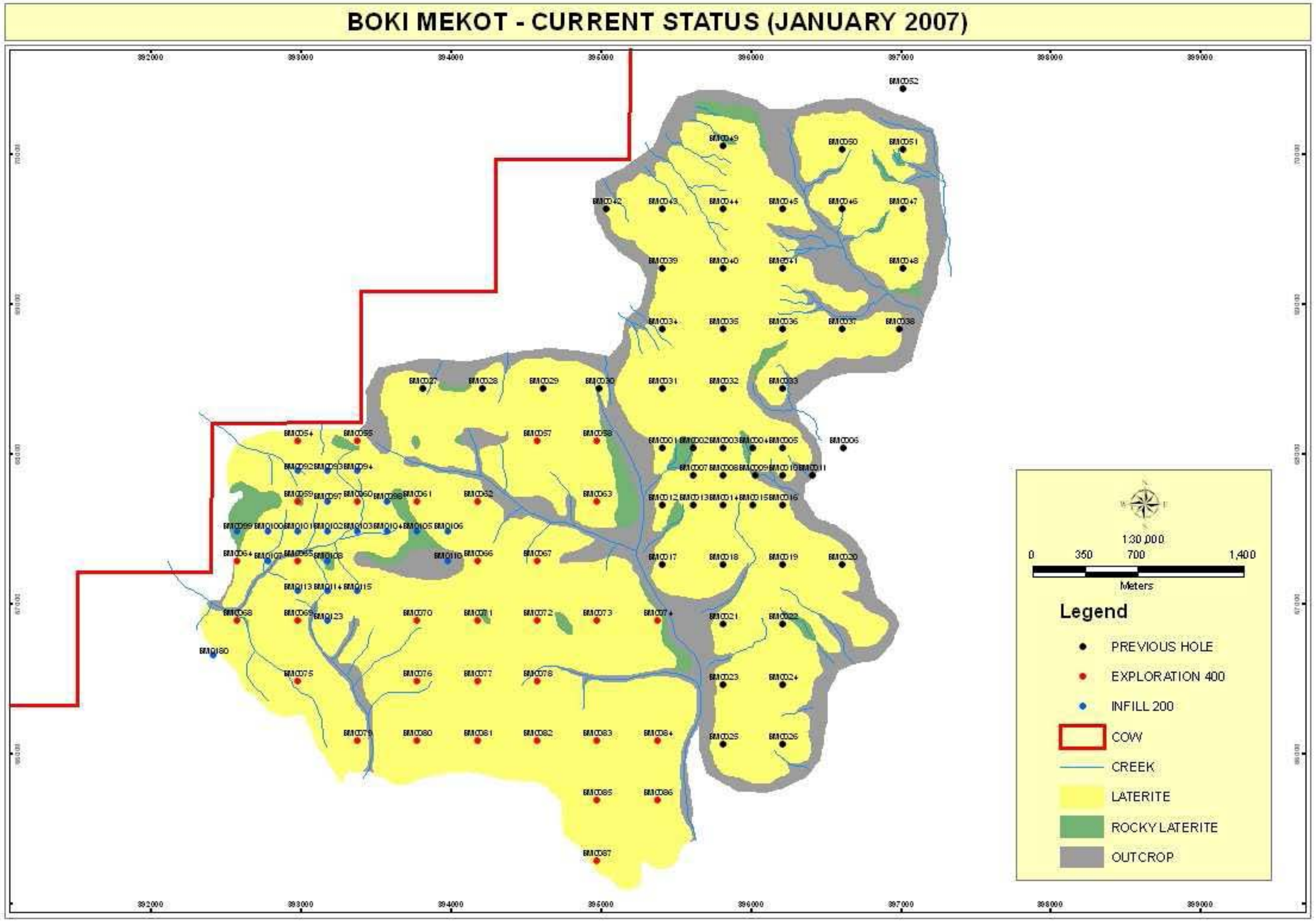
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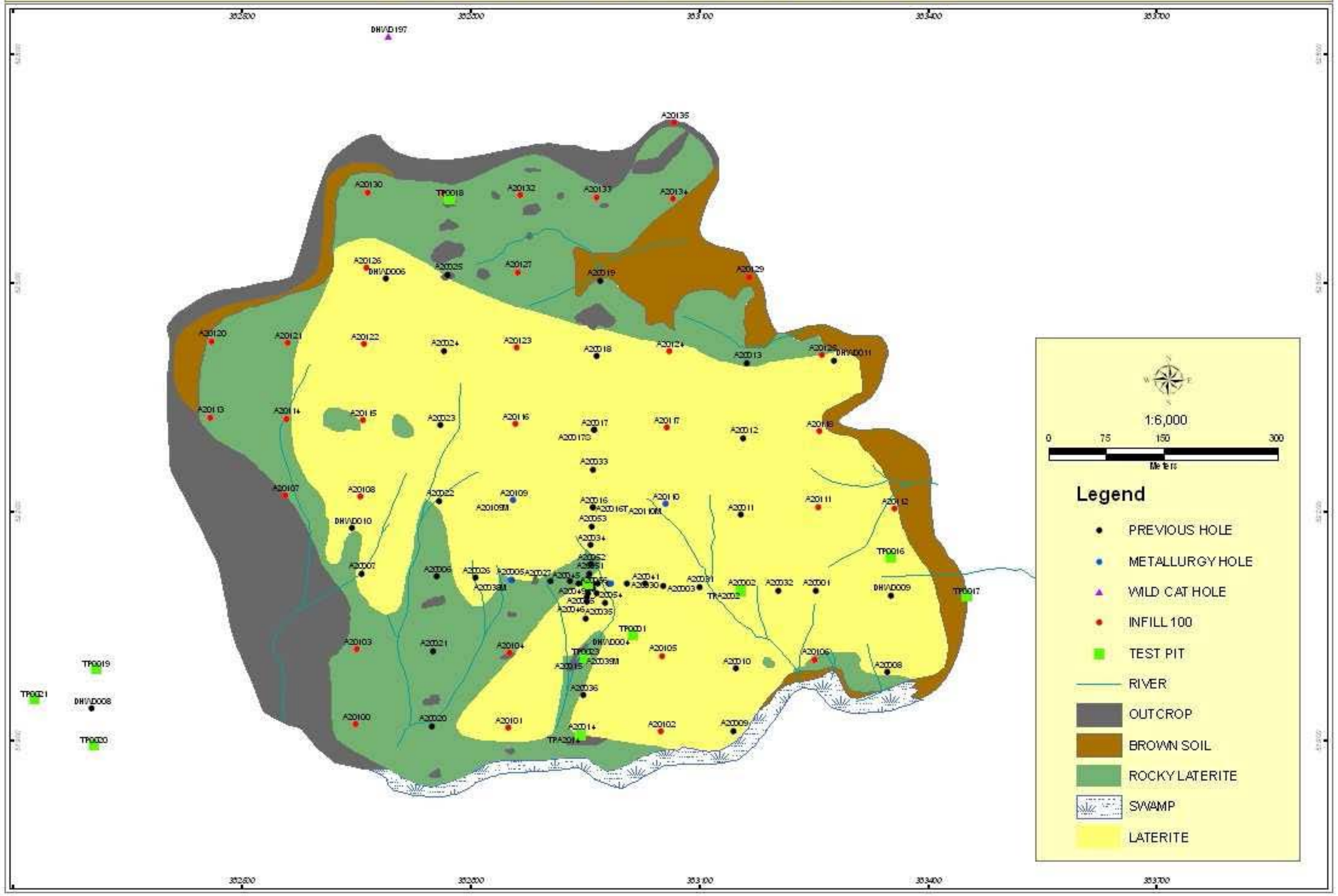
ROCKY LATERITE
OUTCROP

AREA 2 - CURRENT STATUS (NOVEMBER 2007)



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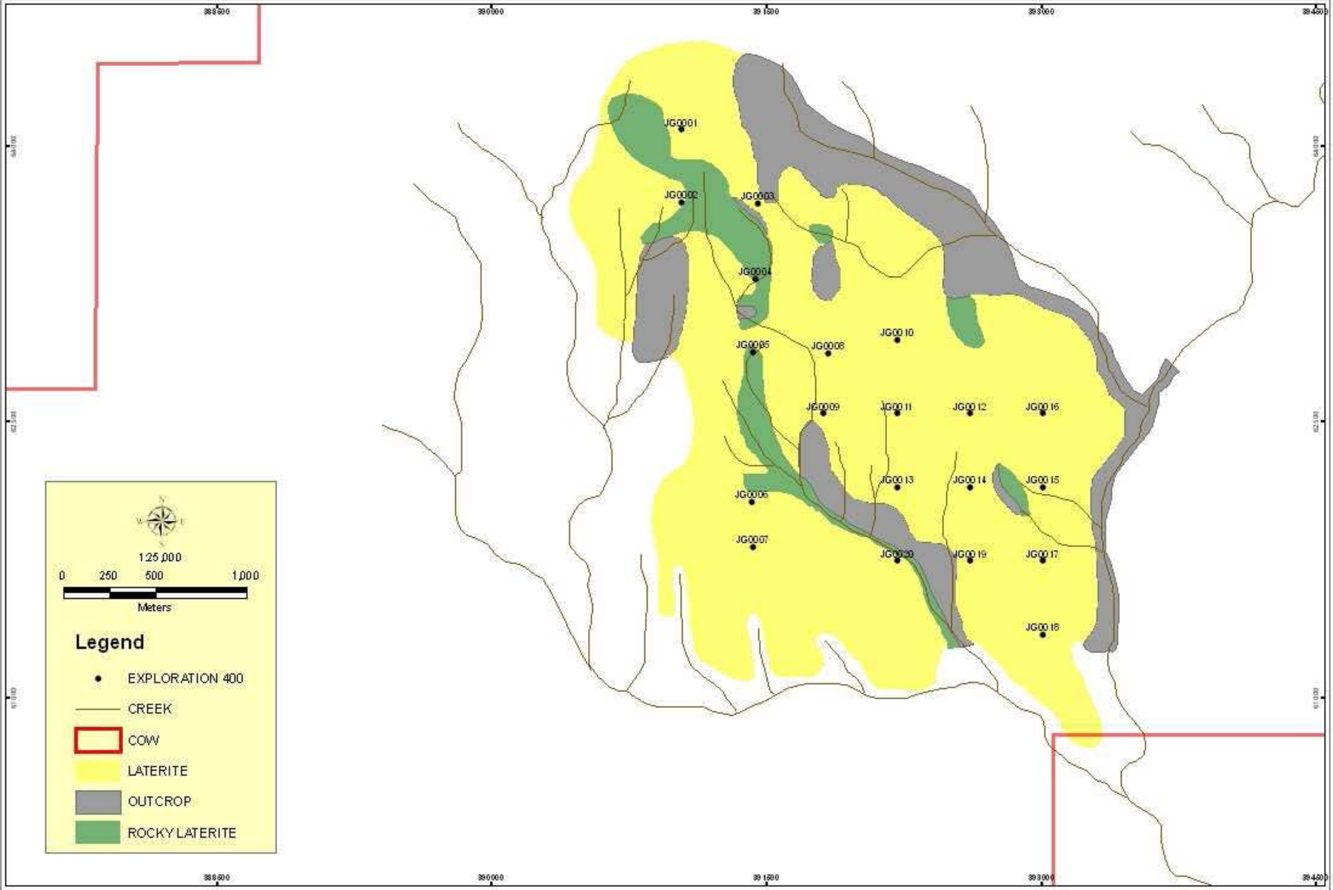
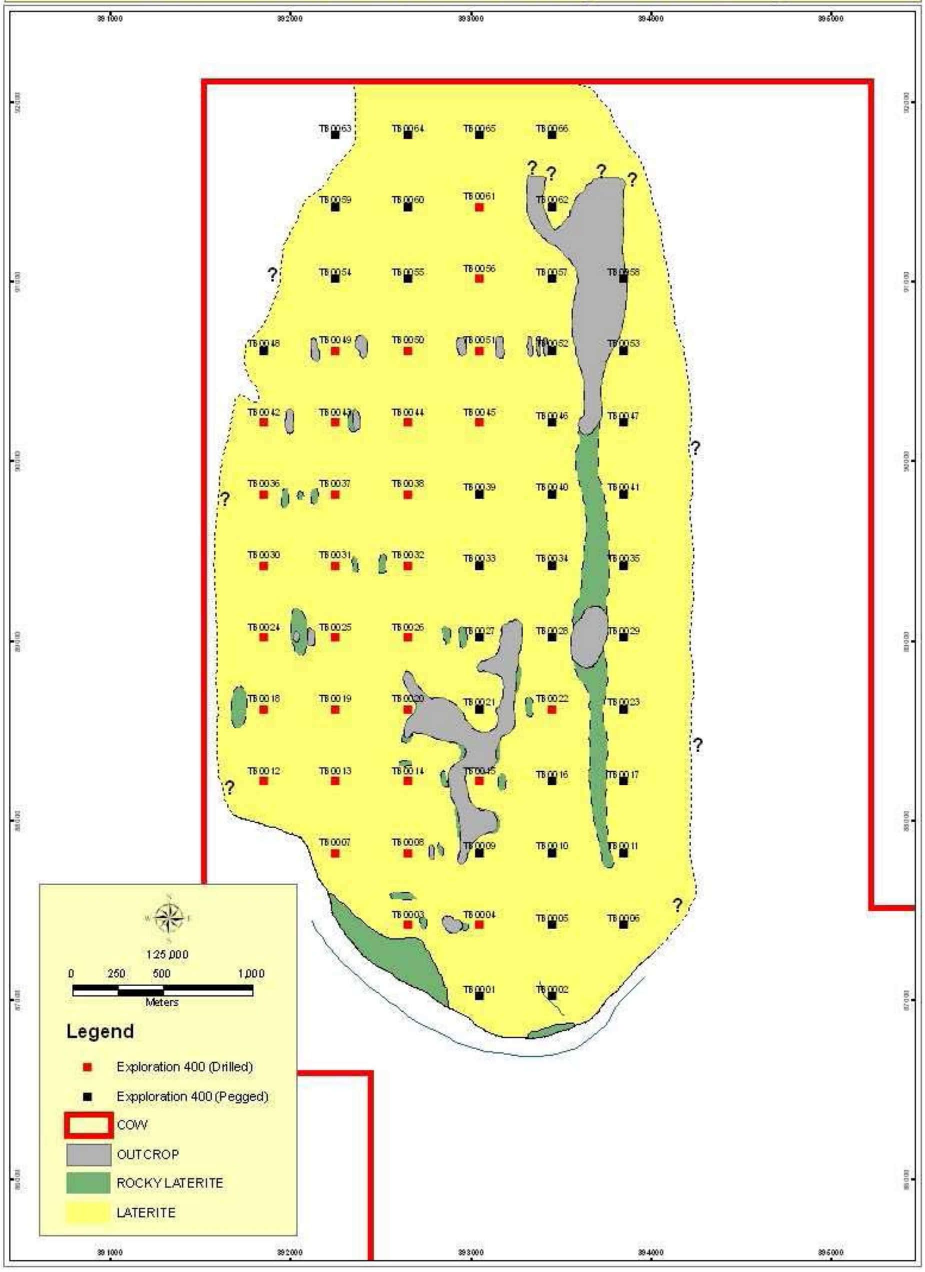


TOFU BLEWEN - CURRENT STATUS (JANUARY 2007)



Appendix B

Regulatory Basis

Currently applicable laws and regulations that are related to the preparation of an Environmental and Social Impact Assessment as well the AMDAL permitting for the Wed Bay Nickel project are listed here.

Law	*Rationale*
Acts of the Republic of Indonesia	
No. 5 Year 1960 regarding Basic Provisions of Agrarian Regulation. (State Gazette of the Republic Indonesia Year 1960 No 104, Supplement to State Gazette of the Republic of Indonesia No 2043)	The project land usage should refer with this regulation.
No. 12 Year 1964 on the Job Dismissal in Private Companies (State Gazette of the Republic of Indonesia No. 93, 1964 and Supplement to State Gazette of the Republic of Indonesia No. 2686)	Job dismissal of workers in this project may happen when the project activities decrease or closure of mining activities.
No. 5 Year 1990 regarding Natural Resource Conservation and Ecosystem (State Gazette of the Republic Indonesia Year 1990 No 49 and Supplement to State Gazette of the Republic of Indonesia No. 3419)	The project proponent needs to refer to this regulation when dealing with natural resource conservation and ecosystems within the project area.
No. 3 Year 1992 regarding the Social Security of Workers (State Gazette of the Republic of Indonesia Year 1992 No.14, Supplement to State Gazette of the Republic Indonesia No. 3468)	WBN, which will employ workforces, should follow social security of workers as stated in this acts.
No. 14 Year 1992 regarding traffic and road transportation (State Gazette of the Republic of Indonesia Year 1992 No 49)	The project proponent must refer to this regulation regarding all transportation aspects of the project.
No. 23 Year 1992 regarding Health (State Gazette of the Republic of Indonesia Year 1992 No.100 and Supplement to State Gazette of the Republic Indonesia No. 3495)	Health programs implemented by WBN shall refer to this act.
No. 5 Year 1994 regarding Ratification on UN convention relating Biodiversity (State Gazette of the Republic of Indonesia Year 1994 No. 41)	Preservation of biodiversity around project area shall refer to this act.
No. 6 Year 1994 regarding Ratification on the UN Convention on Climate Change (State Gazette of The Republic of Indonesia Year 1994 No. 42)	Project activities may potentially generating greenhouse gasses, hence shall refer to this convention.
No. 23 Year 1997 regarding Environmental Management (State Gazette of the Republic of Indonesia Year 1997 No 68, supplement to State Gazette of the Republic of Indonesia No. 3699)	Environmental matters related to the project activities shall comply to this act
No. 41, 1999 regarding Forestry jo Government Regulation Substituting Acts No. 1 Year 2004 regarding Amendment of Acts No. 41 Year 1999 regarding Forestry become Acts (State Gazette of the Republic Indonesia Year 1999 No. 167, supplement to State Gazette of the Republic Indonesia No. 3888)	WBN CoW area is located in forest area; therefore, forest area utilization for project activities shall comply with this act.

Law	*Rationale*
No. 46 Year 1999 regarding the Formation of the Province of North Maluku	By this law Maluku Province is divided into North Maluku and Maluku Provinces, hence WBN project is located in the newly established province.
No. 01 Year 2003 regarding the Expansion of the Regency of North Halmahera, South Halmahera, East Halmahera, the Sula Islands, and the City of Tidore Islands in the Province of North Maluku.	All WBN COW previously was located at Central Halmahera Regency, referring to this law WBN COW area now is partly located at Central Regency and partly at East Halmahera Regency.
No. 13 Year 2003 regarding the Workforce	WBN will recruit workforces during project construction and operation hence workforce related matter will refer to this law.
No. 7 Year 2004 regarding Water Resources (State Gazette of the Republic of Indonesia year 2004 No 32, supplement to State Gazette of the Republic of Indonesia No. 4377)	Water resources use related to the project activities shall comply with this act.
No. 17 Year 2004 regarding the Enactment of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (State Gazette of the Republic of Indonesia Year 2004 No.72, supplement to State Gazette of the Republic of Indonesia No. 4403)	Project activities may potentially generating greenhouse gasses, hence shall refer to this protocol
Government Regulation Substituting Acts No. 1 Year 2004 regarding Amendment of Acts No. 41 Year 1999 regarding Forestry (State Gazette of the Republic of Indonesia Year 2004 No.29, supplement to State Gazette of the Republic of Indonesia No. 4374)	WBN CoW area is located in forest area; therefore, forest area utilization for project activities shall comply with this act.
No. 32 Year 2004 regarding the Regional Government	WBN shall consider this act especially in acknowledging the authority of the regional government
No. 33 Year 2004 regarding the Balance of Funds between the Central Government and the Regional Government	WBN shall consider this act concerning tax related matter to central and regional governments
No. 25 Year 2007 regarding Investments	Weda Bay Project is a foreign investment thus the project shall comply to this act
No. 26 Year 2007 regarding Spatial Planning (State Gazette of the Republic of Indonesia Year 2007 No. 68)	The project location shall be in line with the existing spatial plannings
No. 27 Year 2007 regarding Management of Coastal Area and Isles (State Gazette of the Republic of Indonesia No.44 Year 2007, supplement to State Gazette of the Republic of Indonesia No. 4739)	WBN will refer to this Acts in managing the coastal areas and isles.
Acts No. 4 Year 2009 regarding Mineral and Coal Mining	All mine project in Indonesia shall refer to this Acts as guidelines for mining project
Government Regulation	
No. 32 Year 1969 regarding Implementation of Act No. 11 Year 1967 on General Provision of Mining (State Gazette of the Republic of Indonesia No. 22 Year 1969)	WBN mining concession and operation shall comply with this regulation
No. 35 Year 1991 regarding Rivers (State Gazette of the Republic Indonesia No. 44, Supplement to State Gazette of the Republic of Indonesia No. 3445)	Water for processing plant and domestic water use will be sourced partly from nearby river; therefore, the utilization of water by the project shall refer this regulation.

Law	*Rationale*
No. 79 Year 1992 regarding Amendment of Government Regulation No 32 Year 1969 regarding Implementation of Law No. 11 Year 1967 regarding General Provision of Mining (State Gazette of the Republic Indonesia Year 1992 No. 130, Supplement to State Gazette of the Republic Indonesia No. 3510)	WBN mining concession and operation shall comply with this regulation
No. 7 Year 1999 regarding Flora and Fauna Conservation (State Gazette of the Republic Indonesia Year 1999 No. 14, Supplement to State Gazette of the Republic of Indonesia No 3803)	Conservation of protected flora and fauna within WBN project area shall refer to this regulation.
No. 18 Year 1999 regarding Management of Hazardous and Toxic Wastes (State Gazette of the Republic of Indonesia Year 1999 No 31, Supplement to State Gazette of the Republic of Indonesia No. 3815)	The project will produce non-process wastes including the hazardous and toxic wastes; therefore, management of the wastes shall refer to this regulation.
No. 27 Year 1999 regarding Environmental Impact Assessment (AMDAL) (State Gazette of the Republic of Indonesia Year 1999 No 59, Supplement to State Gazette of the Republic of Indonesia No. 3838)	The project is considered as to generate significant impact to environment, therefore WBN shall prepare AMDAL document in accordance with this regulation.
No. 41 Year 1999 regarding Air Pollution Control (State Gazette of the Republic of Indonesia Year 1999 No 86, Supplement to State Gazette of the Republic of Indonesia No 3853)	Weda Bay project potentially emits gaseous pollutant that may influence the ambient air quality hence control of air pollution by Weda Bay shall refer to this regulation
No. 85 Year 1999 regarding Amendment to Government Regulation No. 18 Year 1999 regarding Management of Hazardous and Toxic Waste (State Gazette of the Republic of Indonesia Year 1999 No 190, Supplement to State Gazette of the Republic of Indonesia No. 3910)	The project will produce non-process wastes including the hazardous and toxic wastes; therefore, management of the wastes shall refer to this regulation.
No. 25 Year 2000 regarding Government Authority and the Authority of Province as a Region with Autonomy (State Gazette of the Republic of Indonesia Year 2000 No. 54, Supplement to State Gazette of the Republic of Indonesia No. 3952).	Administration of the project to government should consider authority portions of local/ regional and central government as stipulated by this regulation.
No. 4 Year 2001 regarding Damage Control and/or Environmental Pollution relating to Forest and/or Land Fires (State Gazette of the Republic of Indonesia Year 2001 No. 10, Supplement to State Gazette of the Republic Indonesia No. 4076)	The project is located in forest area where forest fire might occur. Forest fire protection and control shall refer to this regulation
No. 69 Year 2001 regarding Port (State Gazette of the Republic of Indonesia Year 2001 No. 127, Supplement to State Gazette of the Republic of Indonesia No. 4145)	The project will construct and operate a special port therefore these activities shall refer to regulation.
No. 70 Year 2001 regarding Airports (State Gazette of the Republic Indonesia No. 128, 2001, Supplement to State Gazette of the Republic of Indonesia No. 4146)	The project constructs and operates a special airport therefore these activities shall refer to regulation
No. 74 Year 2001 regarding Hazardous and Toxic Material Management (State Gazette of the Republic of Indonesia Year 2001 No. 138, Supplement to State Gazette of the Republic of Indonesia No. 4153)	Project activities will use chemicals therefore management of the chemicals (transportation, handling, and storage) shall comply with this regulation.

Law	*Rationale*
No. 75 Year 2001 regarding Second Amendment to Government Regulation No. 32 Year 1996 regarding Implementation of Law No. 11 Year 1967 regarding General Provisions of Mining (State Gazette of the Republic of Indonesia Year 2001 No. 141, Supplement to State Gazette of the Republic of Indonesia No. 4154)	WBN mining concession and operation shall comply with this regulation
No. 82 Year 2001 regarding Water Quality Management and Water Pollution Control (State Gazette of the Republic of Indonesia Year 2001 No. 153, Supplement to State Gazette of the Republic of Indonesia No. 4161)	Project activities may potentially impact to water quality; therefore, the project shall maintain the ambient water quality within the standard as stipulated in this regulation.
No. 16 Year 2004 on Land Use (State Gazette of the Republic of Indonesia No. 45, 2004, State Gazette of the Republic of Indonesia No. 4385)	Land use, land usage and land acquisition by project activities shall refer to this regulation.
No. 2 Year 2008 regarding the Type and Tariff for Non Tax State's Income which Comes from Utilization of Forest Area for Development Purpose outside Forestry Activities valid in Department of Forestry (State Gazette year 2008 No. 15, Supplement to the State Gazette of the Republic of Indonesia No. 4813)	Utilization of forest area by WBN activities shall be in accordance with to this regulation
No. 26 Year 2008 regarding the National Spatial Planning (State Gazette Year 2008 No.28, Supplement State Gazette of the Republic of Indonesia No. 4833)	The location of the activities must be in line with the existing spatial plannings.
No. 76 Year 2008 regarding Forest Rehabilitation and Reclamation (State Gazette Year 2008 No.201, Supplement State Gazette of the Republic of Indonesia No. 4947)	WBN will refer to this regulation in rehabilitating and reclaiming disturbed land.
Presidential Decree	
No. 32 Year 1990 regarding Protection Forest Management.	Appropriate management is required wherever Protection Forest is present.
No. B.53/PRES/1/1998 dated 19 January 1998 regarding Agreement on 72 Contract of Work for General Mining, 7th Generation.	WBN shall refer to this decree
No. 125 Year 1999 on Explosive Materials	WBN uses explosives in the limestone mining activities, therefore transportation, handling, usage and storage shall comply with this regulation.
No. 150 Year 2000 regarding Development of Integrated Regional Economy.	Project is conducted in a region classified as a development area for integrated regional economy.
No. 41 Year 2004 regarding Permits and Agreements for Mining in Forest Areas.	WBN is one of 13 (thirteen) permits or agreement on mining location which have been exist before the application of Laws No. 41 Year 1999 regarding Forestry that can continue their activities until the expiration of permits or agreement.
Ministerial Joint Decree	
Letter of Joint Decree Minister of Public Work with Minister of Mining and Energy No. 04/ KPTS/1991, 0076K/101/MPE/1991 regarding Water Use for Mining Activities including Petroleum and Natural Gas and Geothermal.	Water for processing plant and domestic water use will be sourced partly from nearby river; therefore, the utilization of water by the project shall refer this decree.
Minister of Environment	
Decree No. KEP-13/MENLH/3/1995 regarding Emission Standard for Stationary Sources.	Stationary gas emission from WBN activities shall refer with this decree.

Law	Rationale
Decree No. KEP-51/MENLH/10/1995 regarding Effluent Standards for Industrial Activities	Liquid waste will be generated from the project, which should be managed in order to comply with environmental standards.
Decree No. KEP-48/MENLH/11/1996 regarding Noise Standard.	Noise should be managed and monitored in order to meet prevailing environmental noise standards.
Decree No. KEP-49/MENLH/II/1996 regarding Level of Vibration Standard.	Vibration should be managed and monitored in order to meet prevailing vibration standards.
Decree No. KEP-50/MENLH/11/1996 regarding Odor Level	Odor should be managed and monitored in order to meet prevailing vibration standards.
Decree No. KEP-45/MENLH/II/1996 regarding Air Pollutant Index.	Air pollution should be managed and monitored. The monitoring results should be classified based on the Air Pollution Index.
Decree No. 51 Year 2004 regarding Marine Water Quality Standards.	Effluent disposal to marine will be subject to marine water quality standards.
Decree No. 40 Year 2000 regarding Guidelines of EIA Evaluation Commission	EIA documents should be evaluated by EIA commission according to this guideline.
Decree No. 45 Year 2005 regards Guidelines of RKL and RPL Reporting.	Environmental management and monitoring plan (RKL-RPL) implementation should be reported regularly following guideline stipulated in this decree.
Regulation No. 8 Year 2006 regarding Guidelines to Prepare Environmental Impact Assessment.	This regulation, which supersedes previous guidelines such as Decree No. 9 of 2000, provides guidelines for compilation of the KA, ANDAL, RKL, RPL and Executive Summary documents.
Regulation No. 9 Year 2006 regarding Effluent Standards for Mining Activities of Nickel Ore.	Effluent (water discharge) from ore mining and ore processing of WBN activities shall comply with this regulation.
Regulation No. 11 Year 2006 regarding Sort of Business and/or Activities Plan that Require to Conduct Environmental Impact Assessment.	The project is considered as to generate significant impact to environment, therefore WBN shall prepare AMDAL document in accordance with this regulation.
Regulation No. 12 Year 2006 regarding Terms and Permitting Procedures for Effluent Disposal to the Marine Environment.	Effluent water discharge to marine environment by WBN shall refer to this regulation.
Regulation No. 05 Year 2008 regarding Work Guidelines for Appraisal Commission on Environmental Impact Assessment	AMDAL documents shall be evaluated by AMDAL Commission in compliance with this regulation
Minister of Energy and Mineral Resources	
Decree No. KEP-1158.K/008/M.PE/1989 regarding Provision of Environmental Impact Assessment in Mining and Energy Business.	WBN requires to prepare EIA document referring to this decree in conjunction with other relevant regulations
Decree No. KEP-103.K/008/M.PE/1989 regarding Supervision on Environmental Management and Monitoring Plan in the Field of Mining and Energy.	Environmental Management and Monitoring Plan implementation by WBN will be inspected by assigned Mine Inspector
Decree No. 555.K/26/M.PE/1995 regarding Safety and Occupational Health in General Mining	Safety and Occupational Health aspects of the WBN mine operations shall comply with this decree.
Decree No. KEP-1211.K/008/M.PE/1995 regarding Prevention and Control on	WBN project should prevent and control of adverse impacts from project

Law	*Rationale*
Destruction and Environmental Pollution in General Mine Business.	construction and operations referring to this decree.
Decree No. 1261.K/25/M.PE/1999 regarding Supervision on General Mining Production.	Ore and intermediate-metals production by WBN operation will be inspected by Department of Mining or its assignee referring to this decree.
Decree No. 1457K/28/MEM/2000 regarding Technical Guidelines of Environmental Management in Mine and Energy Sector.	EIA preparation by WBN shall refer to this decree
No. 1603.K/40/MEM/2003 regarding Guidelines for Reserving Mine Area	The mine project of WBN shall refer to this regulation.
No. 18 Year 2008 regarding Reclamation and Mine Closure	Reclamation plan, implementation and reporting of reclamation; mine closure plan, implementation and reporting of mine closure; reclamation guarantee, and mine closure guarantee of WBN project shall refer to this regulation.
Minister of Agriculture	
Decree No. 54/kpts/UM/2/1972 regarding Tree Species in Forest which are Protected.	Inventory and study of protected flora in the planned open area for WBN project activities refer to this decree.
Minister of Forestry	
Decree No. 261/kpts-IV/1990 regarding Addendum to Appendices on Decree of Minister of Agriculture No. 54/kpts/UM/2/1972 (Trees Species in Forest which are Protected)	Inventory and study of protected flora in the planned open area for WBN project activities refer to this decree
No. 301/kpts-II/1991 regarding Inventory of Wildlife Protected by Law or Part of Wildlife Maintained by Individual.	Inventory and study of protected wildlife in the planned open area for WBN project activities refer to this decree
Decree No. 464/kpts-II/1995 regarding Management of Protection Forest	Small part of WBN concession area is located in the protection forest. Management of this protection forest in WBN concession area shall refer to this decree.
Decree No. 146/kpts-II/1999 regarding Guidelines of Reclamation of Mined Land within Forest Area.	Reclamation of ex-mined area of WBN that is located in the forest area shall refer to this decree in conjunction with others relevant regulations.
Decree No. 415/kpts-II/1999 regarding the Map of Forest Areas and Water Bodies of the Province of Maluku	WBN CoW area is located in forest areas, therefore, shall consider this decree.
Regulation No. : P. 43/Menhut-II/2008 regarding Guideline for Lend and Use of Forestry Region	Guideline for lend and use of the forest area for mining activities outside forestry activities generally refers to the stipulations contained in this regulation.
Regulation No. P.56/Menhut-II/2008 regarding Guideline to Determine Area Disturbed and Reclaimed and Revegetated for Calculating State Non-Tax Income of the Use Forest Area	Tax payment of the disturbed and reclaimed/revegetated of forest area by the activities shall refer to this regulation.
Regulation No. P. 70/Menhut-Ii/2008 regarding Technical Guidelines for Rehabilitating Forest and Land	Rehabilitation of forest and land shall refer to this regulation.
Minister of Public Works	
Decree No. 45 year 1990 regarding Water Quality Control in Water Resources.	Control and monitoring of water quality from the project activities shall refer to this regulation.
Decree No. 48 Year 1990 regarding Water Management and Water Resources on River Watershed.	There are many rivers across WBN project area, the management of the rivers shall river to this regulation.

Law	*Rationale*
Decree No. 49 Year 1990 regarding Procedure and Permit to Use Water and/or Water Resources.	Considering that WBN plan to use water sources for processing and domestic purposes, therefore the use of such water resources shall refer this regulation.
Decree No. 63 Year 1993 regarding River Boundaries, River Use Area, River Controlled Area, and Ex-River Area	Utilization of the rivers shall consider this regulation.
Minister of Transportation	
Decree No. 68 Year 1993 regarding Land Transportation of Materials.	Public road utilization by WBN project to transport materials shall consider this regulation.
Decree No. KM 55 Year 2002 on the Management of Special Ports.	WBN builds and operates special ports for loading and unloading raw materials and exports product; therefore, shall refer this regulation.
Minister of Health Decree	
No. 416/MENKES/PER/IX/1990 regarding Requirements and Supervision of Water Quality.	Clean water used by the project for employee's domestic use should be monitored to meet clean water standard as stipulated in this decree.
No. 907/MENKES/SK/VII/2002 regarding Requirements and Supervision of Drinking Water.	Drinking water consumed by project's employees should be managed and monitored in order to meet drinking water quality standard as stipulated in this decree.
Head of Impact Control Agency Decree	
No. 056/BAPEDAL/03/1994 regarding Guidelines to Determine Significance Scale of Environmental Impacts.	The scale of impacts should be clearly stated in the environmental impact assessment documents referring to this decree.
No. KEP-01/BAPEDAL/09/1995 regarding Procedures and Requirements for Storage and Collection of Hazardous and Toxic Waste.	Hazardous waste generated by the project should be stored and collected in accordance with this decree.
No. KEP-05/BAPEDAL/09/1995 regarding Symbol and Label of Hazardous Waste.	Hazardous wastes generated by the project should be labeled and signed for in accordance with this decree.
No. KEP-205/BAPEDAL/07/1996 regarding Technical Guideline to Manage Air Pollution of Stationary Sources.	Gas emissions from stationary sources by the project activities should be managed and monitored referring to this decree to meet the prevailing standards.
No. 299/11/1996 regarding Technical Guidelines for Social Study within Environmental Impact Assessment	Social Study is part of Environmental Impact Assessment conducted by WBN
No. 8 Year 2000 regarding Community Involvement and Information Disclosure in the Process of Environmental Impact Assessment	Community involvement and information disclosure in relation to the AMDAL process will refer to this regulation.
Director General of General Mining Decree	
Decree of the Director General of General Mining No. 316.K/2016/DDJP/1990 regarding Guideline for Storage of Explosives for General Mining Activities.	Storage of explosives to be used for the limestone mining activities by WBN shall refer to this decree.
No. 693.K/008/DDJP/1996 regarding Guidelines to Control Erosion in General Mining.	Project proponent should prevent and control erosion as a result of mining activities referring to guidelines stipulated in this decree.
Decree of Director General of Land Transportation	
No. SK. 726/AJ.307/DRJD/2004 on Technical Guide for the Operation of Heavy Equipment Transportation on the Road.	If the project activities mobilized heavy equipment on the public road; its implementation shall refer to this decree.
Provincial Regulation of North Maluku	

Law	*Rationale*
No. 2 Year 2003 regarding the Spatial Plannings of the Province of North Maluku Year 2003 - 2018	The project location and activities shall be in line with the existing spatial plannings as stipulated in this decree
No. 5 Year 2005 regarding the Management of Commercial Mining.	Mining activities of WBN shall refer to this decree.
No. 9 Year 2006 regarding the Management and Control of Environmental Impacts in the Province of North Maluku	The environmental managements and control of environmental impact of WBN activities shall refer to this decree
No. 10 Year 2006 regarding the Standards for Industrial Wastewater and other Businesses in the Province of North Maluku	Wastewaters generated by WBN activities shall comply with this decree
Regulation/Instruction of the Governor of North Maluku	
No. 3 Year 2005 regarding Type/ Project in North Maluku Province that Require AMDAL, UKL and UPL	The project is considered as to generate significant impact to environment, therefore WBN shall prepare AMDAL document in accordance with this regulation.
Regulation No. 4 Year 2005 regarding the Intermediate Work Plan/ *Rencana Kerja Jangka Menengah Daerah (RKJMD)* of the Province of North Maluku Year 2005-2007	The mine activities of WBN refer to the local work program for medium term (*RKJMD)* of the Province of North Maluku
No. 9 Tahun 2005 regarding Separation of Forest and Aquatic Area and Change of Their Function as well as Forest Area Status in North Maluku Province.	WBN CoW area is located in forest areas, therefore shall consider this regulation.
Regulation No. 10 Year 2007 regarding the Operational Guidelines in the Involvement of the Local Community and the Publication of Information in the EIA (AMDAL) Process	WBN's AMDAL preparation, appraisal process and its disclosure to public shall refer to this decree.

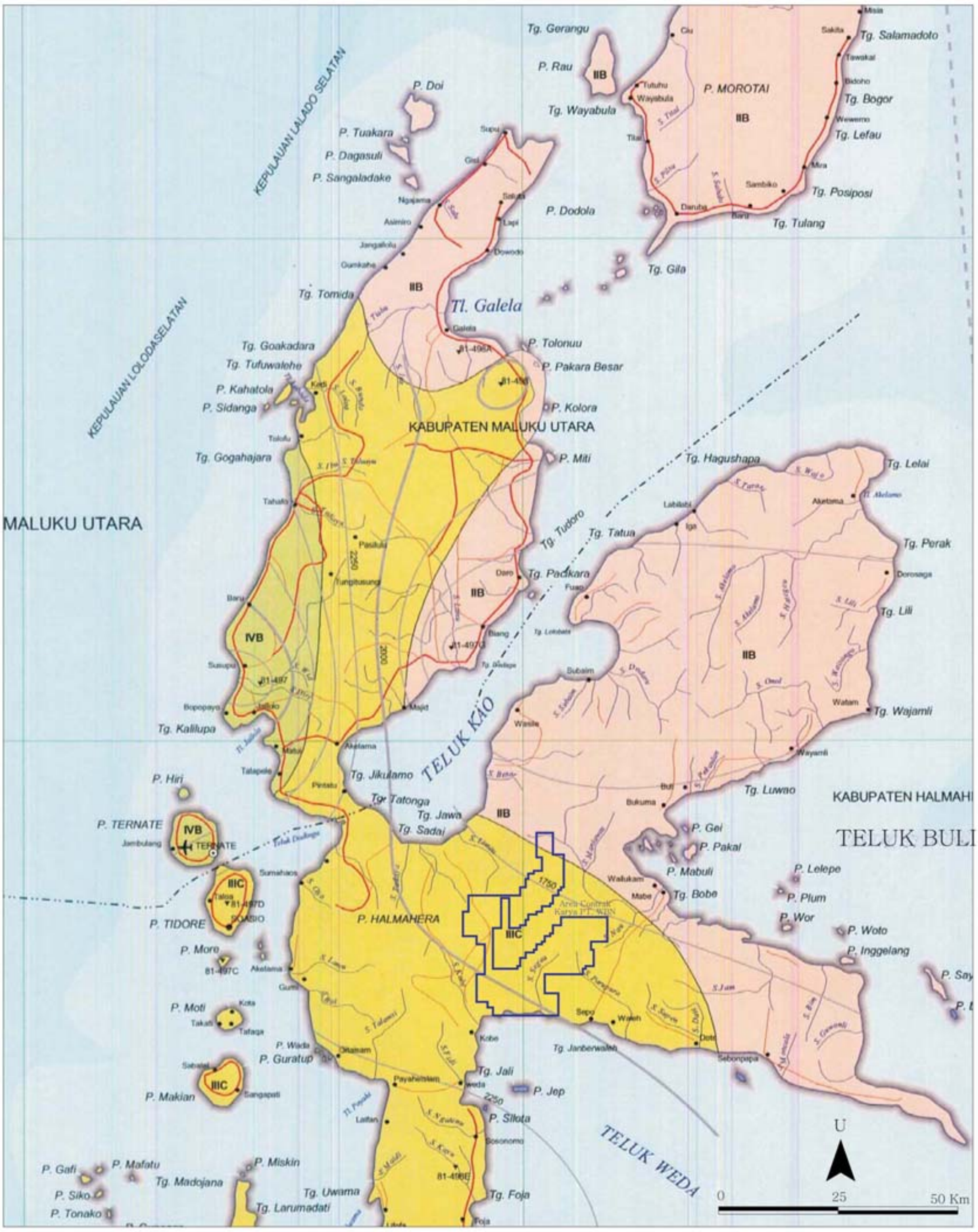
Appendix C

Environmental & Social Baseline Description

Chapter III ANDAL summary of env & social baseline, including public health, administrative boundary, permitting requirements

1 METEOROLOGY AND CLIMATE

In completion of climate information, agro climate map is provided in Map 1. Based on the map, almost all COW area is classified in wet climate type with III-C Pattern (with annual rainfall range between 2,000 and 3,000 mm). Only small area within the COW is classified as dry climate type with II-B pattern (with annual rainfall less than 1,000 mm). The III-C pattern has less than 4 consecutive dry months and 6-8 consecutive wet months. The II-B pattern has less than 4 consecutive dry months and 4 consecutive wet months.



MAP 1 CLIMATE RESOUCE		

weda bay nickel

Scale	–	Drafter	GGG
Revision No	0	Proofreader	AIR
Date Revision	Dec 2009	Compilation	ERM

CLIMATE TYPE	PATTERN	ANNUAL RAINFALL (mm)	CH ≤ 100 (mm/month)	CH ≤ 100-150 (mm/month)	CH ≤ 150-200 (mm/month)	CH ≤ >200 (mm/month)
Dry Climate	IIB	1000 - 2000	≤4	≤5	≤5	≤4
Wet Climate	IIIC	2000 - 3000	≤4	≤4	≤5	6-8
	IVB	3000 - 4000	≤2	≤3	≤3	8-11

RF= Rainfall

Source :
Agroclimate and Hydrology Research Agency, Research and Development Center Soil and Agroclimate, Research and Development Center of Agriculture 2003.

Map 1 Agroclimate of Study Area

1.1 *TEMPERATURE*

Figure 1 shows the average monthly temperatures measured at Ternate station. Records from this station are relevant because the station is based at an altitude similar to the one at the proposed processing plant. The average, maximum, and minimum temperature in Ternate station (using data from 1979 to 2007) are as follows: 26.6 °C, 31.2 °C, and 23.5°C. The lowest average monthly temperature at Ternate was detected in February and the highest in May.

Similar values were measured at Wosea station, i.e. 27.7 °C, 37.2 °C, and 19.7°C for average, maximum and minimum values. Different values were observed at Bukit Limber, which is located at a higher elevation than the other two stations, where lower temperatures were measured, i.e. 21.3 °C, 32.6 °C, and 16.0°C for average, maximum, and minimum values (please see **Figure 2**).

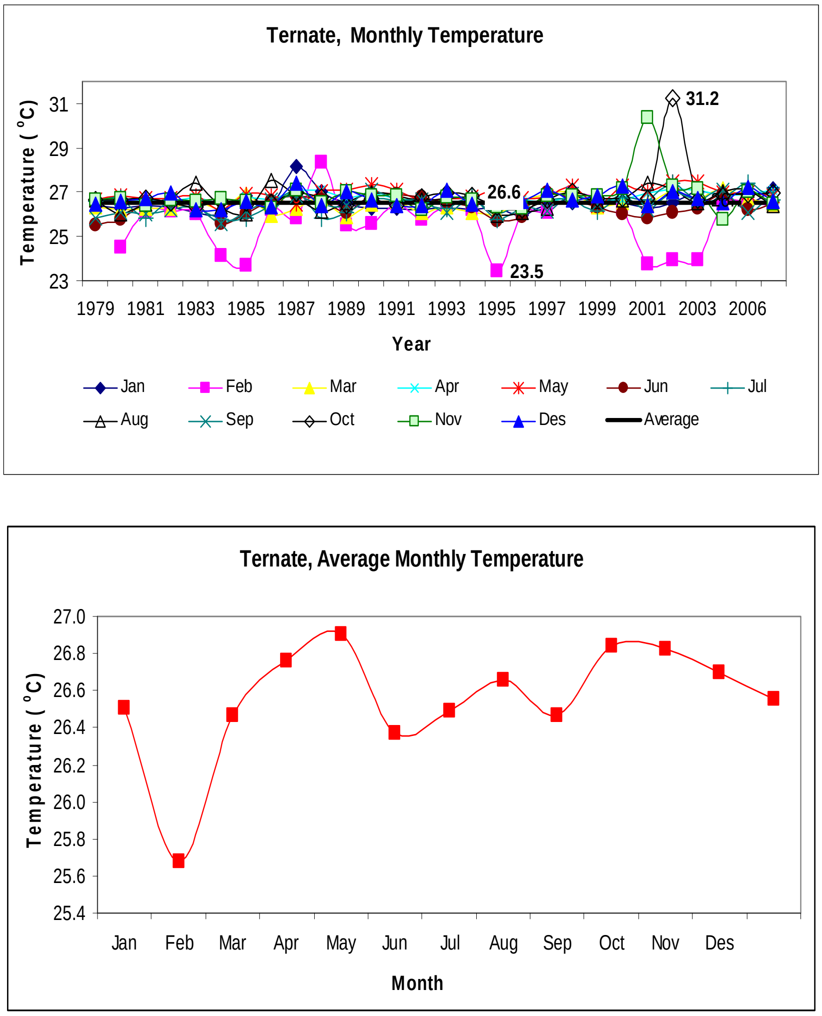
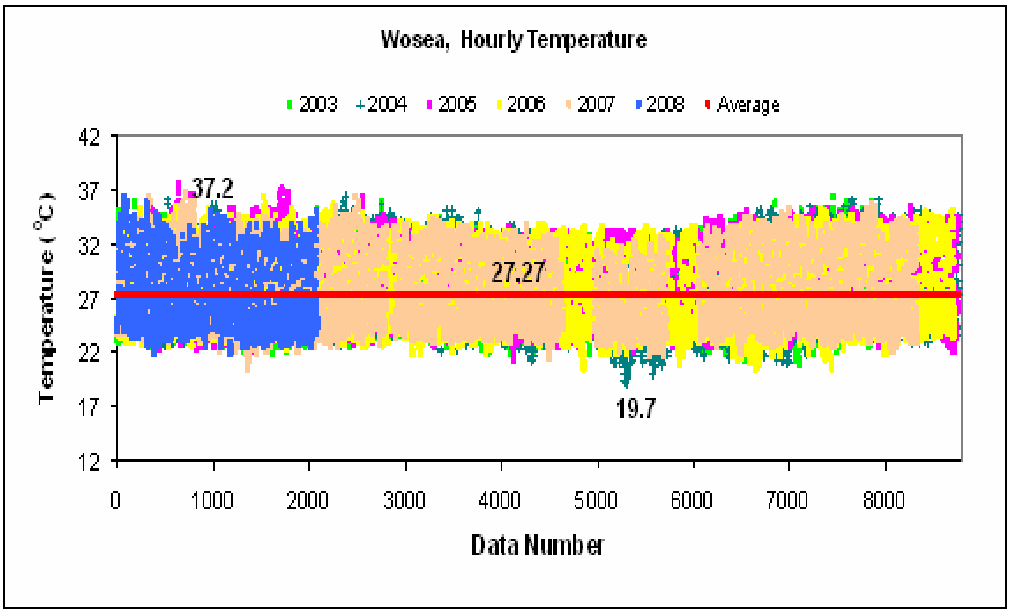
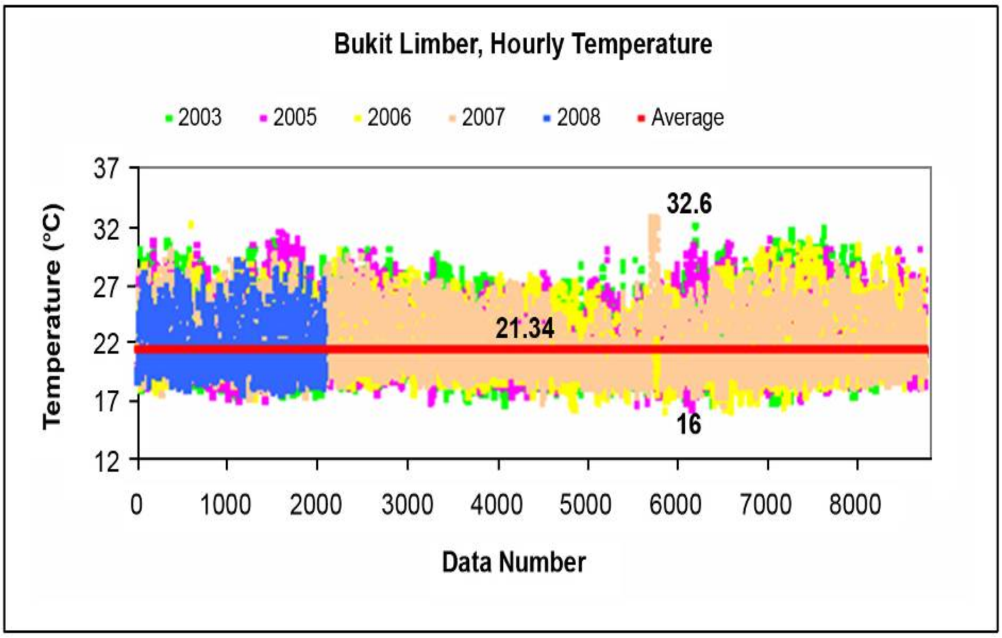


Figure 1 Average Monthly Temperature at Ternate Station

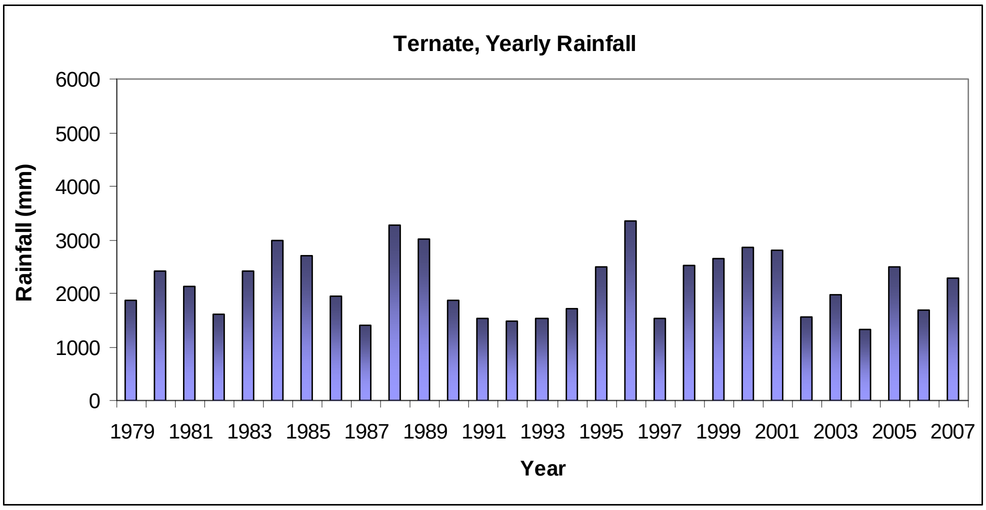


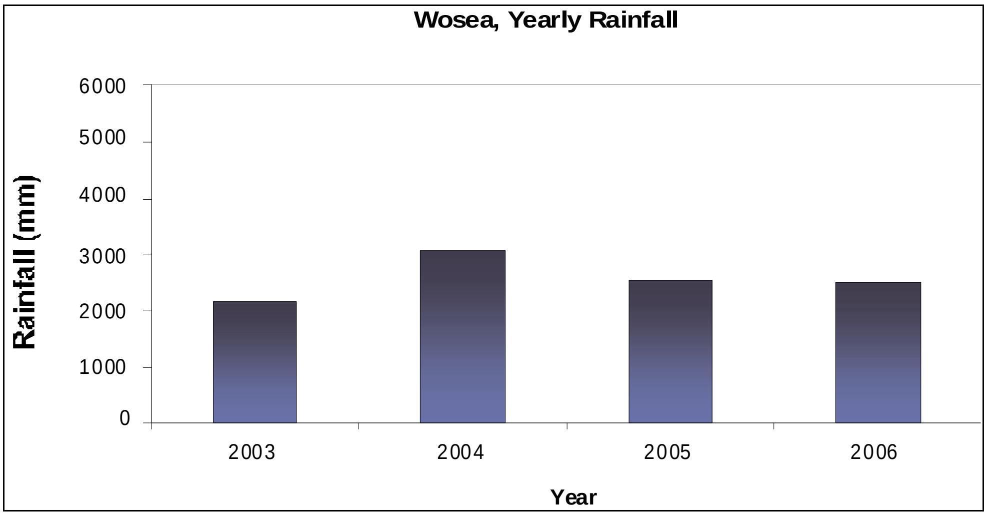


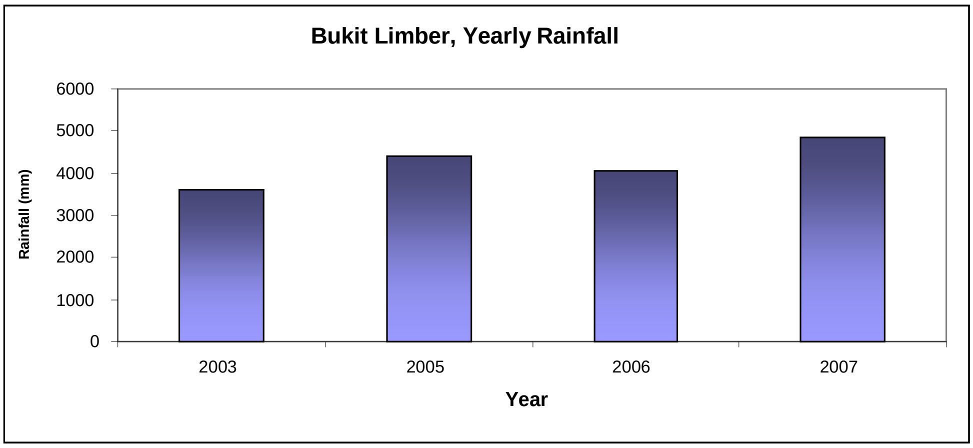
Note: as explained in Section 3.1.1, Ternate Station is not managed by WBN and does not possess a continuous data logger. Hence, hourly data is not available.

Figure 2 Hourly Temperature at Wosea and Bukit Limber Stations

1.2 RAINFALL


Ternate, Yearly Rainfall
Rainfall (mm)
6000
5000
4000
3000
2000
1000
0
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007
Year


Wosea, Yearly Rainfall
Rainfall (mm)
6000
5000
4000
3000
2000
1000
0
2003
2004
2005
2006
Year


Bukit Limber, Yearly Rainfall
Rainfall (mm)
6000
5000
4000
3000
2000
1000
0
2003
2005
2006
2007
Year

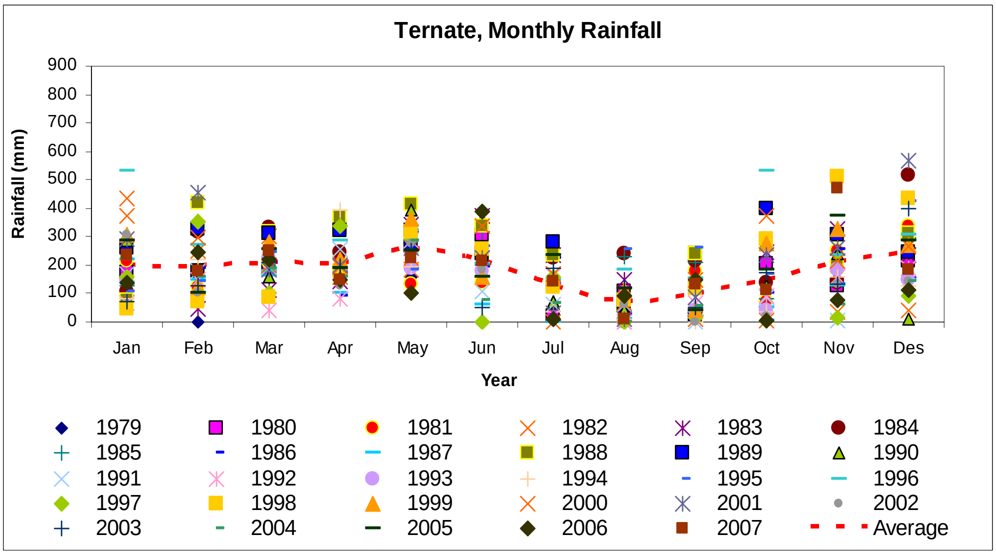
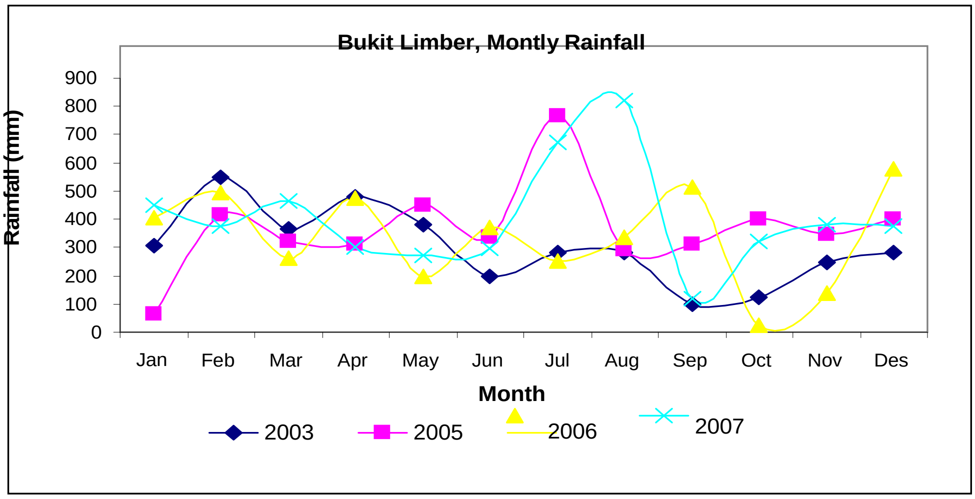


Figure 3 Annual Rainfall



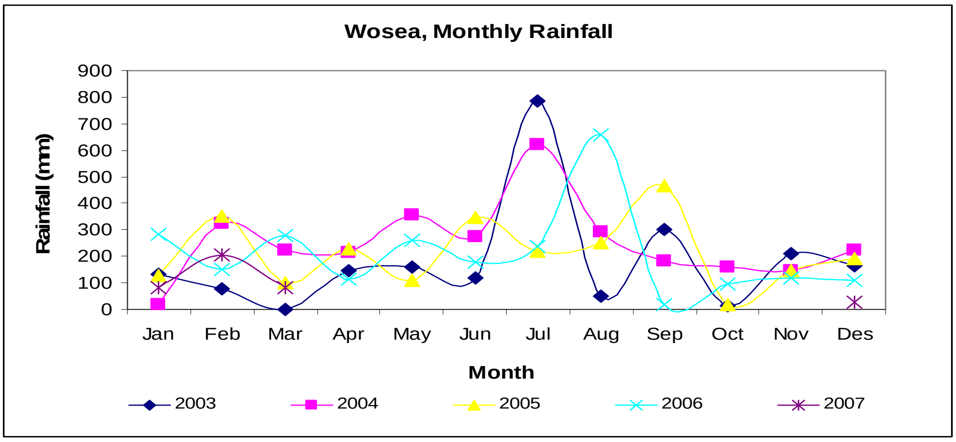
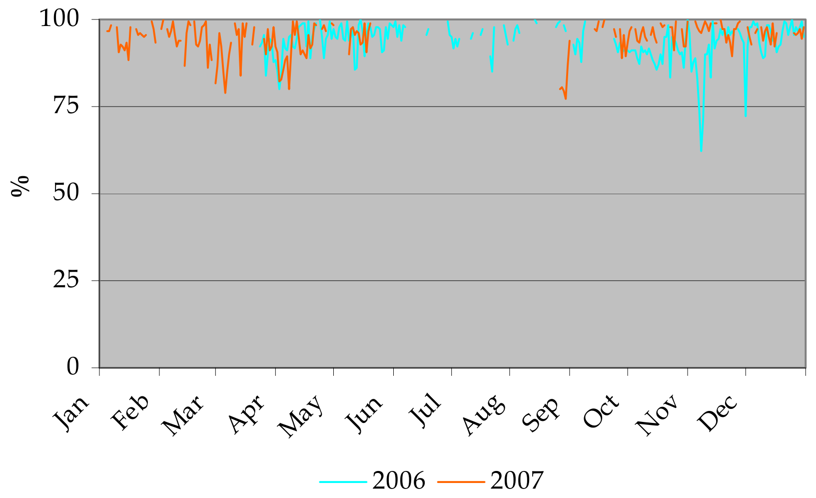


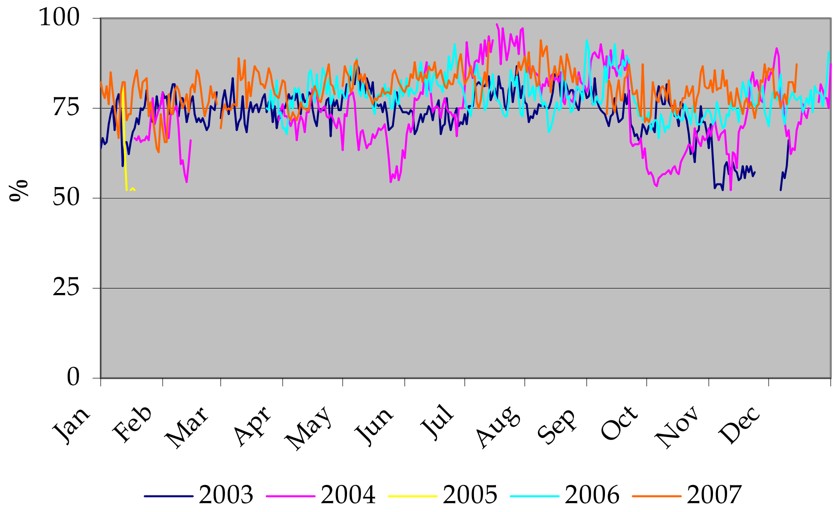
Figure 4 Monthly Rainfall

1.3 RELATIVE HUMIDITY

Humidity is high (50%-100%) at the project area. According to **Figure 5**, the range of relative humidity recorded at Bukit Limber Weather Station was between 75% and 100% during 2006 and 2007. A wider range of relative humidity was recorded at Wosea Weather Station, which was between 50% and 100% in the 2003 to 2007 period.



Bukit Limber Weather Station



Wosea Weather Station

Figure 5 ***Daily Average of Relative Humidity Recorded at Bukit Limber and Wosea Weather Stations.***

1.4 *WIND SPEED AND DIRECTION*

On Halmahera Island, there are two local circulation patterns resulting from unequal surface heating and cooling. These are the land-sea breeze and the mountain valley wind. As discussed in the introduction of this Section, wind speed and direction (as well as atmospheric stability) greatly influence air pollution modeling. Winds must be taken into account in plant sitting and emission control requirements. The pattern of local circulation effects, i.e. the land sea breeze and mountain valley winds, influence dispersion of pollutants.

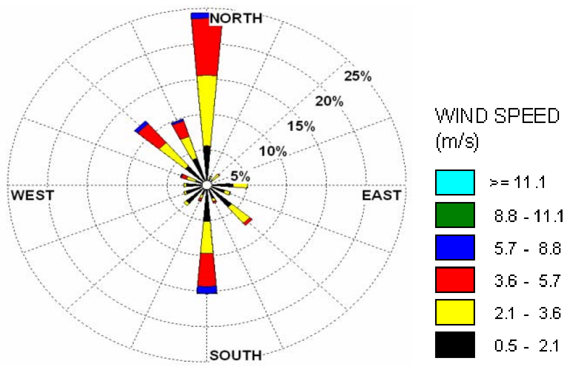
A. ***The Land-Sea Breeze***. In the daytime, the land is heated rapidly, which in turn heats the air above it. The sea temperature remains relatively constant. The air over the heated land surface rises, producing a low pressure relative to the pressure over the water. The resulting pressure gradient produces a surface flow off the water toward the land (a sea breeze). Initially the flow will be onto the land, but as the breeze develops, the Coriolis force will gradually shift the direction so that the flow is more parallel with the land mass. After sunset and several hours of cooling, the land mass will become cooler than the water, causing the reverse flow pattern to develop, resulting in a wind off the land (a land breeze).

B. ***Mountain Valley Winds***. During daylight hours, the air adjacent to the mountain slope heats rapidly and rises. This air then settles over the cooler valley, producing an up slope wind during the day. At night, the cooler air on the mountain slope flows down into valley.

Wind Roses. Wind roses (seasonal or monthly) constitute an effective way to graphically present wind direction and velocity data for a specific location, as shown in Figure 6. In these plots, the average wind direction is shown as one of sixteen compass points, each point separated by 22.5^{o}, measured from true north. The length of the bar plotted for a given direction indicates the percentage of time the wind came from that direction. Since wind direction is constantly changing, the time percentage for a specific compass point actually includes those times with wind directions within 11.25^{o} either side of the point. The percentage of time for a given velocity range is shown by the thickness of the direction bar. A wind rose proves good indications of local pollutant dispersion patterns.

Wind roses for Ternate station (plot of all months 1979-2007), Wosea station (plot of all months from 2003 until 2007), and Bukit Limber station (plot of all months of 2003, 2005, 2006 and 2007) are shown in **Figure 6**. Additional wind roses with hourly data are in Appendix B-5.

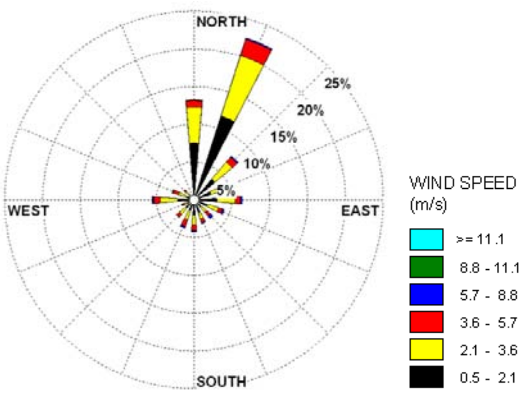
Monthly wind roses for each station were also developed to depict changing wind directions throughout the whole year. Most notable here is the prevalence of easterly (onshore) winds at Wosea, while winds with a northerly component are more common at Bukit Limber and Ternate. At Ternate, southerly winds are common from June to October; however, in the project area, southerly winds rarely occur.



All Months 1979 - 2007

(Ternate)

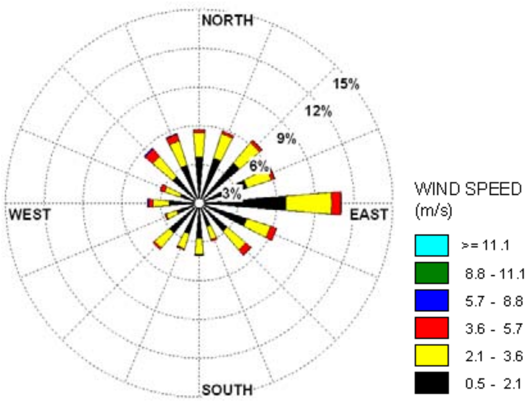
Calm Wind: 0.31%, Average Wind: 2.83 m/s



All months of 2003, 2005, 2006, and 2007

(Bukit Limber)

Calm Wind: 10.72%, Average Wind: 2.22 m/s



All Months 2003 – 2007 (Wosea)

Calm Wind: 16.55%, Average Wind: 1.68 m/s

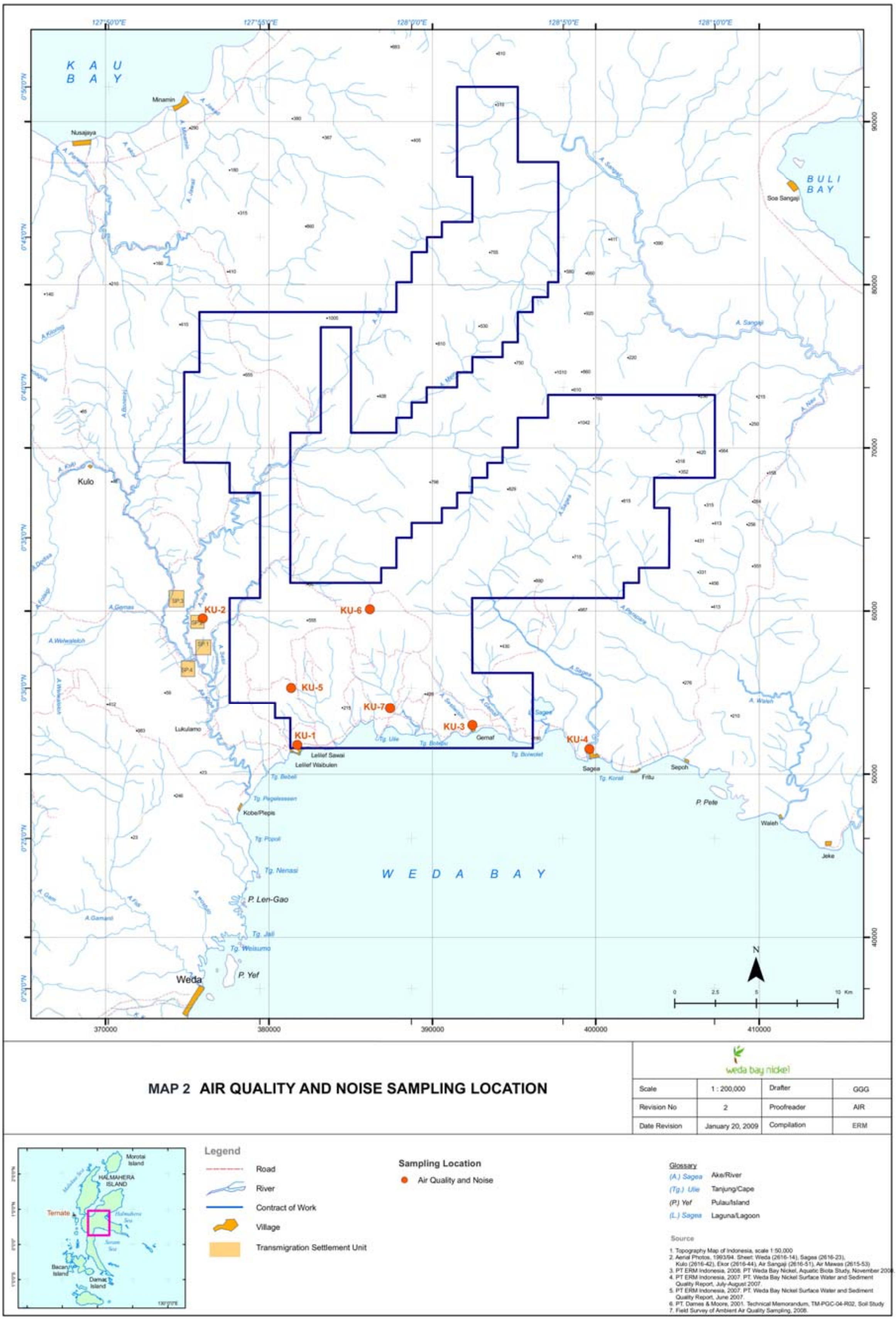
Figure 6 ***Annual windrose***

2 *AMBIENT AIR QUALITY*

The air sampling program addressed seasonal differences; measurements were taken in May-July (wet season) and in Sept-November (the dry season).

The results of ambient air sample analyses (24-hour sampling period), which were taken in May, June and July (to capture seasonal differences) are presented in Map 2. As indicated by Map 2 there were seven sampling points (five in low lands [Lelief, Trans Kobe, Gemaf, Sagea, Ake Sake] and two in the high lands; Camp 11 at 500m and Camp 2 at 900m elevation. Results were compared with the maximum allowable limit as stated in the Government Regulation (GR) No. 41 Year 1999 regarding Air Pollution Control. Per GR 41, the following parameters were included in the suite of analytical tests: SO_2, NO_2, CO, PM-10, TSP, Pb, SO_4 index, and Dustfall. In terms of sampling results, concentrations of SO_2, NO_2, CO, PM-10, TSP, Pb, SO_4 index and dustfall were in compliance with GR 41, and are indicative of a clean atmosphere.

In addition to the parameters above, and to provide a baseline for future operations, the study also investigated the total metals content (Ca, Mg, Ni, Fe, Co, Al, Mn, Cr, and Cu) in the TSP and Dust Fall. It should be noted that GR41 1999 does not regulate trace metals in the TSP and Dustfall.



Map 2 Air quality and Noise Sampling Locations

3 QUALITY OF RAIN WATER

The pH of "normal" rain is around 5.6. The analytical results of rain water samples from the project area indicate the pH of rainwater samples ranges from 5.83 to 6.91, which is typical of a coastal location, featuring ions derived from sea water aerosols and from dissolved carbon dioxide. The rain water in the region is characterized as follows: calcium ranges from 0.01 mg/L to 0.07 mg/L; magnesium ranges from 0.01 mg/L to 1.51 mg/L; sodium ranges from 0.01 mg/L to 0.47 mg/L; potassium ranges from 0.04 mg/L to 0.51 mg/L; sulfate ranges from 0.004 mg/L to 0.06 mg/L; nitrate ranges from 0.001 mg/L to 0.123 mg/L; and carbonate ranges from 3.54 mg/L to 24.31 mg/L.

4 NOISE

Noise measurements from seven locations (prior to operation) (see Map 2) within the project area are presented in Table 1. Values of Ls (*Equivalent Continuous Noise Level in day time),* Lm (*Equivalent Continuous Noise Level in night time*) and Lsm (*Equivalent Continuous Noise Level in day and night times*) were derived and compared against noise standards as stipulated by Minister of Environment Decree No. 48 Year 1996 regarding Noise Standard.

Based on this regulation, the noise standard for a residential area (55 dBA) applies to the sampling locations of Lelilef, Trans Kobe, Gemaf, Sagea, and Ake Sake. The noise standard for Camp 2 and Camp 11 (a proposed mining area, thus considered an industrial area) is 70 dBA. These regulatory standards are highlighted in the Table 1.

Noise measurements from seven regulatory-driven periods of time (L1-L7) in any given day were taken over the course of six months (May–July to account for the wet season and September-November to address dry season). Lsm values, which are the ones to be compared against residential (55 dBA) and industrial (70 dBA) standards, were computed according to the regulation and listed in Table 1 below. Lsm values for residential areas ranged from 44 to 50 dBA for sampling areas representing residential locations (Lelilef, Trans Kobe, Gemaf, Sagea, and Ake Sake) during wet season and 43 to 64 dBA during dry season. Exceedance of Lsm values were observed in Gemaf (October 2008) and Ake Sake villages (November 2008). Lsm values for industrial areas (Camp 11 and Camp 2) ranged from 39 to 63 dBA in wet season and from 39 to 51 dBA during dry season, with a peak in May for Camp 2. The peak values are likely due to insect noise that occurred in the morning.

Table 1 Noise Measurement Results (in dBA) SeaSeason

Season	Month	Item	Time	Lelilef (KU-1) dBA	Trans Kobe (KU-2) dBA	Gemaf KU-3) dBA	Sagea (KU-4) dBA	Camp - 11 (KU-5) dBA	Camp - 2 (KU-6) dBA	Ake Sake (KU-7) dBA
Wet	May-08	L1 (07:00)	06:00-09:00	45	40	44	42	35	43	35
		L2 (10:00)	09:00-11:00	48	42	46	43	31	44	50
		L3 (15:00)	14:00-17:00	48	41	47	42	57	48	45
		L4 (20:00)	17:00-22:00	47	45	44	47	53	46	48
		L5 (23:00)	22:00-24:00	48	46	53	48	52	47	48
		L6 (01:00)	24:00-03:00	51	44	54	47	42	45	47
		L7 (04:00)	03:00-06:00	44	42	45	46	43	67	43
		Ls		46	42	44	44	52	45	46
		Lm		49	44	52	47	47	63	46
		Lsm		50	46	53	49	52	63	49
		ME Decree 48 Year 1996		55	55	55	55	70	70	55
	Jun-08	L1 (07:00)	06:00-09:00	40	39	41	42	45	45	46
		L2 (10:00)	09:00-11:00	42	42	45	43	41	41	50
		L3 (15:00)	14:00-17:00	47	47	42	43	42	42	46
		L4 (20:00)	17:00-22:00	56	53	55	46	46	46	46
		L5 (23:00)	22:00-24:00	45	53	48	44	43	43	44
		L6 (01:00)	24:00-03:00	42	40	43	44	43	43	44
		L7 (04:00)	03:00-06:00	44	42	42	43	42	42	44
		Ls		51	49	51	43	44	44	46
		Lm		43	48	44	44	43	43	44
		Lsm		50	50	50	46	45	45	47
		ME Decree 48 Year 1996		55	55	55	55	70	70	55
	Jul-08	L1 (07:00)	06:00-09:00	38	47	39	36	34	38	45
		L2 (10:00)	09:00-11:00	41	47	45	32	39	35	49
		L3 (15:00)	14:00-17:00	38	40	46	49	37	34	50
		L4 (20:00)	17:00-22:00	41	38	45	52	44	36	48
		L5 (23:00)	22:00-24:00	43	45	43	45	43	38	46
		L6 (01:00)	24:00-03:00	44	48	39	48	42	36	44
		L7 (04:00)	03:00-06:00	42	46	34	37	36	36	42
		Ls		39	43	44	48	40	35	47
		Lm		43	47	40	45	41	37	44
		Lsm		44	48	44	49	43	39	48
		ME Decree 48 Year 1996		55	55	55	55	70	70	55
Dry	Sep-08	L1 (07:00)	06:00-09:00	39	38	41	39	37	39	40
		L2 (10:00)	09:00-11:00	48	44	39	39	37	40	40
		L3 (15:00)	14:00-17:00	39	41	39	38	35	39	39
		L4 (20:00)	17:00-22:00	41	38	54	42	43	47	43
		L5 (23:00)	22:00-24:00	42	40	54	43	44	47	41
		L6 (01:00)	24:00-03:00	42	42	54	42	43	46	40
		L7 (04:00)	03:00-06:00	42	42	54	43	38	46	43
		Ls		42	39	49	39	40	43	40
		Lm		42	42	54	43	42	46	42

Season	Month	Item	Time	Lelilef (KU-1) dBA	Trans Kobe (KU-2) dBA	Gemaf KU-3) dBA	Sagea (KU-4) dBA	Camp - 11 (KU-5) dBA	Camp - 2 (KU-6) dBA	Ake Sake (KU-7) dBA
		Lsm		44	43	55	44	43	48	44
		ME Decree 48 Year 1996		55	55	55	55	70	70	55
	Oct-08	L1 (07:00)	06:00-09:00	43	43	43	43	43	43	43
		L2 (10:00)	09:00-11:00	39	39	75	45	45	44	42
		L3 (15:00)	14:00-17:00	44	44	44	45	47	47	47
		L4 (20:00)	17:00-22:00	39	38	45	52	51	52	52
		L5 (23:00)	22:00-24:00	38	37	35	40	41	41	40
		L6 (01:00)	24:00-03:00	52	54	43	49	50	52	52
		L7 (04:00)	03:00-06:00	54	52	53	48	48	45	43
		Ls		41	40	66	48	48	48	48
		Lm		52	52	49	48	48	49	48
		Lsm		53	52	64	50	51	51	51
		ME Decree 48 Year 1996		55	55	55	55	70	70	55
	Nov-08	L1 (07:00)	06:00-09:00	40	40	40	46	31	40	39
		L2 (10:00)	09:00-11:00	43	41	40	37	32	45	40
		L3 (15:00)	14:00-17:00	42	41	39	36	35	45	50
		L4 (20:00)	17:00-22:00	53	41	47	44	37	49	54
		L5 (23:00)	22:00-24:00	54	40	46	44	37	47	55
		L6 (01:00)	24:00-03:00	54	41	48	43	38	48	55
		L7 (04:00)	03:00-06:00	53	40	47	43	37	51	54
		Ls		49	40	43	42	34	46	50
		Lm		54	41	47	43	37	49	55
		Lsm		55	43	48	45	39	51	56
		ME Decree 48 Year 1996		55	55	55	55	70	70	55

Note:
ME 48 Year 1996 = Minister of Environment Decree No. KEP-48/MENLH/11/1996 regarding Noise Level Standard
Source: Air Quality Survey for WBN, 2008
nd = not detected; Ls=daytime noise level; Lm=nighttime noise level; Lsm=day and night noise level

5 PHYSIOGRAPHY AND GEOLOGY

5.1 PHYSIOGRAPHY

The Halmahera Island Group is located in the northeastern Indonesian archipelago and lies between latitudes 3°N and 2°S and longitudes 127°E and 129°E. The island measures 180 km from north to south and 70 km from west to east. It is surrounded by the smaller islands of Morotai, Ternate, Bacan, Obi, and Gebe. It is bounded by the Molucca Sea to the west and the southern part of the Philippine Sea to the east.

Halmahera Island has a four-armed shape resembling the letter K, similar to but smaller than Sulawesi Island to the west. The bays between the arms are the Kau Bay in the northeast, Buli Bay in the east, and Weda Bay in the south.

	
Weda Bay and Gentle Slope Terrain	Abruptly alterating terrain in the lowland area
	
Mountainous Ridges	Hilly Surfaces

Figure 7 Physiography in the Project Area

Halmahera Island is generally hilly or mountainous, with the exception of flood plains in some areas e.g. the mouth of Ake Kobe adjacent to Weda Bay and most of the eastern coast of the southwest arm. The northeast to southwest trending mountainous ridges alternating with valleys in the NE arm have a relief which varies from 500 m to over 1000 m, the highest point being Bukit Saolat at 1508 m in the central part of the island.

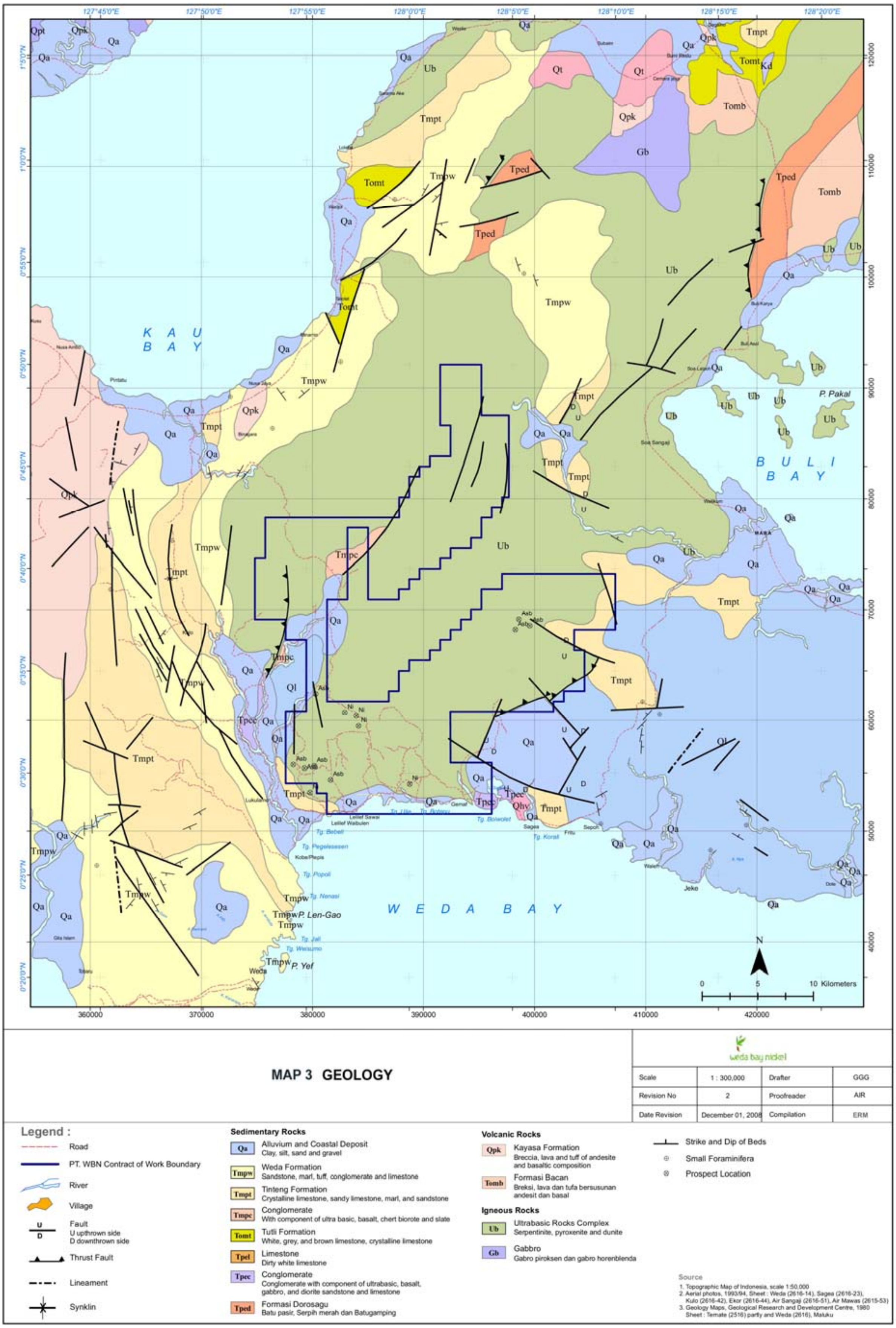
The three areas of highest ground in the western and southern parts of the island correspond to areas of volcanic rock outcrops. These are located in the western part of the central zone (1,170 m), north of Saketa (where the hills rise steeply to 1,250 m), and north of Paspalele (830 m). The only other area of high ground in the southwest arm is a ridge east of Maidi formed of conglomerates which rises to 800 m.

Characteristically, the rivers of Halmahera are generally deeply incised in the mountains, with steep-sided V-shaped valleys, which flatten out over the flood plains close to the coast. The rivers are sinuous in the middle and lower parts of their courses.

5.2 *GEOLOGY*

Based on physiographic and geologic features, Halmahera can be divided into two provinces: the western province and the eastern province. The western province is part of a young volcanic belt extending from Morotai, through the northern part of Halmahera, Ternate and Tidore, to Bacan. The area is largely covered by Neogene to Recent sedimentary and volcanic rocks, with basement continental crystalline rocks and deformed basic and ultrabasic rocks exposed in the southern part of Bacan Island of (Van Bemmelen, 1970; Yasin, 1980; Hall et al. 1988a). Volcanic and volcanoclastic rocks associated are exposed in the southern part and along the west side of the SW arm. The eastern province forms an arc extending east through the islands of Gebe and Gag towards the northern part of Bird's Head of Irian Jaya. The area is underlain by an ophiolite complex and Mesozoic deep water sediments, together with Paleogene sediments and overlain by Neogene marine sediments, including limestones (Sukamto et al., 1981; Suriatmadja, 1981). Basement rocks of the SE arm of the island consist of a complex of basic and ultrabasic rocks, with a variable low-grade metamorphic overprint, together with Mesozoic and Eocene sediments.

For better understanding, geology structure of PT WBN's project area is presented in Map 3.



Map 3 Geology of the study area

5.2.1 *Geologic Structure*

The summary below of the WBN project area structure is based on Hall et al. (1988). The SW arm of Halmahera Island is structurally simple; its present-day topography is highly asymmetrical with a steeply sloping west side, clearly fault-controlled, and an eastern surface sloping gently towards Weda Bay. Shallow, wide reefs extend offshore from the eastern coast of the SW arm and the gentle eastward dip of the land surface continues offshore into Weda Bay. Volcanic rocks of the Oha Volcanic Formation form a rigid basement and topographically high terrain on the west side of the SW arm and are overlain by Late Miocene sedimentary rocks of the Superak Formation. The Neogene sedimentary rocks dip consistently east. The Central Zone extends across the narrow neck of the Halmahera K. The neck contains a range of low mountains with rivers draining into Kau and Weda Bays. West of the neck the mountains rise to a high dissected plain which descends steeply on its west side into the Molucca Sea. The steep west coast is evidently controlled by high angle faults. The Central Zone has a basement of Oha Volcanic Formation overlain unconformably by folded Neogene sediments. The Neogene rocks are deformed by tight folds with an overall north-south axial trend. To the west it appears that these folded rocks are unconformably overlain by younger lavas which dip gently west. Above the folded Neogene sedimentary rocks is an overthrust sheet of Subaim Limestone Formation and younger rocks emplaced from the east.

The SE arm has the form of a broad open half-basin tilted southwards, with its southern part truncated by the coast. The Ophiolitic Basement Complex forms high mountains at its west end. Down-cutting by the Gowondi and Paniti Rivers expose a window of ophiolitic basement rocks which are unconformably overlain by the Subaim Limestone Formation which is separated from the Saolat Formation by a thrust fault. (see Map 3).

5.2.2 *Stratigraphy*

The Eastern Halmahera basement includes ophiolitic, metamorphic, and sedimentary rocks. The ophiolite is made up of strongly sheared and brecciated mafic and ultramafic rocks including serpentinized peridotite, gabbro, basalt, and diabase (Sukamto et al., 1981). Hall et al. (1988a) noted that the rock types vary considerably from area to area, and the basement complex includes about 30% ultrabasic rocks. Basic plutonic rocks are also abundant.

The oldest dated sedimentary rocks are those of the Buli Group. This group includes formations which range in age from Cretaceous to Eocene: the Gau Limestone, Dodaga Breccia, Paniti, Gowonli, and Sagea Formations (Hall *et al*., 1988a; 1988c) of the SE and NE arms. The oldest rocks in the Buli Group are the Gowonli Formation of the SE arm and the Gau Limestone Formation of the NE arm. The Gowonli Formation is interpreted as the deposit of a basin situated in the forearm of an active arc. The lower part of the sequence is dominated by coarse volcaniclastic material and was deposited in the early stages of basin development in a relatively proximal position. Much of material was probably deposited as debris flows. The basal contact is not observed, but the Gowonli Formation probably rests unconformably on the Ophiolitic Basement Complex. The top of the formation is not seen, but is judged to be unconformable. The Gau Limestone Formation is interpreted as a deep water deposit formed in an equatorial ocean basin with subordinate volcaniclastic material derived from active arc volcanism at its margin (Hall et al., 1988a). The oldest rocks known from the SW arm are the Cretaceous to Eocene Oha Volcanic Formation which consists of basalts and basaltic andesites (Hakim, 1989). The lower contact of these volcanics is not observed and the upper contact is probably an unconformity overlain by Neogene sedimentary rocks. Between the Mid-Eocene and Mid-Oligocene there was a major event which uplifted the Basement Complex. Uplift and erosion is marked by an unconformable contact between the Ophiolitic Basement Complex and late Paleogene and Neogene sedimentary rocks: the Onat Marl Formation, the Jawali Conglomerate Formation and the Subaim Limestone Formation of the NE arm (Hall et al., 1988a); and the Gemaf Conglomerate Formation (Hall et al., 1988c) and the Subaim Limestone Formation of the SE arm.

During the Late Miocene, subsidence occurred in the SE arm and the Saolat Formation was deposited. The Saolat Formation is a thick sequence of fossiliferous calcareous mudstones and micritic limestones interbedded locally with sandstones and conglomerates containing ophiolitic debris. A different stratigraphic sequence is found in the SW arm. The Loku Formation was deposited during the Late Miocene; it consists mainly of sandstones, mudstones, and conglomerates which are turbidites and debris flow of material derived from a terrain of volcanic arc rocks and reef limestones. The Loku Formation is thought to be overlain unconformably by the Superak Formation of the Weda Group. The Superak Formation consists of conglomerates and laterally equivalent shallow water sandstones. During the late Miocene to early Pliocene, the Akelamo Formation, consisting mainly of calcareous mudstones rich in organic debris, was deposited. It has a discontinuous distribution in the Central Zone and SW arm. Although the upper contact with the Dufuk Formation is not seen, it is believed to be conformable. The Akelamo Formation is overlain by the Dufuk Formation consisting of calcareous sandstones, siltstones, mudstones and conglomerates, which in turn is overlain by the Gola Formation on the SW arm, while in the Central Zone it is overlain by the Tapaya and Tafonga Volcanic Formations.

The Gola Formation consists of calcareous mudstones and limestones and contains a fully marine fauna indicating an open marine carbonate shelf environment in the Pliocene. Renewed volcanic activity in the Central Zone is recorded by the Tapaya and Tafonga Volcanic Formations which contain conglomerates, sandstones, tuffs, basalts and andesites, with extrusive volcanics dominating the upper part of the sequence (Hall et al., 1988b). Shallow marine to littoral tuffaceous sandstones of the Kulefu Formation are the youngest formation of the Weda Group in the SW arm. This formation is probably laterally equivalent to the Tapaya and Tafonga Volcanic Formations.

A period of deformation and uplift followed by erosion occurred prior to deposition of Quaternary reef limestones, alluvium and volcanic rocks which rest unconformably on older rocks.

5.2.3 Seismicity

Potential geological hazards in Halmahera include volcanic activity, earthquakes, and possibly tsunamis. Quaternary volcanic activity has occurred along Ternate, Tidore, and Makian volcanic chain and at the western part of northwest arm of Halmahera. However, the Weda Bay project area is located well away from areas of active volcanic activity. Nevertheless, it is sufficiently close to active volcanoes that it could receive ash fall.

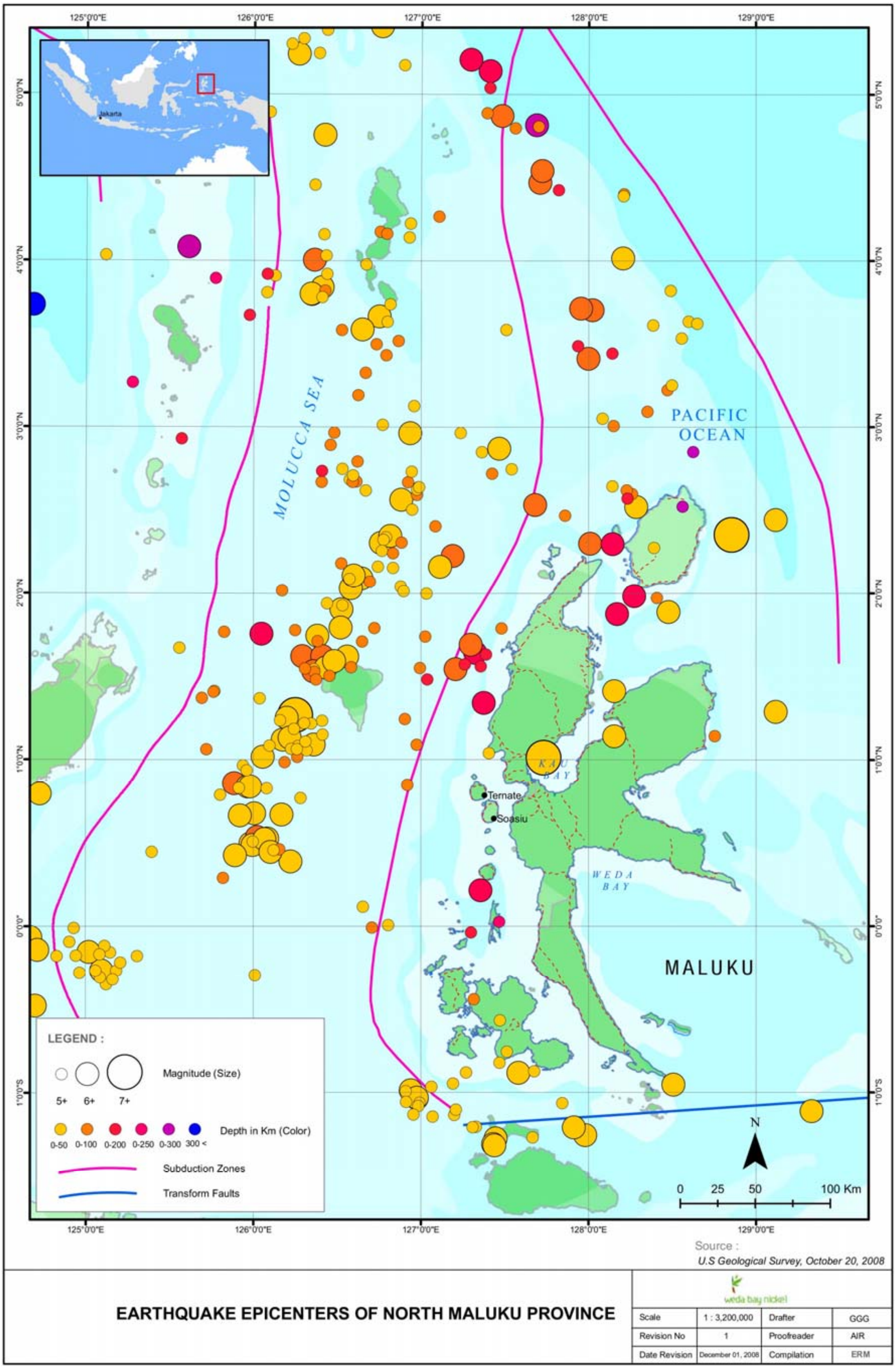
Earthquake epicenters are shown on Map 4**.** The active eastward subduction of Molucca Strait plate controls volcanic activity and triggers the earthquakes that commonly occur along the western part of Halmahera. Earthquakes in the northeast of Halmahera were caused by the active westward subduction of Pacific plate while, the dextral strike slip of Sula-Sorong fault caused earthquakes in southern parts of the island. Earthquake events occurred close to the study area on March 21 and 26, 2007 (USGS, 2007). Such earthquake activity was related to oceanic ridge motion and eastward subduction of the Molucca Sea Plate. There has been no tsunami events reported around Halmahera caused by earthquakes.

A tsunami may be triggered by submarine earthquakes related to plate convergence or submarine volcanic eruption. Theoretically, only shallow (less than 30 km depth) earthquakes with a magnitude of more than 6.3 within a vertical displacement will trigger a tsunami. The western, north, and northeast area of Halmahera are potentially areas to be affected by tsunami, but no historical tsunami has been reported from Halmahera. The earthquakes along the strike slip of the Sorong fault theoretically cannot trigger a tsunami.

Seismic records showing earthquake activity in the vicinity of Halmahera since 1990, are shown on Map 4**.** The majority of the earthquakes recorded have epicenters at depths no more than 300 km.

The area regularly experiences earthquakes categorized as M5 to M6. Earthquakes categorized as M7 and above rarely occur with an epicenter depth shallower than the lower magnitude earthquakes. A recent earthquake was recorded in the Halmahera area, with a magnitude of M6.6. The earthquake was recorded 115 km North of Ternate with a depth of 98.3 km. This occurred on September 11, 2008 and was located on the eastern fault area of the Molucca strait.

Based on the seismic record, an earthquake seismic hazard map has been derived to illustrate the potential seismic hazard in Halmahera.



Map 4 Earthquake Epicenters of North Maluku Province

6 LAND USE

The WBN CoW area is located between Kau Bay to the north and Weda Bay to the south with a total area of 54,874 ha. The topographic condition (Section 3.1.5.1) of most of the WBN CoW area is classified as Moderately Steep (11,489.20 ha or 45.64%) with slope class range of 15-25%.

Ecosystems in the project area include:

(i) Lower montane forest;

(ii) Lowland forest on ultrabasic rocks;

(iii) Lowland forest on limestone;

(iv) Lowland forest on alluvial soils;

(v) Freshwater swamp forest (dominated by Metroxylon spp./Sago);

(vi) Mangrove forest;

(vii) Lands under cultivation or coconut plantation; and

(viii) Riverine/alluvial forest.

Based on interpretation of Landsat Images (Path 10, Row 60 dated 18 May 2007), land cover condition in the WBN project area consists of: (i) sparse vegetation; (ii) bushes; (iii) forest; (iv) mangroves; (v) community area; and (vi) water bodies. Land cover details are presented in Table 2 and ***Map 5***.

Table 2 Land Cover Condition in Project Area

No	Land cover condition	Area (ha)	Percent (%)**
1	Sparse vegetation	1,580	2.88
2	Bushes	410	0.75
3	Forest	40,320	73.48
4	Mangrove	110	0.20
5	Settlement area	900	1.64
6	Cloud cover	9460	17.24
7	Water bodies (sea and river)	2090	3.81
	Total	**54,870**	**100.00**

Source: interpretation from a Landsat Image (Path 10, Row 60 and date of 18 May 2007)

Forest types and forest issues are described in more detail in the Biodiversity and Sustainable Resource Management section.

7 *TOPOGRAPHY*

The topography of the WBN CoW and surrounding areas is shown, with a contour interval of 250 m, on ***Map 6***. The area of interest is dominated by two southwest-northeast trending ridges, which are separated by the Jira River, a tributary of the Kobe River.

The more northerly ridge intersects the northeast part of the CoW, and then extends to the west of its north part. The ridge attains a maximum elevation 1,500 m, but within the CoW elevations are generally less than 1,000 m.

The southerly ridge occupies much of the southern part of the CoW, and includes all areas to be mined in the first 20 years of operations. This ridge, the crest of which reaches just over 1,000 m, is bounded on the southeast side along most its length by the valley of the Sagea River. At its southwest end, the ridge is dissected by numerous, smaller south-flowing streams including the Gemaf and Wosea Rivers.

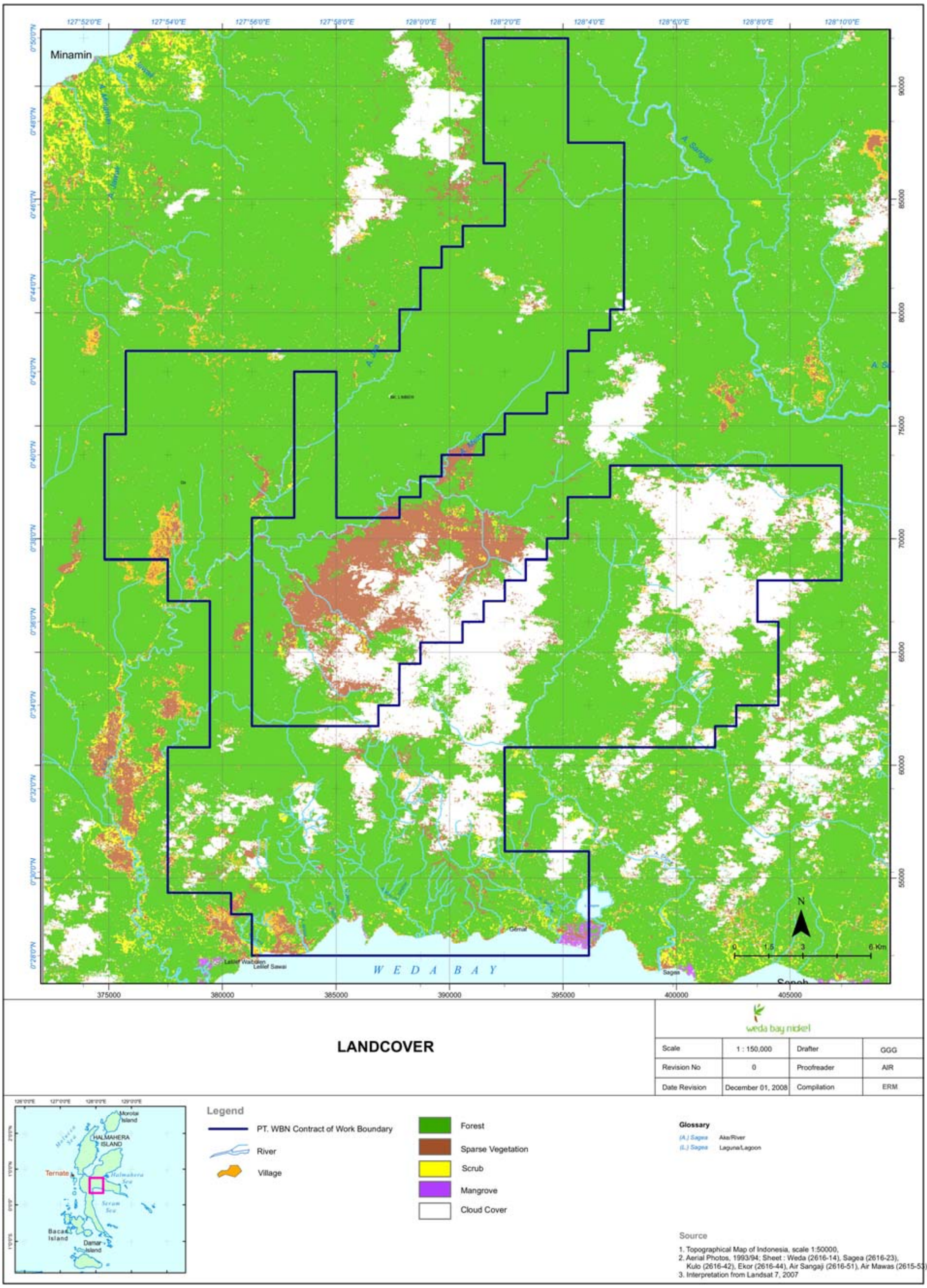
The Kobe River and lower portion of its major tributary, the Jira River, wind through a broad alluvial plain up to 7 km wide. A discontinuous coastal plain up to 1 km wide adjoins Weda Bay. Mangrove swamps occupy back-water lagoons in several near-shore portions of this plain. Most of the process plant and infrastructure will be located on the coastal plain and the adjacent low foothills.

Based on topographic data, slopes in WBN's CoW area have been categorized into five classes, as shown in Table 3 and ***Map 5***. It can be seen that 70% of the CoW area comprises slopes that are moderate, steep and very steep, with moderately steep slopes being the most prevalent.

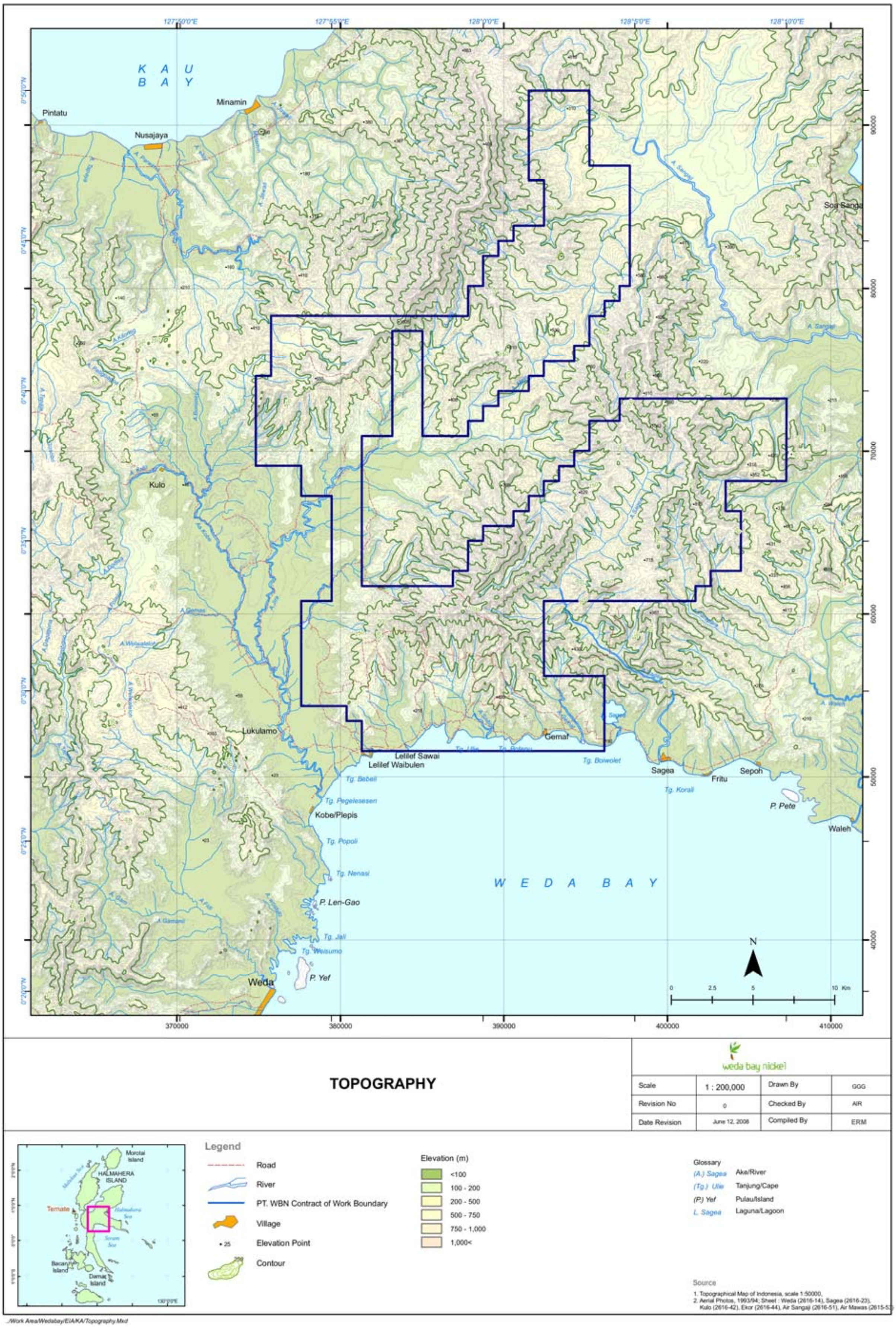
Table 3 Slope Classes in the WBN CoW Area

No	Slope class	Relief	Area	
			ha	%
1	0-8%	Flat	5,110	9.32
2	8-15%	Gentle to Moderate	11,490	20.95
3	15-25%	Moderately Steep	25,030	45.64
4	25-45%	Steep	10,400	18.96
5	>45%	Very Steep	2,810	5.13
Total			**54,840**	**100.00**

Source : Interpretation from topography map



Map 5 Land Cover



Map 6 Topography

8 SOILS

This section summarizes soil type data compiled by a 2001 soil survey and information interpreted from a 1:250,000 land system map (sheet Maluku 2616). Distribution of soil types in the WBN project area is show in Map 7. Key to soil types is shown in Table 4.

Table 4 Soil Types in the PT WBN Project Area

Land unit Code	*Soil Type*
LIT	Lithic Troporthents
LAG	Association Lithic Argiustolls and Lithic Troporthents
FVE	Fluventic Eutropepts
ASF	Association Fluventic Eutropepts and Typic Rhodudalfs
ASS	Association Fluventic Eutropepts and Typic Troposaprist
FVC	Fluventic Eutropepts
UDH	Udic Halpustalfs
TDY	Typic Dystropepts
TRH	Typic Rodudalfs
ATR	Association Typical Rhodudalfs and Udic Halpustalfs
AST	Association Typical Halpudalfs and Typical Dystropepts
CTR	Complex Typical Dystropepts, Typical Eutropepts and Typical Rhodudalfs
DTA	Tropudults, Dystropept
FLU	Fluventic Dystropepts
CTD	Typic Halpudalfs
MAR	Complex Rendoll, Ustropepts, Hapludoll
ADS	Complex Rendoll, Entropepts and Tropudalfs
BMI	Complex Haplorthox, Acrorthox and Dystropepts
APR	Complex Tropudults and Dystropepts
FAG	Complex Tropaquepts and Tropofluvents
KMM	Complex Humitropepts, Dystropepts and Tropaquod
PPL	Tropoquepts, Eutropepts, Tropfluvent

Source : Land system map (sheet Maluku 2616) and Soil Survey (PT Dames & Moore-2001)

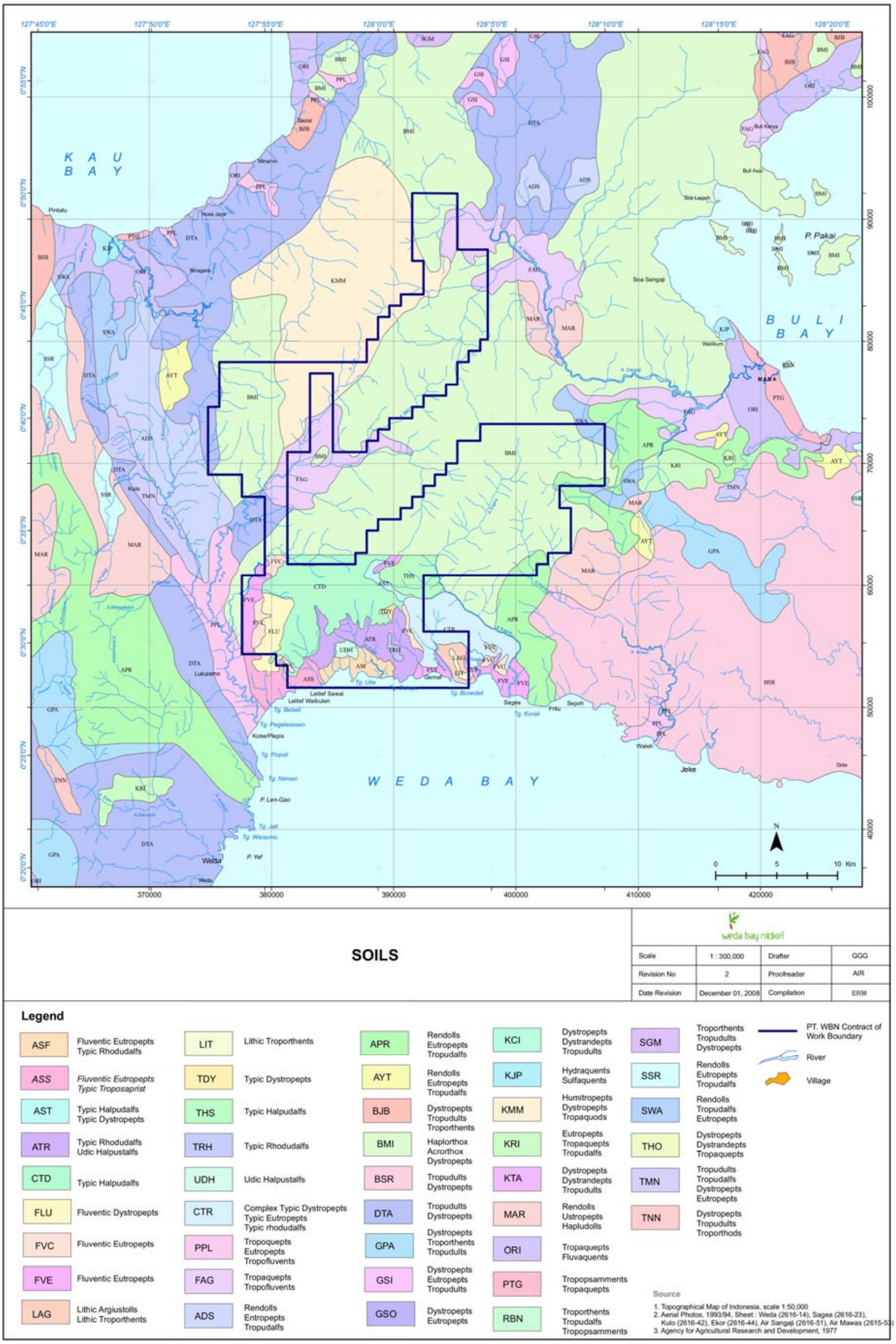
The 2001 soil survey was conducted using land system methods, where soil observations were made on the basis of soil profile information, parent material, slope class, land form and vegetation condition. Soil observations were conducted by drilling to 120 cm (or until host rock was encountered), making miniprofiles (mini pedon) and generating representative soil profile descriptions. Locations of soil samples are shown on Table 4. Of 68 samples collected from the field survey, 52 samples were submitted for chemical soil analyses at the laboratory of the Soil and Agroclimate Development and Research Center, Bogor, and 16 samples were submitted for soil permeability analyses at the Soil Laboratory, Agriculture Faculty, University of Sam Ratulangi, Manado. Chemical analyses included pH, C organic, N, P, K, Cation Exchange Capacity (CEC), Exchangeable Cation, Texture (4 fraction), and Micronutrients (Fe, Mn, Cu, Zn).

Of the soil types shown in Table 4, the CTD land unit with Typic Halpudalf soils predominates in the upland laterite areas, including the Bukit Limber deposits where mining will take place. The ATR land unit, which includes coastal deposits to be mined, comprises eroded laterite areas with Typical Rhodudalf and Udic Halpustalf soils. All these lateritic soils have relatively thin topsoil layers, generally less than 40 cm and sometimes as thin as 20 cm.

On the coastal plain, the main land units are ASS and ASF, which are alluvial soils – Fluventic Eutropepts and Typical Rhodudalfs. Two land units – ASS and ASF -- are associated with the Sagea Limestone deposits, the main soil types being Lithic Troporthents and Lithic Argiosolls.

8.1 SOIL CHARACTERISTICS

Soil fertility assessment indicates the majority of the soils display low fertility. Such conclusion is not surprising, as low fertility is characteristic of lateritic soils. Based on soil sample analyses, the soil fertility characteristics can be summarized as follows. Carbon and nitrogen concentrations are low. Phosphorus concentration (as P2O5) is also generally low but some locations indicate moderate concentration. Calcium and potassium concentration is generally low. On the contrary, magnesium concentration is generally high. Cation Exchange Capacity (CEC) is generally low but it is high in several locations. Base saturation is generally low. Although soil in study area is fertile, it still requires fertilizer containing nitrogen and phosphorus.

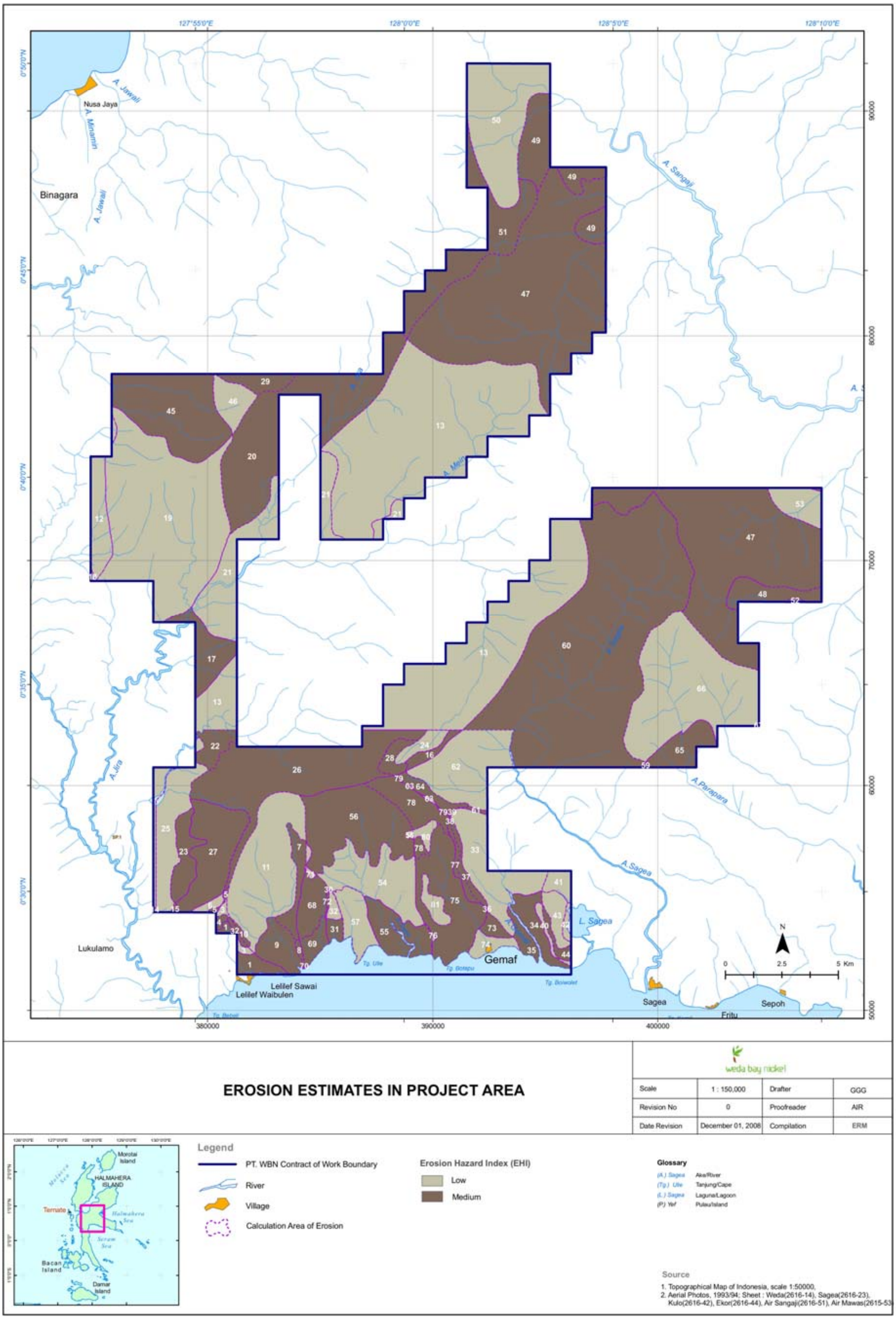

KAU BAY
BULI BAY
WEDA BAY
P. Pakai
SOILS
weda bay nickel
Scale 1 : 300,000
Drafter GGG
Revision No 2
Proofreader AIR
Date Revision December 01, 2008
Compilation ERM
Legend
ASF Fluventic Eutropepts Typic Rhodudalfs
ASS Fluventic Eutropepts Typic Troposaprist
AST Typic Halpudalfs Typic Dystropepts
ATR Typic Rhodudalfs Udic Halpustalfs
CTD Typic Halpudalfs
FLU Fluventic Dystropepts
FVC Fluventic Eutropepts
FVE Fluventic Eutropepts
LAG Lithic Argiustolls Lithic Troporthents
LIT Lithic Troporthents
TDY Typic Dystropepts
THS Typic Halpudalfs
TRH Typic Rhodudalfs
UDH Udic Halpustalfs
CTR Complex Typic Dystropepts Typic Eutropepts Typic rhodudalfs
PPL Tropoquepts Eutropepts Tropofluvents
FAG Tropaquepts Tropofluvents
ADS Rendolls Entropepts Tropudalfs
APR Rendolls Eutropepts Tropudalfs
AYT Rendolls Eutropepts Tropudalfs
BJB Dystropepts Tropudults Troporthents
BMI Haplorthox Acrorthox Dystropepts
BSR Tropudults Dystropepts
DTA Tropudults Dystropepts
GPA Dystropepts Troporthents Tropudults
GSI Dystropepts Eutropepts Tropudults
GSO Dystropepts Eutropepts
KCI Dystropepts Dystrandepts Tropudults
KJP Hydraquents Sulfaquents
KMM Humitropepts Dystropepts Tropaquods
KRI Eutropepts Tropaquepts Tropudalfs
KTA Dystropepts Dystrandepts Tropudults
MAR Rendolls Ustropepts Hapludolls
ORI Tropaquepts Fluvaquents
PTG Tropopsamments Tropaquepts
RBN Troporthents Tropudalfs Tropopsamments
SGM Troporthents Tropudults Dystropepts
SSR Rendolls Eutropepts Tropudalfs
SWA Rendolls Tropudalfs Eutropepts
THO Dystropepts Dystrandepts Tropaquepts
TMN Tropudults Tropudalfs Dystropepts Eutropepts
TNN Dystropepts Tropudults Troporthods
PT. WBN Contract of Work Boundary
River
Village
Source
1. Topographical Map of Indonesia, scale 1:50,000
2. Aerial Photos, 1993/94, Sheet : Weda (2616-14), Sagea (2616-23), Kulo (2616-42), Ekor (2616-44), Air Sangaji (2616-51), Air Mawas (2615-53)
3. Agency for Agricultural Research and Development, 1977

Map 7 Soils

8.2 *SOIL EROSION*

Rates of soil erosion were predicted using the USLE (Universal Soil Loss Equation) formula (Wishmeir and Smith, 1978). Rain erosivity is calculated using the formula from Bols (1978), and employing rainfall data from the three weather stations from 2004-2007. Soil erodibility is calculated using the formula from Wisch, Mayer and Smith (1978) that takes the following parameters into consideration: soil texture (very fine sand, silt, and clay), soil organic content, permeability and form and development of soil structure.

Slope length is measured from the top of the slope to a flattening of slope configuration where deposition could occur or where flow will enter drainage. Results of erosion calculations are illustrated in Map 8.



Map 8 Erosion Estimates in Project Area

Erosion threat is characterized by HEI (Hazard Erosion Index), which relies on the level of potential erosion (expected when land is cleared) and on the solum condition. HEI is provided by the Directorate General of Land Revegetation and Rehabilitation (1996), Department of Forestry of Indonesia. Based on calculations, erosion threat in 27% (14,647 ha) of the project area is considered to be low whilst the erosion threat in 73.31% (40,227 ha) of the project area was considered to be medium. The HEI results are provided in Appendix B-3. There are two solums in the project area (i.e. solum ranging in depth from 60 to 90 cm and solum deeper than 90 cm). In the solum with depth from 60 to 90 cm, the HEI ranges from 28 to 46 tons per year and is categorized as medium. HEI levels detected in solum deeper than 90 cm are considered low (from 15 to 38 ton per year).

9 HYDROLOGY

The main rivers in the WBN project area and the boundaries of their watersheds are shown on Map 9. The two major rivers draining the WBN project area are the Kobe River on the west side, and Sagea River on the east side. While both these rivers are located mainly outside the CoW boundary, major portions of the CoW are located within their watersheds. The headwaters of the watersheds are in the mountains to the north and flow to the south, southwest and southeast.

Sagea River Upstream

Kobe River Downstream

Figure 8 Sagea and Kobe River

The largest watershed is that of the Kobe River (64,135 ha), with the Jira, Seloi and Kulo Rivers as its main tributaries. The headwaters of the Seloi River are partly located within the Bukit Limber Barat Ore Deposit. This river has the most potential to be impacted by the initial mining activities. It flows to the southwest for about 10 km and joins the Jira River which then flows into the Kobe River.

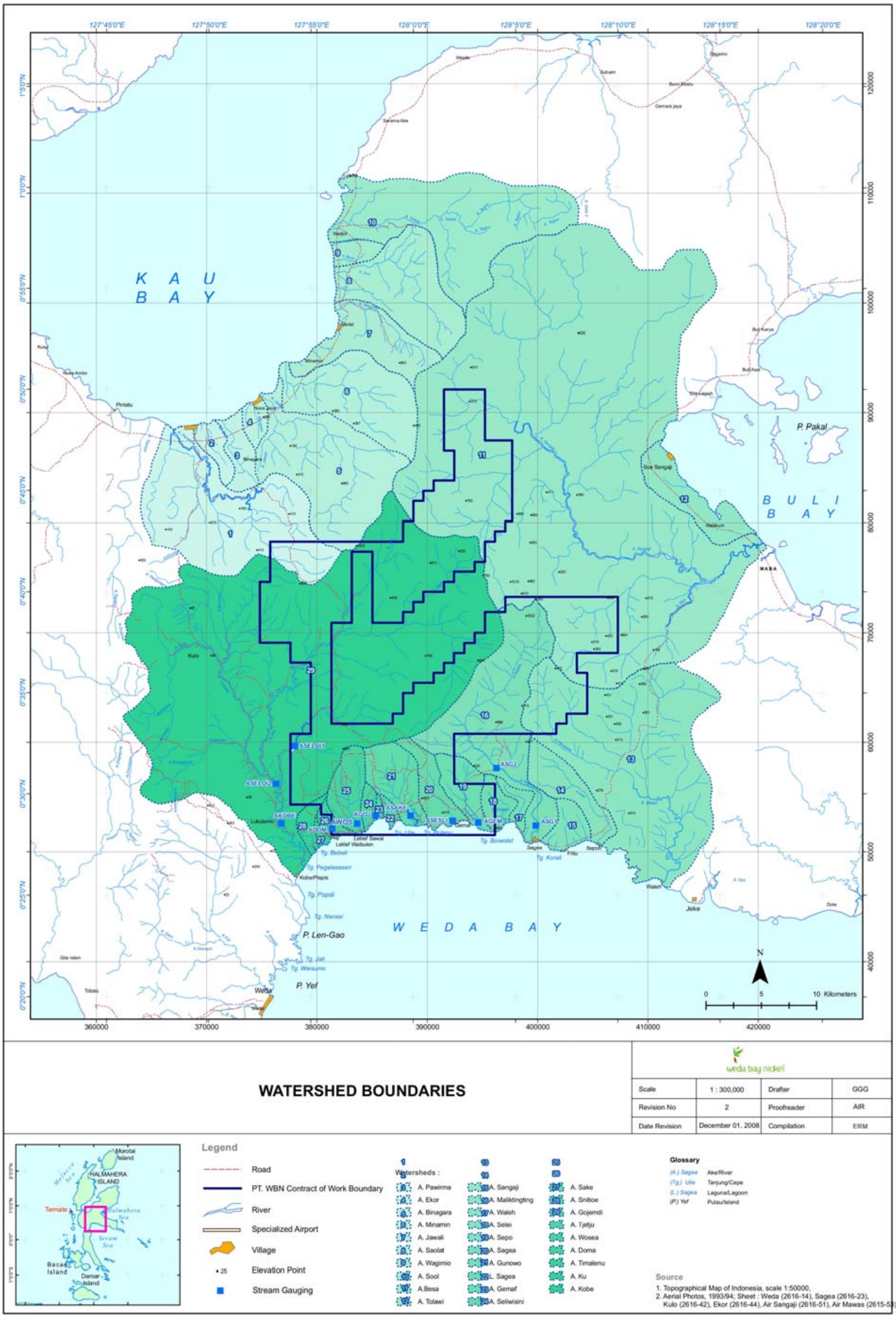
Another major watershed is drained by the Sagea River, with a catchment area of 10,938 ha. This river is located to the east of the project area; however, the Boki Mekot and Pintu ore deposits are located within its watershed. From its headwaters, the Sagea River flows southwest for about 15 km, turns to the south east and then south, flowing underground for several kilometers. The Sagea estuary borders Sagea Village on the western side.

Smaller watersheds in the project area are drained by the Doma, Wosea, Tjetju, Gowomdi, Sake, Sesliwisini, and Gemaf Rivers, which all flow into Weda Bay. The spring fed Sagea Lagoon also has an outlet stream that flows south to Weda Bay.

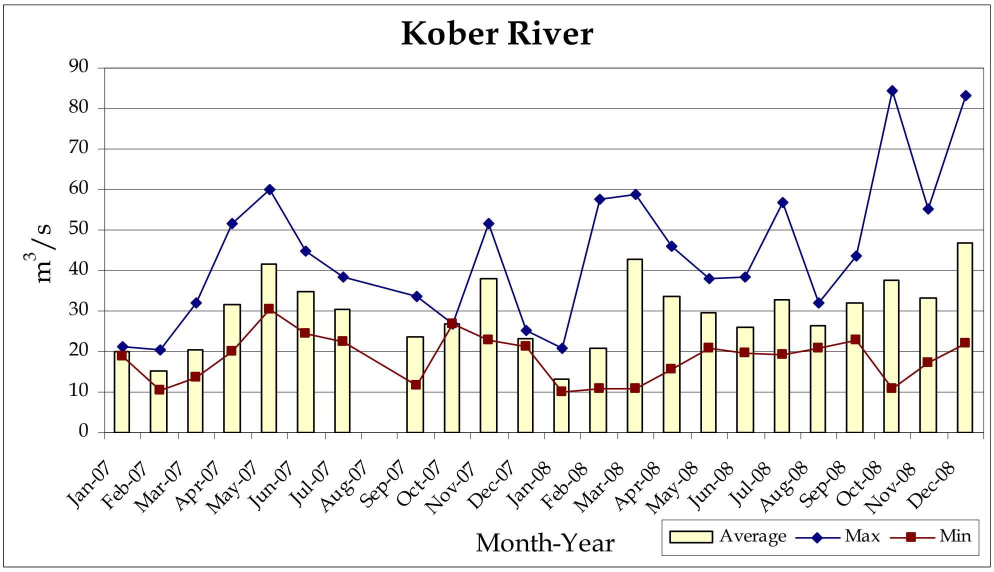
Stream gauging conducted at nine rivers in the project area in December 2006 indicates that the two largest rivers (Kobe and Sagea) had discharge rates of 22.1m^3/s and 9.3 m^3/s, respectively. The other seven small watersheds had discharge rates ranging from 0.01 to 0.75 m^3/s. Gauging locations are shown on Map 9**.**

Stream gauging weekly measurements on Kobe, Seloi, Wosea, Sagea, Sake and Gemaf Rivers carried out continuously since 2007. Results of stream gauging, converted to discharge rates, are shown in ***Figure 9*****.**

This graph shows the seasonal variation of water discharge between June and September. The seasonal variation of water is in line with monthly average rainfall during June to September in the project area**.**



Map 9 Watershed Boundaries


Kober River
m3/s
90
80
70
60
50
40
30
20
10
0
Jan-07
Feb-07
Mar-07
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May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
Mar-08
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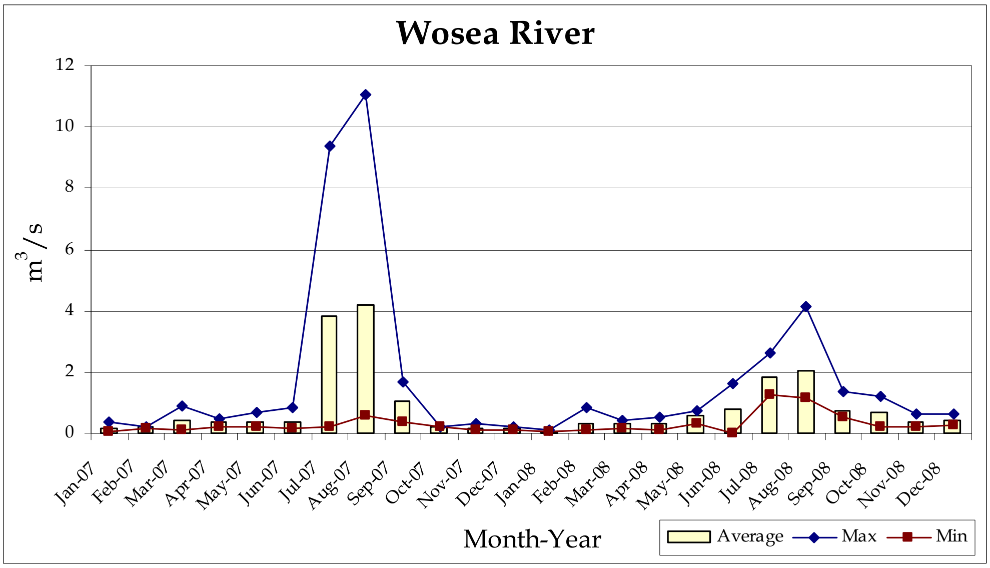
Month-Year
Average
Max
Min


Wosea River
m3/s
12
10
8
6
4
2
0
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
Mar-08
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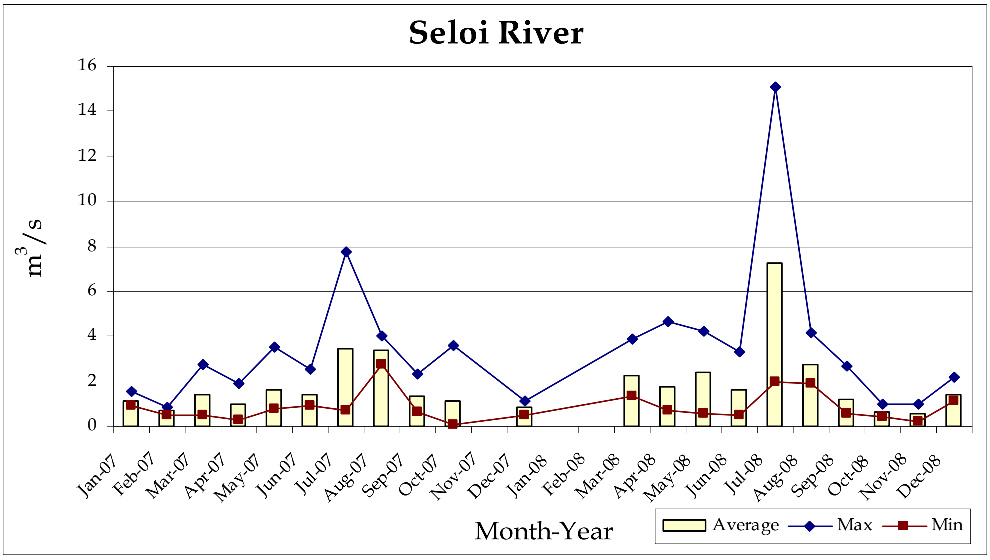
Month-Year
Average
Max
Min


Seloi River
m3/s
16
14
12
10
8
6
4
2
0
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
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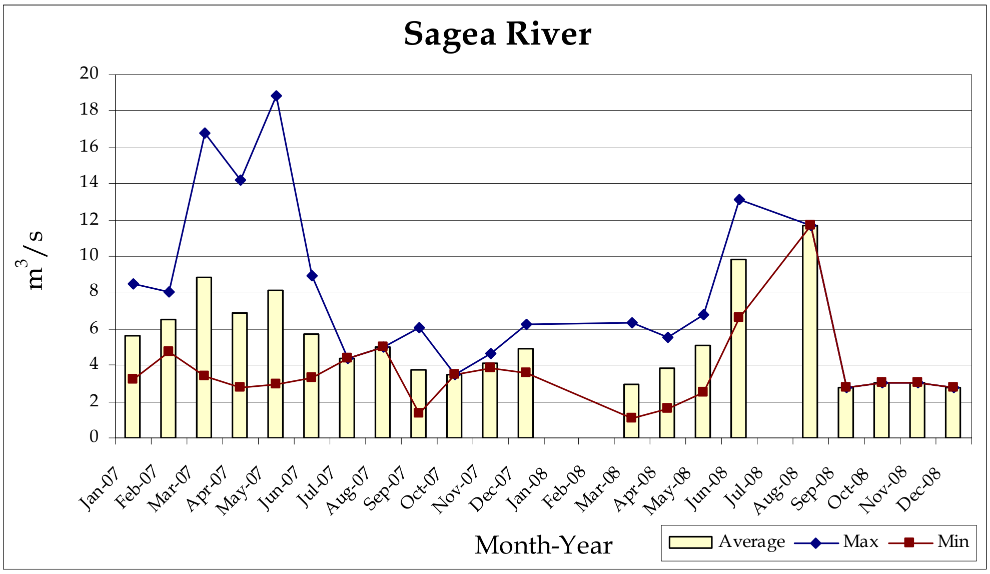
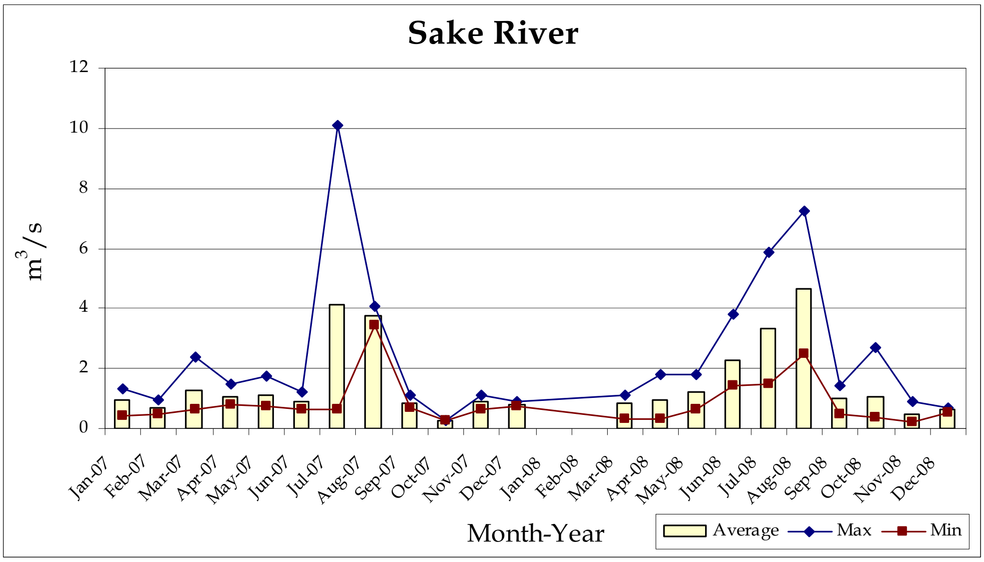
Month-Year
Average
Max
Min





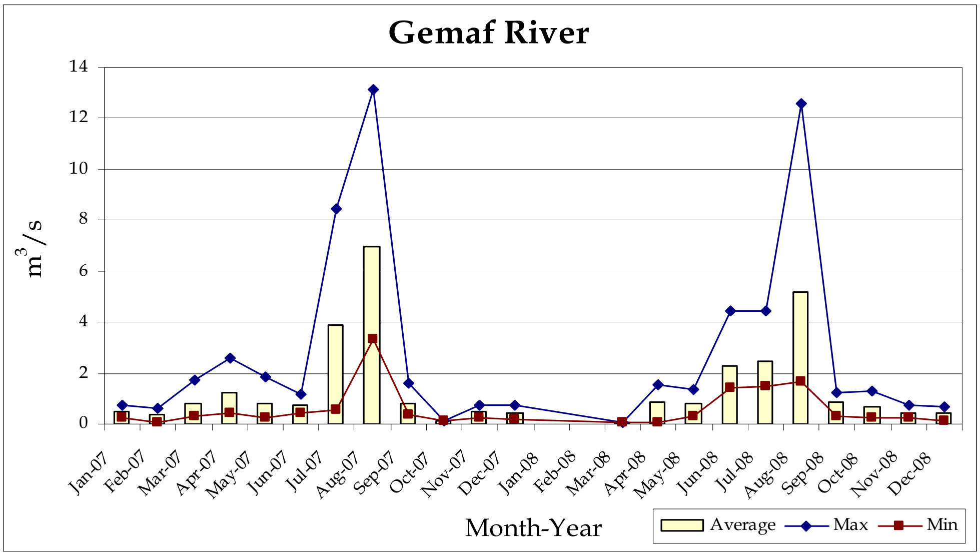


Figure 9 ***Seasonal variation of water discharge in Kobe, Seloi, Wosea, Sagea, Sake and Gemaf Rivers***

10 HYDROGEOLOGY

Hydrogeological conditions in the Weda Bay study area are summarized on Map 10. As illustrated, the upland areas are generally not prospective for development of groundwater supplies. Moderately productive aquifers underlie the alluvial plains of the major rivers and small areas of the coastal plain.

10.1 GROUND WATER LEVELS

The depth to ground water measured from piezometers (SM 008 and SM 115) installed in a highland area (Bukit Limber) over six months in 2008 are presented in Figure 10 and Figure 11. Groundwater depths for two coastal areas (HG 008 and HG 028) are shown in Figure 12 and Figure 13. Locations of these piezometers are shown on Map 11.

At Bukit Limber, at an elevation about 1,006 m, the depth to the water table in Piezometer SM 008 (Figure 10) fluctuated between 13 m and 36 m. At Piezometer SM 115, at an elevation of about 930 m, the water level fluctuated between depths of 10 m and 34 m (Figure 11).

By contrast, in coastal areas the water table is much closer to the ground surface, varying from 0.3 m to 1.4 m in HG 008 (Figure 12), and from 0 to 0.7 m at HG 028 (Figure 13).

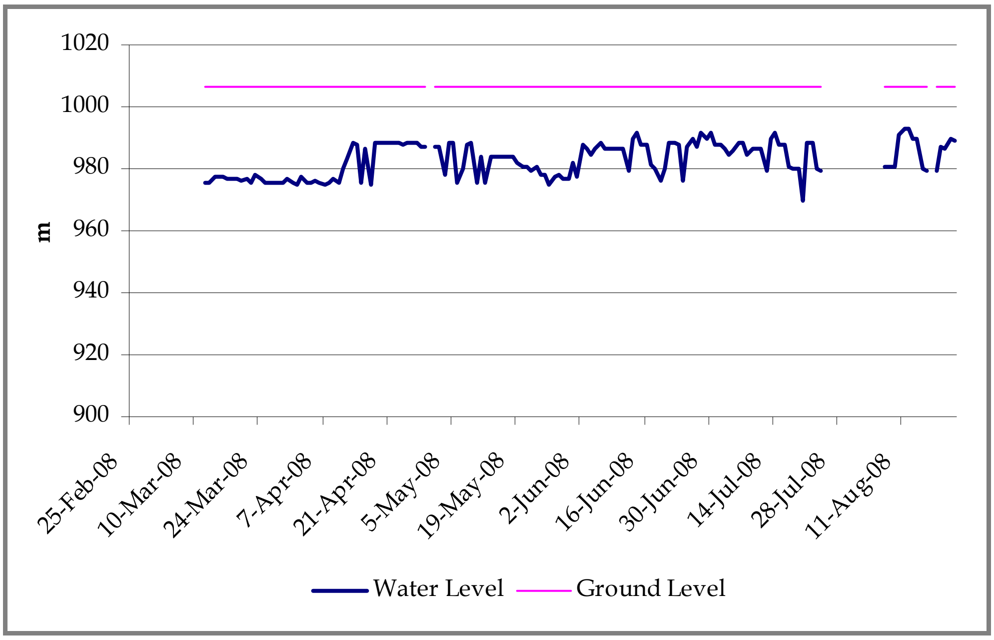


Figure 10 Water Level in Bukit Limber Piezometer, SM 008

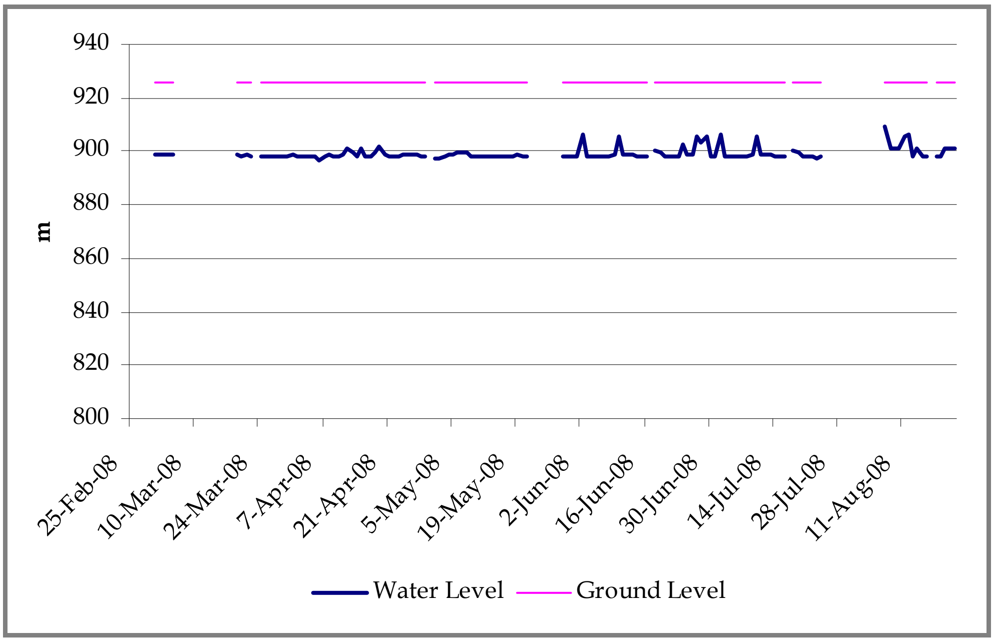


Figure 11 ***Water Level in Bukit Limber Piezometer, SM 115***

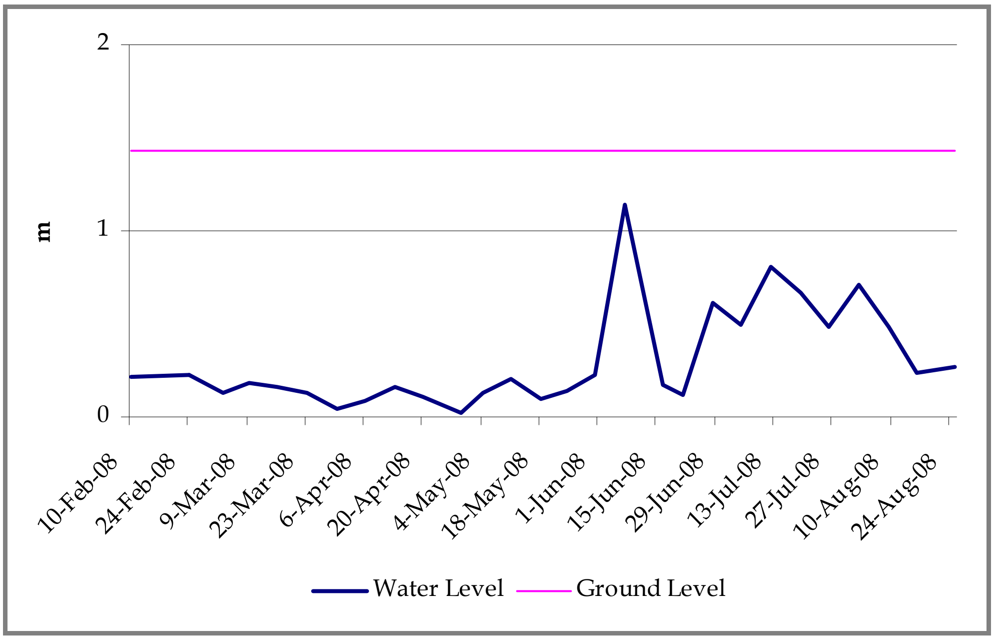


Figure 12 ***Water Level in Coastal Area, Piezometer HG 008***

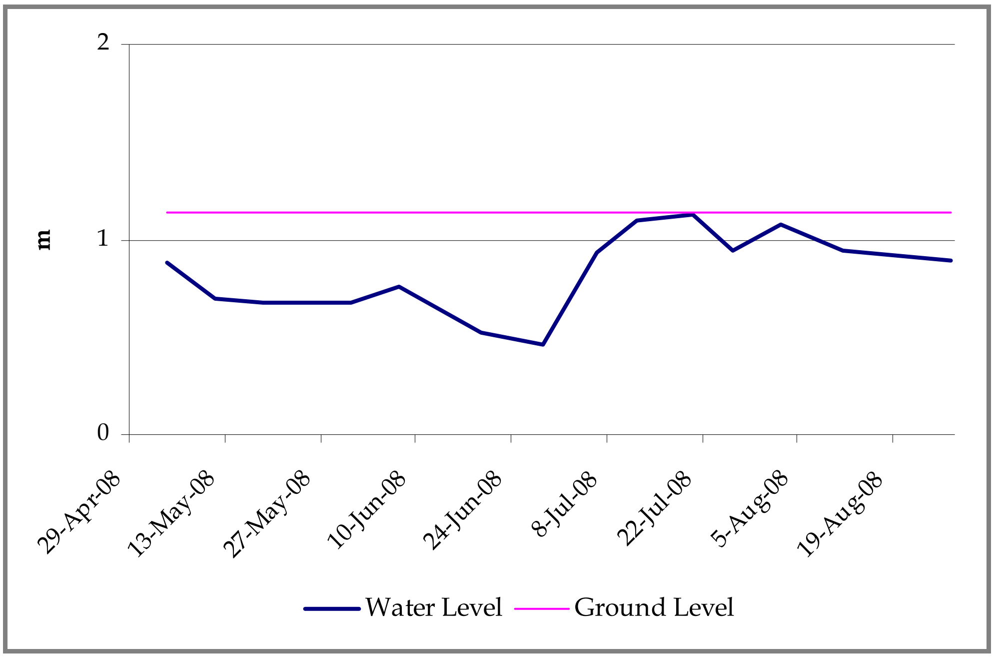


Figure 13 Water Level in Coastal Area, Piezometer HG 028

10.2 *GROUND WATER QUALITY*

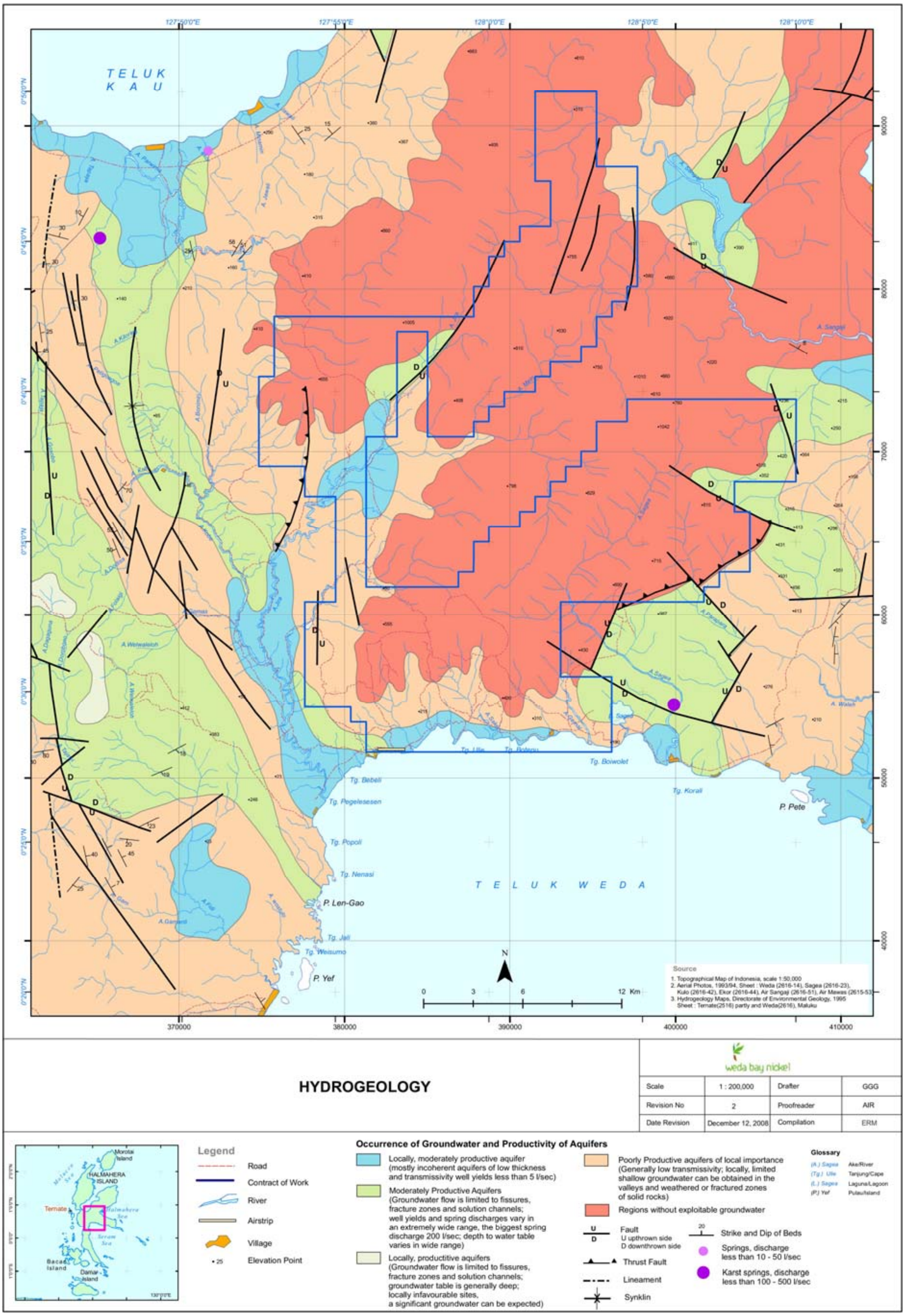
Ground water quality samples in the project area were taken in December 2008, representing highland and lowland areas. Sampling locations are shown in Map 11 and the analytical results of the water samples are shown Table 5.

Table 5 Analytical Results of Groundwater Samples

Parameter	Unit	Sample										HM Reg. No 416 of 1990
		GA - 08	SM - 008	SM - 1148	HG - 04	PPG - 001	HG - 003	HG - 008	GA - 05	GA - 01	GA - 04	
		13-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	15-Dec-08	16-Dec-08	16-Dec-08	
		Proposed RSF Site	Bukit Limber	Bukit Limber	Plant Site	Coastal Deposit Site	Plant Site	Plant Site	Proposed RSF Site	Proposed RSF Site	Proposed RSF Site	
Water Level	m	1.22	19.78	25.6	2.1	11.7	0.54	1.22	4.2	1	8	NA
Physical Tests												
pH		7.9	7	7.4	7.9	7.7	8.3	7.7	8.3	6.3	6.4	6.5 - 9
Conductivity	μS/cm	216	70.6	137	73	317	290	9560	239	89	59.9	NA
Total Dissolved Solids, TDS	mg/L	210	40	90	490	183	236	5670	190	52	47	1,000
Total Suspended Solids, TSS	mg/L	3	131	-	31	129	29	21	62	45	840	NA
Anions												
Chloride, Cl^-	mg/L	1.7	1.3	3.3	7.2	7.1	2.2	3250	2.2	1.0	1.7	600
Fluoride, F	mg/L	0.04	< 0.02	0.03	0.12	< 0.02	< 0.02	< 0.02	0.08	0.04	0.04	1.5
Sulphate, $SO_4{}^{2-}$	mg/L	< 2	< 2	11	< 2	< 2	< 2	351	3	< 2	< 2	400
Sulphide as H_2S	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	NA
Total Cyanide, CN	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.1
Nutrients												
Ammonia, NH_3-N	mg/L	0.06	0.04	0.09	1.35	0.20	0.08	0.21	0.08	0.04	0.04	NA
Total Phosphate as P	mg/L	0.039	0.024	0.037	0.061	0.007	0.015	0.058	0.027	0.064	0.079	NA
Dissolved Metals												
Arsenic, As	mg/L	< 0.0005	< 0.0005	< 0.0005	0.0008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.05
Barium, Ba	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NA
Boron, B*	mg/L	0.2	0.3	0.2	0.6	0.1	< 0.1	0.5	0.7	0.2	0.3	NA
Cadmium, Cd	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005

Parameter	Unit	Sample										HM Reg. No 416 of 1990
		GA - 08	SM - 008	SM - 1148	HG - 04	PPG - 001	HG - 003	HG - 008	GA - 05	GA - 01	GA - 04	
		13-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	14-Dec-08	15-Dec-08	16-Dec-08	16-Dec-08	
		Proposed RSF Site	Bukit Limber	Bukit Limber	Plant Site	Coastal Deposit Site	Plant Site	Plant Site	Proposed RSF Site	Proposed RSF Site	Proposed RSF Site	
Chromium Hexavalent, Cr^{6+}	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.05
Cobalt, Co	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	NA
Copper, Cu	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NA
Iron, Fe	mg/L	0.40	0.11	0.18	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1
Lead, Pb	mg/L	-	< 0.001	< 0.001	0.005	< 0.001	< 0.001	0.004	< 0.001	< 0.001	< 0.001	0.05
Manganese, Mn	mg/L	0.08	< 0.01	< 0.01	0.04	0.02	< 0.01	0.20	< 0.01	0.04	0.02	NA
Mercury, Hg	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00006	0.00010	< 0.00005	< 0.00005	< 0.00005	0.001
Selenium, Se	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.01
Zinc, Zn	mg/L	0.015	0.014	0.013	0.013	0.010	0.007	0.015	0.008	0.014	0.013	15
Miscellaneous												
COD	mg/L	11	< 2	4	7	< 2	< 2	6	3	< 2	< 2	NA
Oil & Grease	mg/L	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	NA
Total Phenol*	mg/L	0.004	0.003	0.005	0.003	0.003	0.003	0.004	0.003	0.005	0.002	NA

Source : Analytical Results, Intertek (http://www.intertek-cb.com/asiapacific/indonesia.shtml); KAN-accredited laboratory.
Analysis of samples done in accordance with standard methods from the American Public Health Association (APHA).



Map 10 Hydrogeology

A. Physical Characteristics

Most of the TDS results of all the groundwater samples were found to be less than 500 mg/L (threshold limit is 1000 mg/L), with the exception of groundwater sample from HG008, which was reported to be 5,670mg/L. This can probably be attributed to the proximity of this monitoring well to the sea shore and intruded by sea water as indicated by high conductivity (9,560 µmhos), chloride (3,250mg/L) and sulphate (351 mg/L).

Most of the TSS results of all the groundwater samples were found to be less than 100 mg/L, with the exception of groundwater samples from SM08, PPG01 andGA04, which were reported to be 131, 129 and 840 mg/L, respectively. TSS concentration for clean water is not regulated in Minister of Health Regulation No. 416 Year 1990 Appendix II.

pH of all groundwater samples was found ranging from 6.3 to 8.3. Allowable limit of pH for clean water source in accordance with Minister of Health Regulation No. 416 Year 1990 is 6.5 – 9.0. Two groundwater sampling locations (GA01 and GA04) at proposed RSF site showed values lower than 6.5.

B. Anions

Most of the chloride concentration in the groundwater samples range from 1 to 7.2 mg/L, except for the groundwater sample from HG008, which was reported to be 3,250 mg/L. This can probably be attributed to the proximity of this monitoring well to the sea shore. The concentrations of fluoride, sulphate, sulphide and total cyanide in all the groundwater samples were in compliance with Minister of Health Regulation No. 416 Year 1990.

C. Nutrients

Minister of Health Regulation No. 416 Year 1990 does not regulate concentrations of total phosphate in water. Total phosphorous in all the groundwater samples ranged from 0.007 to 0.079 mg/L. Most of the ammonia concentrations in the groundwater samples were within clean water standard of Minister of Health Regulation No. 416 Year 1990, except for the groundwater sample from HG004, which was reported to be 1.35 mg/L.

D. Dissolved Metals

The concentrations of As, Ba, B, Cd, Cr(VI), Co, Cu, Mn, Fe, Hg, Se and Zn in all the groundwater samples were within the clean water standard as of Minister of Health Regulation No. 416 Year 1990. Pb concentrations in all the groundwater samples were within the clean water standard, except for the groundwater sample from GA08, with Pb concentration of 0.147 mg/L (threshold limit: 0.05 mg/L). There is no direct explanation for this elevated baseline data.

E. Organics

COD, phenol and oil & grease are not regulated in Minister of Health Regulation No. 416 Year 1990. COD concentrations in all the groundwater samples were ranged from < 2 to 11 mg/L, phenol ranged from 0.002 to 0.005 mg/L and oil and grease was detected at concentrations less than 1 mg/L.

10.3 COMMUNITY SHALLOW GROUNDWATER WELLS

Six community shallow groundwater well samples were collected from four villages in WBN project area and vicinity. The villages were Sagea, Gemaf, Lelilef Sawai, Lelilef Waibulen, Kobe Peplis and Transmigration Unit. The shallow groundwater wells were used by people in the villages for daily needs including drinking and cooking therefore the analytical results of the samples were compared with Minister of Health Regulation No. 416 of 1990 regarding water quality requirements as clean water.

During community groundwater wells sampling, some parameters were recorded as shown in **Table 6** and complete analytical results are shown in **Table 7** With the exception of Gemaf Village, the distance between the sampled wells and septic tanks is greater than 15 meters, which fulfills the sanitation standard. Sanitation around the wells was observed to be fair. All groundwater wells were observed clear with no odor and taste. Depth to water table was ranging from 0.12 to 1.05 m having water layer ranging from 1 to 2.3 m. Well water by the community is used as drinking, washing and bathing water source.

A. Physical Characteristics

Field measurements showed that pH of the wells water ranged from 6.7 and 7.8, which were in compliance with the pH's requirement for clean water as stated in Minister of Health Decree No. 416 Year 1990 Appendix II. Electrical conductivity (EC) was detected ranging from 254 to 994 μmhos/cm and total dissolved solid (TDS) from 256 to 2,005 mg/L. These two parameters correlate positively one to the other; looking at the values of these parameters, groundwater wells in the coastal villages were slightly influenced by seawater. The intrusive of salt water was indicated by high TDS in the well of Kobe Peplis Village. Slightly elevated TDS in well water at the Transmigration Unit was mainly due to bicarbonate and magnesium content. The clarity of the water in all wells was good indicated by low values of TSS, turbidity and color.

Table 6 Community Shallow Ground Water Quality Field Data

Location	*Sagea Village*		*Gemaf Village*		*Lelilef Sawai Village*		*Lelilef Waibulen Village*		*Kobe Peplis Village*	*Transmigration Unit (SP 3)*
Sample Code	SGL		GML		SWL		WBL		KPL	SP-3
Sampling Date	***2-Aug-07***	28-Dec-06	***2-Aug-07***	28-Dec-06	3-Aug-07	1-Aug-07	28-Dec-06	2-Aug-07	29-Dec-06	6-Aug-08
Sampling Time	***9:45***	10:40	14:15	14:05	8:05	17:00	17:45	6:11	17:15	10:40
Easting	***399466***	399474	392305	392314	381754	377585	381754	381039	381035	374905
Northing	***51119***	51121	52744	52744	51864	47441	51864	51559	51571	60677
Weather	***Cloudy***	Drizzling	Cloudy/ Rainy	Cloudy	Partly Cloudy	Cloudy/ Rainy	Rainy	Cloudy/ Rainy	Rainy	Cloudy
Surrounding Area	***Settlement***	Residential	Settlement/ Husbandry	Residential	Settlement/ Farmland	Settlement	Residential	Settlement/ Farmland	Residential	Settlement
Distance to Septic Tank (m)	***20***	25	10	15	30	15	30	-	-	-
Sanitation	***Good***	Fair	Fair	Good	Fair	Fair	Fair	Fair	Good	Good
Well Casing	***Concrete***	Drum	Concrete	Concrete	Drum	Concrete	Drum	Concrete	Concrete	Concrete
Water Table (m)	***0.5***	1.05	1.2	1.93	0.8	0.12	1.4	0.72	1.73	1.10
Water Usage	***1,2,3***	1,2,3	2,3	2,3	1,2,3	2,3	1,2,3	1,2,3	1,2,3	1,2,3
Air Temperature (°C)	***26.8***	27.8	27.3	31.7	25.4	27.8	28	27.2	28.2	29
Water Temperature (°C)	***27.2***	28	27.2	29.2	24.2	27.9	28.9	26.4	28.3	26.5
Conductivity (µmhos/cm)	***746***	760	254	638	412	994	467	964	874	950
Total Dissolved Solids/ TDS (mg/L)	***350***	365	256	304	192	2005	221	467	424	499
pH	***7.51***	6.89	7.50	6.72	7.34	7.02	6.87	7.10	6.66	7.30
Dissolved Oxygen/ DO (mg/L)	***3.4***	2.1	4.2	2.4	3.1	7.6	2.0	2.4	2.2	2.2
Taste	***No Taste***	No Taste	No Taste	No Taste	No Taste	No Taste	No Taste	No Taste	No Taste	No Taste
Smell	***No Smell***	No Smell	No Smell	No Smell	No Smell	No Smell	No Smell	No Smell	No Smell	No Smell

Source : Analytical Results, ALS ; KAN-accredited laboratory.
Analysis of samples done in accordance with standard methods from the American Public Health Association (APHA).

Table 7 Shallow Ground Water Well Analytical Results

Location	Unit	Lelilef Waibulen Village		Lelilef Sawai Village		Sagea Village		Gemaf Village		Kobe Peplis Village	Transmigration Unit (SP-3)	Minister of Health Decree No. 416 of 1990, Clean Water
Date Sampled		Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Aug-08	
Laboratory		ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	Intertek	
Physical Tests												
Colour	TCU	6	<5	6	<5	<5	<5	<5	<5	13	-	50
Hardness Total	mg/L	474	392	474	216	279	300	261	328	402	-	500
pH	-	7.1	7.2	7.3	7.1	7.5	7.3	7.5	7.1	7.0	7.8	6.5-9.0
Total Dissolved Solids (TDS)	mg/L	467	560	192	268	350	386	256	360	2005	499	1500
Total Suspended Solids (TSS)	mg/L	2	3	<1	1	<1	2	<1	1	6	-	50
Turbidity	NTU	4.8	5.3	0.9	1.8	2.9	1.4	0.2	1.4	7.5	-	25
Dissolved Anions												
Alkalinity ($CaCO_3$)	mg/L	459	427	128	189	262	264	242	318	535	480	-
Alkalinity-Bicarbonate ($CaCO_3$)	mg/L	459	427	128	189	262	264	242	318	535	480	-
Alkalinity-Carbonate ($CaCO_3$)	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Chloride (Cl^-)	mg/L	23.1	14.3	11.5	11.7	24.4	35.3	9.3	4.6	283.9	13.5	600
Fluoride (F^-)	mg/L	0.12	0.19	0.08	0.25	0.05	0.08	0.15	0.21	0.37	<0.02	1.5
Free Chlorine (Cl_2)	mg/L	0.01	0.02	0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	-	-
Silica (Si)	mg/L	38	28	36	28	30	21	32	21	10	-	-
Sulphate ($SO4^{2-}$)	mg/L	2	<2	14	13	26	24	47	9	47	7	400
Sulphide (H_2S)	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-
Nutrients												
Total Ammonia (T-NH_3)	mg/L	0.05	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	0.22	<0.02	-
Nitrate (N-NO_3)	mg/L	0.029	<0.005	0.82	2.16	6.47	6.8	1.6	<0.005	0.144	0.136	10
Nitrite (N-NO_2)	mg/L	<0.001	<0.001	0.001	0.004	0.02	0.003	<0.001	<0.001	0.028	<0.001	1
Total Phosphorous (T-PO_4)	mg/L	0.356	0.083	0.035	0.062	0.068	0.026	0.032	0.129	0.023	0.028	-
Total Nitrogen (TKN+NO_3+NO_2)	mg/L	0.25	0.08	1.02	2.374	6.55	6.8	1.6	<0.05	0.67	0.26	-

Location	Unit	Lelilef Waibulen Village		Lelilef Sawai Village		Sagea Village		Gemaf Village		Kobe Peplis Village	Transmigration Unit (SP-3)	Minister of Health Decree No. 416 of 1990, Clean Water
Date Sampled		Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Aug-08	
Laboratory		ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	Intertek	
Ortho Phosphate	mg/L	-	<0.005	-	0.005	-	0.010	-	0.020	-	0.015	-
Total Kjeldahl Nitrogen (TKN)	mg/L	0.22	0.08	0.2	0.21	0.06	<0.05	<0.05	<0.05	0.5	0.12	-
Total Cyanide	mg/L	<0.005	-	<0.005	-	<0.005	-	<0.005	-	<0.005	<0.005	
Dissolved/ Total Metals												
Aluminium (Al)	mg/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.02	-
Arsenic (As)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005	0.05
Barium (Ba)	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.1	-
Boron (B)	mg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.1	-
Cadmium (Cd)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005
Calcium (Ca)	mg/L	66.5	58.3	10.3	22.9	61.7	54.5	42.7	54.6	46.1	9.0	-
Chromium (Cr)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Chromium (Cr6+)		-	-	-	-	-	-	-	-	-	<0.002	0.05
Cobalt (Co)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Copper (Cu)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Iron (Fe)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1
Lead (Pb)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	0.05
Magnesium (Mg)	mg/L	74.8	56	28.3	35.7	30.4	34.9	37.6	41.4	69.7	120	-
Manganese (Mn)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.5
Mercury (Hg)	mg/L	0.0001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.0002	0.00006	0.001
Nickel (Ni)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Potassium (K)	mg/L	3.53	5.76	1.69	0.58	14	14.5	0.85	0.46	20.1	0.15	-
Selenium (Se)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	0.01
Sodium (Na)	mg/L	15.0	30.5	19.8	8.04	30.3	30.8	11.8	7.2	268	7.8	-
Zinc (Zn)	mg/L	<0.005	0.007	0.074	<0.005	0.005	<0.005	<0.005	0.007	<0.005	<0.005	15
Bacteriology*												
Total Coliform Bacteria	MPN/100	50	276	517	816	>2420	>2420	>2420	186	435	>2420	50

Location	Unit	Lelilef Waibulen Village		Lelilef Sawai Village		Sagea Village		Gemaf Village		Kobe Peplis Village	Transmigration Unit (SP-3)	Minister of Health Decree No. 416 of 1990, Clean Water
Date Sampled		Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Dec-06	Aug-07	Aug-08	
Laboratory		ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	Intertek	
	ml											
E.coli Bacteria	MPN/100 ml	1	3	66	2	1	29	1733	6	18	186	-
Organics												
Biochemical Oxygen Demand (BOD_5)	mg/L	0.55	<5	0.55	<5	0.75	<5	0.75	<5	2.11	<2	-
$KMnO_4$	mg/L	<1	-	<1	-	<1	-	<1	-	<1	-	
Phenols	mg/L	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	-
Surfactants (MBAS)	mg/L	0.03	0.02	0.08	0.09	0.11	0.25	0.06	0.06	0.15	0.03	0.5
Total Organic Carbons	mg/L	8.5	1.9	3.4	2.8	3.4	4.6	4.7	5.4	9.8	-	-
Dissolved Organic Carbons	mg/L	8.3	-	3	-	3.3	-	4.3	-	7.8	-	-

Source : Analytical Results, ALS Indonesia (2006 and 2007); Intertek (http://www.intertek-cb.com/asiapacific/indonesia.shtml); KAN-accredited laboratories.
Analysis of samples done in accordance with standard methods from the American Public Health Association (APHA).

Remarks:
- Results are expressed as milligrams per liter except where noted.
- Maximum quantifiable limit for coliforms is 2420 MPN.
- ND Not detected ND, Blank space Not analyzed, > : greater than
- Value in red color is the value that exceeds the standard threshold

B. Major Anions and Cations

Water hardness in all wells was high ranging from 261 to 474 mg/L equivalent $CaCO_3$, and is considered as "very hard water". The dominant cation and anion in all community groundwater wells were calcium and bicarbonate, respectively; except for Kobe Peplis Village and Transmigration Unit. The dominant ions in Kobe Peplis were Na and Cl (as indication of sea water influence) and for Transmigration Unit (SP 3) was magnesium and bicarbonate.

Fluoride was detected in all wells with very low concentration ranging from 0.05 to 0.37 mg/L. Suphide was detected ranging from <0.002 to 0.03 mg/L (no standard for Sulphide). Chlorine was detected ranging from <0.01 to 0.01 mg/L. Nitrate and Nitrite was detected ranging from 0.029 to 6.47 mg/L and from <0.001 to 0.028 mg/L, respectively. All these anions concentrations met with the standard required as stated in Minister of Health Regulation No. 416 Year 1990 Appendix II regarding Requirements List of Clean Water Quality.

C. Dissolved Metals

Dissolved metals Al, As, Ba, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, and Se were generally not detected in all sampling sites. Mercury was detected in Lelilef Woebulen and Kobe Peplis wells with very low concentration (0.00010 and 0.00020 mg/L), which was close detection limit (0.00005 mg/L). Zinc in all wells was not detected, except in Lelilef Sawai well with very low concentration of 0.074 mg/L.

D. Organics

Phenol was not detected in all wells. Surfactant (MBAS) was detected ranging from 0.03–0.15 mg/L. The main source of surfactant in those wells is detergent used by the well owners for washing utensils and clothes near the wells. Total organic carbon (TOC) and dissolved organic carbon (DOC) were detected in all wells with low concentration ranging from 3.4 and 9.8 mg/L and 3 to 8.3 mg/L, respectively. In general, the TOC concentrations in August 2007 were slightly higher than the results in December 2006 sampling program.

E. Bacteriology

Total coliform and *E. coli* bacteria were detected in all wells ranging from 50 to >2420 MPN/mL and from 1 – 1733 MPN/100mL respectively. The highest total coliform and *E. coli* content were detected at Sagea and Gemaf Village wells; coincidently these wells also had an elevated concentration of surfactant, TOC and DOC indicated these wells were slightly contaminated by organic matters from domestic activities compared with other wells.

11 QUALITY OF SURFACE WATER AND STREAM-BED SEDIMENT

Seventeen surface water quality and sediment sampling sites were established on 12 rivers and streams within the study area (Cetral Halmahera and East Halmahera Regencies), as shown on Map 11 and on Table 8. Water quality samples were taken in March 2006, December 2006, August 2007 and August 2008; stream bed sediment was taken in 2001, March 2006, December 2006, August 2007 and August 2008.

Table 8 Surface Water Quality and Sediment Sampling Locations

Location	Location Code	Regency	Coordinates (UTM)	
			East Longitude	North Latitude
Seloi Upstream	ASELOI2	Halmahera Tengah	377028	60148
Seloi Downstream	ASELOI1	Halmahera Tengah	376332	56227
Bukit Limber	ASM	Halmahera Tengah	386744	60688
Gemaf	AGEM	Halmahera Tengah	394634	52717
Sagea Downstream	ASG1	Halmahera Tengah	399824	52431
Seslewesini	ASESLI	Halmahera Tengah	392290	52880
Sake	ASAKE	Halmahera Tengah	388124	53374
Gowomdi	AGOM	Halmahera Tengah	385316	53373
Wosea	AWOS	Halmahera Tengah	383395	52593
Kobe	AKOBE	Halmahera Tengah	376768	52631
Doma	ADOM	Halmahera Tengah	381377	52152
Sagea Upstream	ASG2	Halmahera Tengah	396276	57635
Jira Upstream	Ajira3	Halmahera Tengah	376177	56199
Jira Middle	Ajira2	Halmahera Tengah	377599	60186
Jira Downstream	Ajira1	Halmahera Tengah	376892	65157
Sangaji Upstream	ASJ1	Halmahera Timur	401426	86105
Sangaji Downstream	ASJ2	Halmahera Timur	415408	74808

11.1 SURFACE WATER

Field condition observation of the sampling locations during sampling campaigns in July-August 2007 and August 2008 are shown in Table 9. Most of sampling sites are surrounded by forest area and/or farmland, only several sampling sites are adjacent to residential area.

Most of river's flow at the sampling sites was turbulent, with flow velocity ranging from fast to slow, except Ake Seloi was stagnant. Generally, bottom substrate of streams and rivers at the sampling sites composed of a combination of sand, gravel and stone (see Table 9). All of surface water sampling sites were identified as continuous water flowing river; and most of the rivers were clear water, with very low turbidity. Turbid water was only observed at Ake Bukit Limber (in August 2007) and Ake Kobe.

Table 9 Water and Sediment sampling location condition during sampling campaign in August 2007 and August 2008

Location	Date	Location Code	Weather Condition	Surrounding Environment	Bottom Substrate	Type of River	Water Flow	Water Appearance
Ake Seloi Upstream	31-Jul-07	ASELOI2	Cloudy	Forest	Sand/Gravel/Stone	Continuous	Turbulent/Fast	Clear
Ake Seloi Down Stream	31-Jul-07	ASELOI1	Cloudy	Settlement/ Forest	Sand/ Gravel	Continuous	Stagnant/Slow	Clear
Ake Bukit Limber	1-Aug-07	ASM	Cloudy	Forest	Stone	Continuous	Turbulent/Fast	Turbid
Ake Gemaf	2-Aug-07	AGEM	Cloudy	Farmland	Sand/Gravel/Stone	Continuous	Turbulent/Fast	Clear
Ake Sagea Downstream	2-Aug-07	ASG1	Cloudy/Rain	Forest	Gravel/Stone	Continuous	Turbulent/Slow	Clear
Ake Seslewesini	2-Aug-07	ASESLI	Cloudy/Rain	Settlement/Farmland	Sand/Gravel/Stone	Continuous	Turbulent/Fast	Clear
Ake Sake	2-Aug-07	ASAKE	Cloudy	Farmland	Sand/Gravel/Stone	Continuous	Turbulent/Fast	Clear
Ake Gowomdi	2-Aug-07	AGOM	Cloudy	Forest	Sand/Gravel/Stone	Continuous	Turbulent/Fast	Clear
Ake Wosea	2-Aug-07	AWOS	Cloudy/Rain	Farmland/ Forest	Sand/Gravel/Stone	Continuous	Turbulent/Fast	Clear
Ake Kobe	2-Aug-07	AKOBE	Cloudy	Settlement/Farmland	Stone	Continuous	Turbulent/Fast	Turbid
Ake Doma	2-Aug-07	ADOM	Cloudy	Settlement	Sand/ Gravel/ Stone	Continuous	Turbulent/Slow	Clear
Ake Sagea Upstream	3-Aug-07	ASG2	Partly Cloudy	Forest	Sand/Gravel/Stone	Continuous	Turbulent/Fast	Clear
Sangaji Upstream	5-Aug-08	ASJ1	Sunny	Forest	Sand/Gravel/Stone	Continuous	Turbulent/Slow	Clear
Sangaji Downstream	5-Aug-08	ASJ2	Sunny	Forest	Sand/Gravel/Stone	Continuous	Turbulent/Slow	Clear
Jira Upstream	1-Aug-08	AJIRA3	Cloudy	Forest	Mud	Continuous	Turbulent/Slow	Clear
Jira Middle	31-July-08	AJIRA2	Rain	Forest	Gravel	Continuous	Turbulent/Fast	Clear
Jira Downstream	1-Aug-08	AJIRA1	Sunny	Forest	Sand/gravel	Continuous	Turbulent/Fast	Clear

Notes: (1) Sediment sampling locations correspond to water sampling locations

Table 10 Surface Water Field Parameter

Location	*pH*				*DO (mg/L)*				*Conductivity (mmhos/cm)*				*Water Temperature (°C)*				*Air Temperature (°C)*		
	Aug-08	*Jul/ Aug-07*	*Dec-06*	*Mar-06*	*Aug-08*	*Jul/ Aug-07*	*Dec-06*	*Mar-06*	*Aug-08*	*Jul/ Aug-07*	*Dec-06*	*Mar-06*	*Aug -08*	*Jul/ Aug-07*	*Dec-06*	*Mar -06*	*Aug-08*	*Jul/ Aug-07*	*Dec-06*
Surface Fresh Water																			
Ake Doma River		8.0	6.8	7.4		6.9	4.5	4.7		454.0	522.0	340.0		25.3	26.6	28.0		25.0	30.4
Ake Gemaf River		7.9	7.0	7.5		8.5	5.3	4.2		269.9	280.0	280.0		23.9	28.6	30.5		23.9	31.5
Ake Gowomdi River		7.9	7.0	8.1		7.9	3.4	4.2		271.0	346.0	340.0		26.1	26.0	28.0		25.7	26.0
Ake Kobe River		7.4	7.0	7.6		7.1	4.5	4.2		125.0	258.0	240.0		25.8	27.5	28.5		25.5	27.3
Ake Sagea River- before cape		7.8	6.6	-		8.8	6.4	-		227.5	153.5	-		25.4	24.4	-		24.6	25.3
Ake Sagea River-Downstream		8.0	6.9	7.5		8.3	6.3	5.4		160.9	207.0	215.0		24.9	24.8	27.0		23.8	*29.5
Ake Sake River		7.9	7.1	7.8		7.4	5.1	4.5		209.1	222.5	230.0		25.7	27.7	31.5		24.8	29.7
Ake Bukit Limber River		8.1	6.5	7.9		8.8	5.2	4.7		103.9	107.1	255.0		21.2	21.4	25.5		20.5	*22.2
Ake Seloi River-Downstream		7.9	7.3	7.8		7.3	5.0	4.6		266.6	258.2	270.0		25.6	27.5	30.5		27.5	28.6
Ake Seloi River-upstream		8.0	7.2	-		7.6	4.4	-		247.1	270.0	-		25.4	27.9	-		28.0	27.7
Ake Sesliwisini River		8.2	7.7	7.9		7.6	5.4	5.2		370.0	504.0	390.0		26.7	26.4	29.5		25.5	31.1
Ake Wosea River		7.3	7.0	7.8		8.0	5.9	4.2		297.0	270.0	280.0		25.7	27.7	29.0		25.4	29.0
Ake Jira River Downstream	7.0				7.7				239				26.5				30		
Ake Jira River Middle	8.3				8.4				380				24				28		
Ake Jira River Upstream	8.2				7.7				100				23.5				28		
Ake Sangaji Upstream	8.1				9.0				205				24				32		
Ake Sangaji Downstream	8.3				9.8				210				25.5				34		

Source : Analytical Results, ALS Indonesia (2006 and 2007); Intertek (2008) - KAN-accredited laboratories.
Analysis of samples done in accordance with standard methods from the American Public Health Association (APHA)

During surface water sampling, field water quality parameters were recorded as shown in Table 10. The analytical suite of tests included anions, dissolved metals, organics and bacteriology. Results of each suite of surface water quality analysis are shown in Table 11. Considering that surface water in the area is used as both for drinking water and domestic use (clean water for bathing, washing), the analytical results are compared with Class I Criteria of Government Regulation No. 82 Year 2001 regarding the Management of Water Quality and Control of Water Pollution.

Table 11 Surface water quality laboratory analytical results for August 2008 sampling event

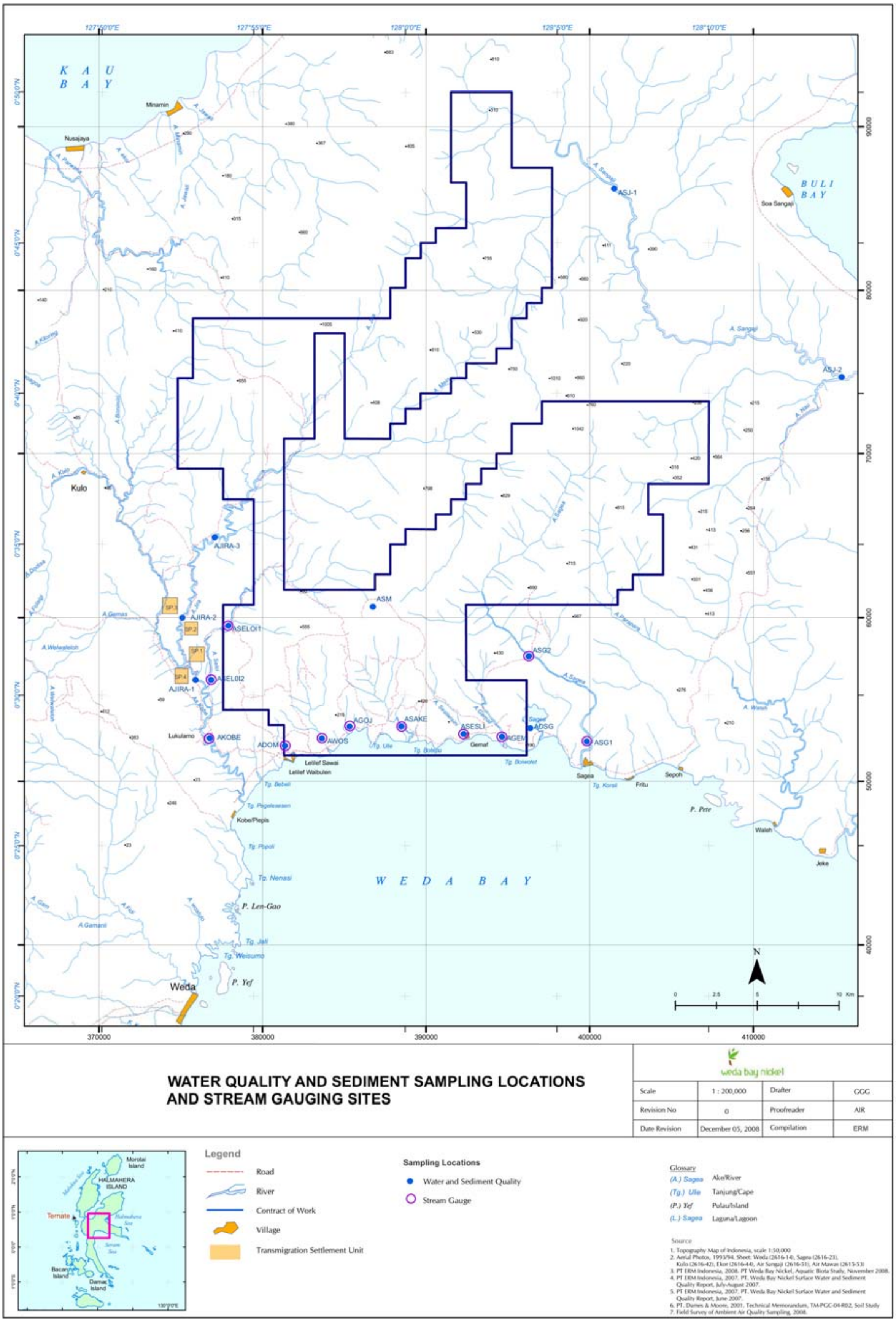
Location	Unit	Ake Jira (AJIRA 1)	Ake Jira (AJIRA 2)	Ake Jira (AJIRA 3)	Ake Sangaji (ASJ 1)	Ake Sangaji (ASJ 2)	GR No. 82 Of 2001, Class I
Physical Tests							
Colour	TCU	-	-	-	-	-	-
Hardness Total	mg/L	-	-	-	-	-	-
pH	-	7.91	8.19	8.06	8.14	7.87	6-9
Total Dissolved Solids (TDS)	mg/L	169	115	121	131	135	1000
Total Suspended Solids (TSS)	mg/L	9	1	< 1	< 1	< 1	50
Turbidity	NTU	-	-	-	-	-	-
Dissolved Anions							
Alkalinity ($CaCO_3$)	mg/L	118	96	99	98	102	-
Alkalinity-Bicarbonate ($CaCO_3$)	mg/L	118	96	99	98	102	-
Alkalinity-Carbonate ($CaCO_3$)	mg/L	< 1	< 1	< 1	< 1	< 1	-
Chloride (Cl^-)	mg/L	0.8	< 0.5	< 0.5	1.7	0.7	600
Fluoride (F^-)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.5
Free Chlorine (Cl_2)	mg/L	0.03	0.01	0.03	0.01	0.01	0.03
Silica (Si)	mg/L	13.5	15.4	16.1	15.5	14.3	-
Sulphate ($SO4^{2-}$)	mg/L	7	7	< 2	7	7	400
Sulphide (H_2S)	mg/L	0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.002
Nutrients							
Total Ammonia ($T-NH_3$)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.5
Nitrate (NNO_3)	mg/L	0.122	0.235	0.255	< 0.005	0.108	10
Nitrite (NNO_2)	mg/L	0.002	0.001	< 0.001	< 0.001	0.001	0.06
Total Phosphorus ($T-PO_4$)	mg/L	0.010	0.007	< 0.005	< 0.005	0.007	0.2
Total Nitrogen ($TKN+NO_3+NO_2$)	mg/L	0.24	0.35	0.42	0.07	0.22	-
Ortho Phosphate	mg/L	0.004	< 0.001	< 0.001	< 0.001	< 0.001	-
Total Kjeldahl Nitrogen (TKN)	mg/L	0.12	0.11	0.16	0.07	0.11	-
Cyanide	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Dissolved Metals							
Aluminium (Al)	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	-
Arsenic (As)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.05
Barium (Ba)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1
Boron (B)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1
Cadmium (Cd)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.01
Calcium (Ca)	mg/L	22.2	4.25	3.62	11.0	11.4	-
Chromium Heksavalen (Cr6+)	mg/L	<0.002	0.003	0.003	0.004	0.004	0.05
Cobalt (Co)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Copper (Cu)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02
Iron (Fe)	mg/L	0.11	0.09	< 0.05	< 0.05	< 0.05	0.3
Lead (Pb)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.03
Magnesium (Mg)	mg/L	17.0	23.2	24.2	18.5	19.6	-

Location	*Unit*	*Ake Jira (AJIRA 1)*	*Ake Jira (AJIRA 2)*	*Ake Jira (AJIRA 3)*	*Ake Sangaji (ASJ 1)*	*Ake Sangaji (ASJ 2)*	*GR No. 82 Of 2001, Class I*
Manganese (Mn)	mg/L	0.02	< 0.01	0.01	< 0.01	< 0.01	0.1
Mercury (Hg)	mg/L	0.00005	0.00008	< 0.00005	< 0.00005	< 0.00005	0.001
Nickel (Ni)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Potassium (K)	mg/L	0.49	0.14	0.08	0.13	0.07	-
Selenium (Se)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.01
Sodium (Na)	mg/L	2.07	1.16	1.02	2.71	1.61	-
Zinc (Zn)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.05
Bacteriology							
Total Coliform Bacteria	MPN/100 ml	> 2420	> 2420	> 2420	> 2420	> 2420	1000
E.coli Bacteria	MPN/100 ml	127	108	99	96	138	100
Organics							
Biochemical Oxygen Demand (BOD_5)	mg/L	< 2	< 2	< 2	< 2	< 2	2
Chemical Oxygen Demand (COD)	mg/L	8	< 2	< 2	5	3	10
Oil and Grease	mg/L	< 1	< 1	< 1	< 1	< 1	1
$KMnO_4$		-	-	-	-	-	
Phenols	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Surfactants (MBAS)	mg/L	0.05	0.08	0.04	0.04	0.03	0.2
Total Organic Carbons	mg/L	-	-	-	-	-	
Dissolved Organic Carbons	mg/L	-	-	-	-	-	-
QA/QC							Standard
Total Kation	meq/L						
Total Anion	meq/L						
Anion-Kation Balance							X<5%
[Anion] + [Cation]	mg/L						
TDS Analyses	mg/L						
Measured TDS : Calculated TDS							1<X<1.2

Source : Analytical Results, ALS Indonesia (2006 and 2007); Intertek (2008); KAN-accredited laboratory. Analysis of samples done in accordance with standard methods from the American Public Health Association (APHA).

Remarks:

- Government Regulation No 82 of 2001 regarding Management of Water Quality and Control of Water Pollution for Class I, which refers to water designated for drinking and/or other purposes that require similar water quality



Map 11 Water and sediment quality sampling locations and stream gauging sites

A. Physical Characteristics

- ***Dissolved Oxygen***

In-situ readings of dissolved Oxygen (DO) ranged from 6.2 to 8.8 mg/L were generally met the Government Regulation No 82 Year 2001 for Class I standard of 6 (minimum allowable level for class I). DO value in clean water is not a subject in the Minister of Health Regulation No. 416 Year 1990.

- ***Conductivity***

There is no relevant standard for conductivity that is applicable for surface water. In December 2006 sampling program, the conductivity of surface water in all sampling sites ranged from 100 μmhos/cm (in Ake Jira) to 522 μmhos/cm (in Ake Doma).

- ***TSS***

The TSS results from the first 3 sampling periods (March 2006, December 2006 and August 2007) show that TSS levels in the study area ranged from 0 mg/L to 27 mg/L, the maximum shown at the Ake Kobe sampling location, with a majority of the samples ranging from 1 mg/L to 3 mg/L shown in Figure 14.

The Ake Kobe is a river flowing from a residential area and farmland; thus a higher value of TSS may be expected due to human activities along the Ake Kobe. Recorded values indicate a low level of TSS compared to the Governmental Regulation No. 82 of 2001 Class I defining a threshold level of 50 mg/L.

The TSS results from the fourth sampling period (August 2008) show that the TSS concentrations in Ake Jira and Ake Sangaji ranged from below 1 mg/L to 9 mg/L, as shown in Figure 14, well within the standard specified in the Governmental Regulation No.82 of 2001 for Class I.

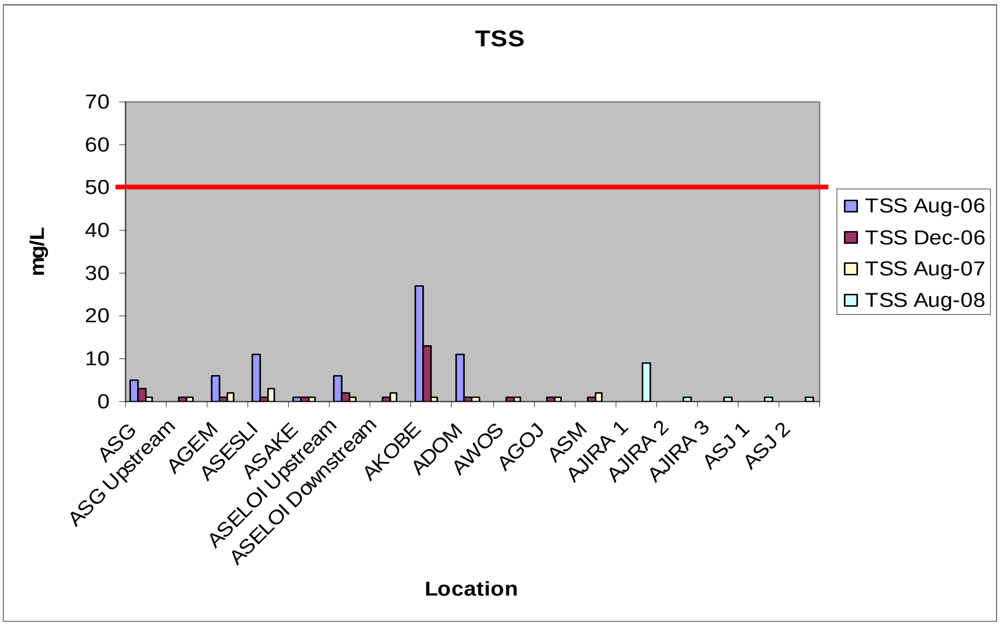


Figure 14 TSS Values of the Study Area (The Red Line Showing the Threshold Level Value)

- ***pH***

pH was measured in situ during all sampling periods (2006, 2007 and 2008). The pH results (6.6 to 8.3) shown in Figure 15, are within the threshold levels (6 to 9) as defined by the Governmental Regulation No.82 of 2001 Class I.

The pH results for Ake Jira and Ake Sangaji (7.0 and 8.3) are also within the threshold defined by the Governmental Regulation No.82 of 2001 Class I (Figure 15).

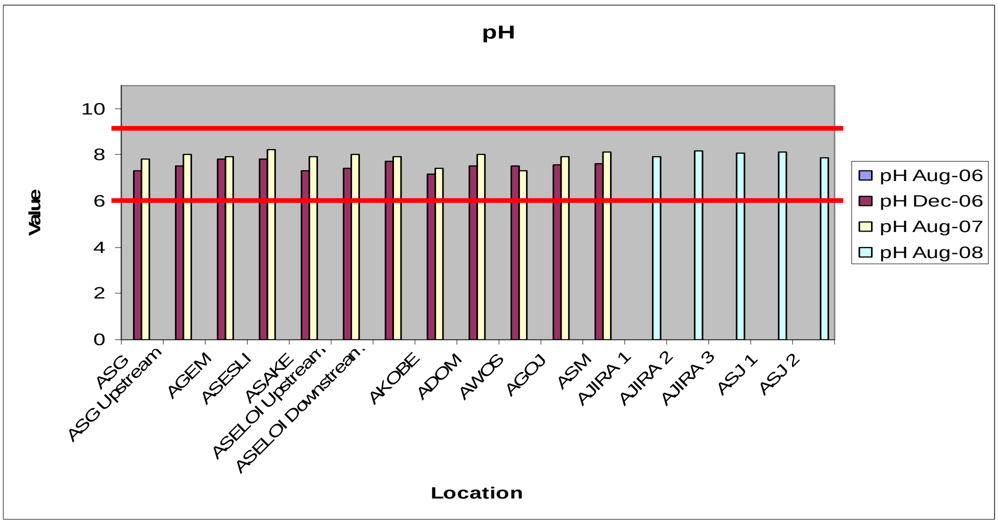


Figure 15 pH Values of the Study Area (The Red Lines Showing the Threshold Range)

- ***Water Color***

Water color in all rivers detected ranging from < 5 to 14 TCU (total color unit). The highest water color was detected at upstream of Ake Doma River (14 TCU), color in water mainly caused by humic substances resulted from degradation of plant debris. Water color is not defined in GR No. 82 Year 2001.

B. Dissolved Anions and Cations

- ***Water Hardness***

The total hardness of water is made up of the cations of alkali earth metals, mainly calcium and magnesium ions. The quantity of calcium and magnesium bound to carbonates and bicarbonates is called carbonate hardness. Total hardness is the sum total of both the carbonate and the non-carbonate hardness (alkali earth sulphates and chloride, or 'permanent' hardness). USGS classifies water hardness into four categories as follows:

Soft : 0 – 60 mg/L eq. $CaCO_3$

Moderately hard : 61 – 120 mg/L eq. $CaCO_3$

Hard : 121– 180 mg/L eq. $CaCO_3$

Very hard : > 180 mg/L mg/L eq. $CaCO_3$

Total hardness values of river water in the study area ranged from 52 mg/L to 229 mg/L equivalent $CaCO_3$. As such, the water in the study area can be classified as "soft" to "very hard" water. Water hardness in Ake Bukit Limber (52 mg/L eq. $CaCO_3$) is classified as "soft water". Ake Sagea downstream, Ake Sagea upstream, Ake Sake River, Ake Seloi upstream (values ranging from 78 to118 mg/L eq. $CaCO_3$) are classified as "moderately hard" water. The water hardness in Ake Gemaf, Ake Sake, Ake Seloi downstream, Ake Gowomdi, Ake Kobe and Ake Wosea have hardness values ranging from 128 to 158 mg/L eq. $CaCO_3$, which renders them as "hard water". Water in Ake Seslewesini and Ake Doma, which have hardness values of 188 mg/L eq. $CaCO_3$ and 229 mg/L eq. $CaCO_3$ respectively, fall under category as "very hard water".

C. Ion Abundance Comparison

Major cations in the water constitute of alkali earth metals mainly calcium, magnesium, sodium and potassium; and the major anions are mainly carbonate – bicarbonate, chloride, sulphate and nitrate. In most of the rivers, except for Ake Sagea downstream, Ake Seslewesini and Ake Kobe, the majority of cation is dominated by magnesium and anion by bicarbonate. As previously indicated by the results (see December 2006 sampling program), the concentrations of other alkali earth metals such as sodium and potassium were low in almost all of the rivers (sodium ranging from 0.5 to 7.4 mg/L and potassium from <0.05 to 0.8 mg/L). Based on this fact, the water hardness in the study area is mainly made up of magnesium and bicarbonate ions, which can be considered as 'non-permanent' hardness.

Chloride

The range of Chloride concentration in July-August 2007, December 2006, March 2006 and August 2008 sampling programs were 0.6-3.1 mg/L, 0.7-6.2 mg/L, 2.3-3.7 mg/L and <0.5 -1.7 mg/L, respectively. Chloride content in all rivers in the study area can be considered as low and normal for rain water fed rivers. Threshold limit of chloride for Class I water quality is 600 mg/L.

- ***Sulphate***

The range of sulphate concentration in July-August 2007, December 2006, March 2006 and August 2008 sampling programs were <2 to 6 mg/L, <2 to 8 mg/L , <2 to 4 mg/L and <0.5 to 7 mg/L respectively. Sulphate content in all rivers in the study area can be considered as low and normal for rain water fed rivers. Threshold limit of chloride for Class I water quality is 400 mg/L.

- ***Bicarbonate***

Bicarbonate is the main anion detected in all rivers in WBN project area. This is in agreement with the water pH (ranging from 7.1 to 8.2) that dictates components of carbonate equilibrium (CO_2–HCO_3-CO_3) in water should be around 80-95% in the form of bicarbonate. Bicarbonate in all rivers was detected ranging from 51 to 219 mg/L as $CaCO_3$; the highest bicarbonate concentration was detected at Ake Doma and the lowest at Ake Bukit Limber.

D. Nutrients

Nutrients in water consist of Nitrogen (as N-NO_3, N-NO_2, N-NH_3 and Total Kjeldahl Nitrogen) and phosphate (as Total-PO_4). In general, nutrients content in all rivers in the study area are considered low and in oligotrophic stage. This is proven by no algae or aquatic weed growth observed in rivers. Total nitrogen was detected ranging from 0.1 to 0.4 mg/L and total-phosphate ranged from <0.005 to 0.108 mg/L. In general, there was no significant difference in nutrient content between the sampling programs.

E. Dissolved Metals

Many of the metals analyzed at the ALS Laboratory have concentrations below or close to the detection limit of the laboratory. These results are referred to as non-detected (ND). For some groups of analyses, a few laboratory detection limits were above the threshold level value defined by the Governmental Regulation No.82 of 2001 Class I.

The dissolved metals Al, As, Ba, B, Cd, Cr, Co, Cu, Mn, Pb, Hg and Se were not detected in samplings sites and at all sampling programs. Out of all dissolved metals only Fe, Mn, Zn, and Ni and were detected in some sampling sites.

Fe was detected with a concentration of 0.33 mg/L at Ake Dome (March 2006) and Ake Jira at concentration of 0.09 -0.11 mg/L (August 2008). Threshold level value for Class I water use is 0.3 mg/L.

Zn was detected with a concentration of 0.047 mg/L at Ake Sagea upstream (August 2007) and Ake Seloi upstream with a concentration of 0.009 mg/L (August 2007), these values were within the threshold of 0.05 mg/L as defined by the Governmental Regulation No.82 of 2001 for Class 1 waters.

Ni was detected at low concentrations of 0.05 – 0.06 mg/L in Ake Bukit Limber. This may be due to the proximity of the sampling site to the nickel ore body. The dissolved nickel values detected at Ake Bukit Limber are close to the laboratory detection limit of 0.02 mg/L. The regulations do not specify a threshold value for Ni.

F. Organics

Organic constituents commonly measured in water are $KMnO_4$, total organic carbon (TOC), Dissolved Organic Compound (DOC), phenols, and surfactants. TOC in all rivers was detected with very low concentration ranging from 1.3 to 4.1 mg/L; the lowest concentration was detected at Ake Limber River and the highest at Ake Kobe River. DOC was ranging from 0.7 to 3.7 mg/L, the lowest is at Limber River and the highest is at Ake Doma River. There is likely a positive correlation between TOC and DOC. No guidance was found related to TOC and DOC concentration in water.

Surfactant comprise one of the most widely spread group of substances which pollute the water. The permissible concentration in water used for sanitary and domestic use is 0.3 to 0.5 mg/L; however maximum allowable limit in Indonesian Government Regulation No. 82 Year 2001 for surfactant is 0.2 mg/L. Surfactant was ranging from <0.01 to 0.03 mg/L. The highest concentration was detected at Ake Seslewesini River, probably originated from detergent used by local community.

The composition of phenols present in water is so complex and varied that the accuracy and reliability of their determination by any known method is quite low. The laboratory analytical results reported the detection limit (<0.002 mg/L) of phenols is higher than maximum allowable limit (0.001 mg/L) as set forth in Government Regulation N0. 82 Year 2001. Phenols concentration in all sampling sites in July/August Sampling Program was less than 0.002.

G. Bacteriology

Coliform bacteria are organisms that are present in the environment and in the feces of all warm-blooded animals and humans. Coliform bacteria will not likely cause illness. However, the presence of coliform bacteria in water indicates that disease-causing organisms (pathogens) may be present in the water system. Total coliform, fecal coliform, and E. coli are all indicators of drinking water quality. The total coliform group is a large collection of different kinds of bacteria. The fecal coliform group is a sub-group of total coliform. *E. coli* is a sub-group of fecal coliform.

In general, total coliform bacteria content were high in all sampling locations at all sampling programs and were exceeding the maximum allowable limit of 1,000 MPN/100mL, except in two locations i.e. Ake Kobe and Ake Seslewesini were below the maximum allowable limit. *E. coli* bacteria results in some rivers were detected non compliance to the standard as stated in Government Regulation No. 82 Year 2001. The allowable limit for *E. coli* Bacteria is 100 MPN/100mL. The ranges of *E. coli* Bacteria was <1 to >2,420 MPN/100 ml.

Total coliform bacteria are commonly found in the environment (e.g., soil or vegetation) and are generally harmless. If only total coliform bacteria are detected in water, the source is probably environmental. Most *E. coli* are found in great quantities in the intestines of people and warm-blooded animals. The presence of *E. coli* in a water sample almost always indicates recent fecal contamination – meaning that there is a greater risk that pathogens are present. In the study area, rivers are used by local community for washing, bathing and toileting. It is suspected the main source of *E. coli* is from human feces.

11.2 SEDIMENT

Sediment samples were collected at 13 locations representing various watersheds (see Map 11) in 2001, 2006 and 2007. Based on grain size data, most of the sediment samples were dominated by sand. Per the unified soil classification system based on grain size, sediments are classified in Table 12**.**

Table 12 Particle Classification of Sediment Samples (July-August 2007 and December 2006)

Lokasi	Juli-Agustus 2007	Desember-2006
Ake Sagea-Hilir	Sand	Sand
Ake Sagea-Hulu	Loamy sand	N/A
Ake Lake Sagea	Sand	Loamy sandl
Ake Gemaf	Sand	Sand
Ake Sesliwisini	Sand	Sand

Lokasi	Juli-Agustus 2007	Desember-2006
Ake Sake	Sand	Sand
Ake Seloi-Hilir	Sand	Sand
Ake Seloi -Hulu	Sand	Sand
Ake Kobe	Loamy sand	Sand
Ake Doma	Sand	Sand
Ake Wosea	Sand	Sand
Ake Gowomdi	Sand	Sand
Ake Bukit Limber	Sandy loam	Sandy loam

Note: NA = Not Available

There are no regulatory- driven standards for sediment in Indonesia. Results relating to metal contents are provided in the paragraphs below.

Arsenic was detected in Ake Sagea Lake sediment with a concentration of 11 mg/dry kg in 2001 and 10 mg/dry kg in 2007. Arsenic concentrations in most of the other 12 sampling locations were below 4 mg/dry kg.

Most Cadmium concentrations fell between 1 mg/dry kg and 5.5 mg/dry kg. The exceptions were recorded in December 2006 in Ake Seslewesini (9.4 mg/dry kg); Ake Doma (6.4 mg/dry kg); Ake Gowomdi (6.0 mg/dry kg) and Ake Bukit Limber (19.4 mg/dry kg). Cadmium was not detected in the March 2006 sampling event. While there is no clear explanation for this discrepancy, the laboratory indicated the use of different instrumentation to analyze the samples (March 2006 used flame photometer and December 2006 employed ICP). Despite the change in instrumentation, the detection limit for both methods were reported the same.

For chromium, the highest concentration was detected in August 2007 at Ake Bukit Limber (2,406 mg/dry kg). With the exception of the Ake Sagea Downstream (went from 295 to 406 mg/dry Kg), all recorded concentrations from the August 2007 program were lower than those recorded in December 2006: Seslewisini (1,200 dropped to 693 mg/kg); Sake (824 to 48 mg/dry kg); Doma (827 to 701 mg/dry kg); Wosea (972 to 784 mg/dry kg) and Bukit Limber (3,150 to 2,406 mg/dry kg).

Cobalt concentrations ranged from 33 mg/dry kg to 504 mg/dry kg in the July/August sampling program. High concentrations were also detected in the December 2006 sampling program. Cobalt content in Ake Sagea River-upstream, Ake Seslewesini River, Ake Seloi River downstream and upstream, Ake Doma River, Ake Wosea River, Ake Gowomdi and Ake Bukit Limber River sediment samples were all detected with concentrations above 50 mg/dry kg. The highest concentration was detected at Ake Bukit Limber (504 mg/dry kg).

Copper concentrations in sediment ranged from 2 to 51 mg/dry kg for the July-August 2007 sampling program and 0.3 to 27.8 mg/dry kg for December 2006. With the exception of two March 2001 results (51.5 mg/dry Kg in Ake

Seloi Downstream and 40.8 mg/dry Kg in Ake Kobe), all copper concentrations from all sampling locations were computed to be 30 mg/kg.

In December 2006, lead ranging from 3 to 29 mg/dry kg was detected in all sampling locations. The July-August 2007 program recorded lead concentrations within a range of 23 to 175 mg/dry kg in all sampling locations. These concentrations are significantly higher than the December 2006 results. There is no clear explanation about this discrepancy besides the use of different instrumentation by ALS laboratory. The highest lead content was detected at Ake Limber (175 mg/dry kg). The lead content in all sediment sampling locations (with the exception of the spike in Bukit Limber and 52 mg/dry kg detected in Seslewisini) are below 50 mg/dry kg.

Mercury was detected at all sampling locations in the July-August 2007, December 2006 and March 2006 sampling programs. The mercury content in July-August 2007 ranged from 0.03 to 0.11 mg/dry kg, from 0.003 to 0.053 mg/dry kg in December 2006 and from 0.009 to 0.033 mg/dry kg in March 2006. The highest mercury content in August 2007 was detected at Ake Doma (0.112 mg/dry kg) in 2007 and in Ake Seloi Downstream in 2001 (0.118 mg/dry kg). The mercury content at all sampling locations for all sampling programs is below 0.5 mg/dry kg.

Nickel was detected ranging from 417 to 4,870 mg/dry kg. In December 2006, Nickel was detected from all sampling locations with concentrations ranging from 633 to 9,360 mg/dry kg. The highest Nickel concentration in July-August 2007 was detected at Ake Bukit Limber (4,870 mg/dry kg). Except for Ake Seslewesini (417 mg/dry kg), all other sampling locations had nickel contents higher than 500 mg/dry kg.

Zinc was detected at all sampling locations during the July-August 2007, December 2006 and March 2006 sampling programs. The zinc content in July-August 2007 ranged from 0.1 to 99 mg/dry kg; from 11.3 to 87.6 mg/dry kg in December 2006; and from 22.2 to 51.1 mg/dry kg in March 2006. The highest zinc content was detected at Ake Bukit Limber (in July-August 2007 and December 2006) and in Ake Kobe (in August 2007). The zinc content at all sampling locations for all sampling programs were below 200 mg/dry kg.

Selenium (< 1 mg/dry kg), silver (<0.4 mg/dry kg) and barium (<20 mg/dry kg) were not detected in any sampling sites during the July-August 2007, December and March 2006 sampling programs.

12 OCEANOGRAPHY

12.1 WIND AND WAVE

The climatology of the Weda-Bay is strongly influenced by a seasonal monsoon phenomenon. Between the months of November and April, winds blow mainly from the WNW to NNW sector, at an average speed of around 3 m/s and a maximal velocity of around 12m/s. The sea-states generated are limited by the fetch at the study location and remain consequently weak.

Between the months of May and October, the winds blow mainly from the ESE to SSW sector, at an average speed of around 3 m/s and a maximal velocity of around 12-13 m/s.

The sea-states generated can generate wave heights above 1.5 m on occasions. Monsoon strengths vary from year to year.

Swells, generated in the Pacific Ocean are strongly attenuated by the time they reach Weda Bay. Swells with wave heights above 0.3 m are very rare. They combine with the sea-states generated locally by the monsoon regime.

Thunderstorm squalls, typical of the Inter-Tropical Convergence Zone (ITCZ), may occur locally, most frequently from the South-East to South-West sector. They can be very violent but persist for relatively short durations (less than one hour). However, such squalls may generate local sea states more severe than other weather conditions.

Project values (Hs and Tp) are summarized in the Table 13 through Table 15 below:

- Hs: Significant wave height – value characteristic of a sea state. Corresponds appreciably to the mean of the 33% highest waves over a significant sample.
- Tp: Peak period– value characteristic of a sea state. Corresponds to the period (time between the passages of two waves) of waves containing the most energy.

Table 13 North-West Monsoon: [300°N - 350°N]

Project Duration (yr)	Hs mode (m)	Hs- 90% confidence interval (m)	Tp[2] (s)	H_{max}-mode
1	0.80	0.80 – 0.85	3 – 4	1.6
10	0.90	0.90 – 1.00	3 – 4	1.8
30	0.95	0.95 – 1.10	$3^{1/2}$ – $4^{1/2}$	1.9
50	1.00	0.95 – 1.15	$3^{1/2}$ – $4^{1/2}$	2.0
100	1.05	1.00 – 1.20	$3^{1/2}$ – $4^{1/2}$	2.1

Table 14 South-East Monsoon: [125°N - 175°N]

Project Duration (yr)	*Hs mode (m)*	*Hs- 90% confidence interval (m)*	*Tp^2 (s)*	*H_{max}-mode*
1	1.3	1.3 – 1.4	5 - 7	2.5
10	1.6	1.5 – 1.8	5 - 7	3.1
30	1.7	1.6 – 1.9	5 - 6	3.3
50	1.8	1.7 – 2.0	5 - 6	3.5
100	1.9	1.8 – 2.1	5 - 6	3.7

Table 15 Conditions of Squalls: [mainly SE to SW sector]

Duration/ Wind speed (m/s)	*¼ h*	*1/2h*	*1h*	*2h*
Hs in meters				
20	0.4	0.7	1.2	1.9
25	0.6	1.0	1.6	2.7
30	0.8	1.3	2.2	X
35	1.0	1.6	2.7	X
Tp in seconds				
20	2	2 1/2	3 1/2	5
25	2	4	4	6
30	2 1/2	4 1/2	4 1/2	X
35	2 1/2	5	5	X

12.2 TIDES

The following tide data (Table 16) are based on observations and measurements of water levels carried out at the proposed port site by LIPI ("Bathymetry Study of Weda Bay", November – December 2007):

Table 16 Tide Levels

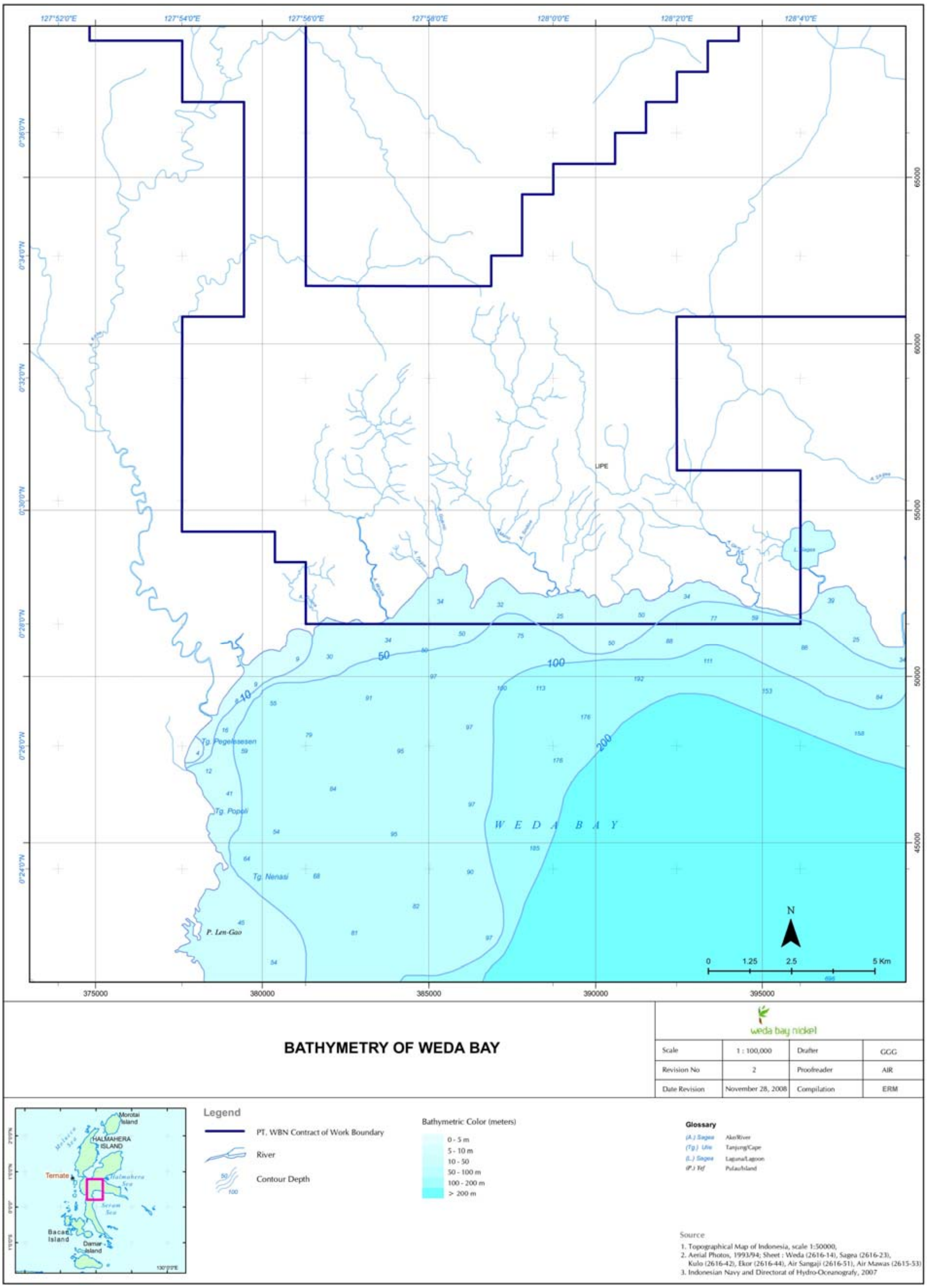
Code	*Designation*	*Design levels Weda Bay*
HAT	Highest Astronomical Tide	+1.35 m
MHWS	Mean High Water Springs	+0.917 m
MHWN	Mean High Water Neaps	+0.655 m
MSL	Mean Sea Level	+0.553m
MLWS	Mean Low Water Springs	+0.188 m
MLWN	Mean Low Water Neaps	+0.451 m
LAT/CD	Lowest Astronomical Tide	+0.00 m

12.3 CURRENTS

Due to the characteristics of Weda Bay no significant tidal currents occur at the proposed berth location. A tidal current of 2 knots (1.03 m/s) generally acting parallel to the shore has been adopted for design purposes.

12.4 *BATHYMETRY*

The bathymetry of Weda Bay is shown on Map 12. A detailed bathymetry of the plant and port site vicinity is shown on ***Map 13***. Weda Bay is open to the southeast and its bathymetry is distinguished by two terraces, two slopes, a valley and a basin. The first terrace is characterized by a shallow and flat bench between depths of 50m and 100m. The first slope ranges from 100m to 180m depth and continues to the second terrace at 200m depth. Isolated hills and ridges are commonly observed along the margin of the 200m isobath. Between depths of 200m and 350m is a moderate slope which occupies a limited area, which is bordered by a steep slope extending to 500m. The basin which forms the deepest part of the bay is between 600m and 1100m in depth and has a smooth seabed. The southern part of Weda Bay is dissected by a wide and deep valley with an opening to the northeast direction.



Map 12 Bathymetry of Weda Bay

13 MARINE WATER AND SEDIMENT QUALITY

The laboratory results for anions, of water 4 water samples (see ***Map 13***), are presented in Table 17. Of these parameters, only total cyanide and sulphide are regulated by the State Minister of Environment Decree No. 51 Year 2004, and the results generally comply with this regulation.

All major anions are at concentrations that are typical for sea water.

Nutrients included in parameters analyzed are ammonia, nitrate, nitrite, nitrogen and phosphate. Nitrogen is present in sea water as dissolved N2 gas, nitrite, ammonia, and nitrate, as well as in organic forms. Phosphorus is potentially available in sea water in particulate matter and phosphate ions are in equilibrium with various cations and dissolved organic compounds. Apart from that, the State Minister of Environment No. 51 Year 2004 Appendix III (standard of sea water for sea organism) has regulated the content of ammonia, phosphate, and nitrate at 0.3 mg/L, 0.015 mg/L and 0.008 mg/L respectively. Ammonia was detected less than 0.02 mg/L in all water samples collected. Most of nitrate and nitrite results were less than 0.005 mg/L and 0.001 mg/L respectively. Total phosphate was detected ranging from 0.015 mg/L to 0.027 mg/L, at or above the regulatory limit. Total nitrogen ranged from 0.12 mg/L to 0.32 mg/L. Both ammonia and nitrate were in compliance with the national standard.

Major cations such as sodium, magnesium, calcium and potassium are at concentrations typical of marine water. Most trace metal concentrations were less than the applicable laboratory detection limits, and concentrations of all regulated dissolved metals (arsenic, cadmium, chromium (VI), cobalt, copper, lead, mercury, nickel, and zinc) were well below the limits for these parameters specified in the State Minister of Environment Decree No. 51, Year 2004.

Analytical results of sediment sampled at the same locations as water sampling location are provided in Table 18. In general, total Fe, Mn and Cr are higher than other metals.

Table 17 Marine Water Quality Analytical Results

Sample I.D.		MKP 1	MLS 1	MGF 1	MTB 1	Laboratory Detection Limit	Regulation ME 51-2004 Attachment III
Date Sampled		31-Jul-08	31-Jul-08	31-Jul-08	31-Jul-08		
Time Sampled (WIT)		11.30	10.35	9.40	9.00		
Test Description	Unit	Results					
Physical							
pH (in lab)	-	8.1	8.1	8.3	8.2	0.1	7-8.5
Conductivity (in lab)	µS/cm	68,400	68,700	85,500	79,600	1	-
Total Dissolved Solids, TDS	mg/L	33,200	33,900	39,200	38,600	1	-
Total Suspended Solids, TSS	mg/L	15	17	8	23	1	20
Major Anions							
Total Alkalinity as $CaCO_3$	mg/L	111	125	109	109	1	-
Bicarbonate as $CaCO_3$	mg/L	111	125	109	109	1	-
Carbonate as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	1	-
Total Cyanide, CN	mg/L	<0.005	<0.005	<0.005	<0.005	0.005	0.5
Fluoride, F	mg/L	0.36	0.38	0.30	0.04	0.02	-
Sulphate, SO_4	mg/L	2190	2280	2670	2310	2	-
Sulphide as H_2S	mg/L	0.002	<0.002	<0.002	<0.002	0.002	0.01
Silicon, Si	mg/L	2.5	4.7	0.2	0.7	0.1	-
Nutrients							
Ammonia, NH_3-N	mg/L	<0.02	<0.02	<0.02	<0.02	0.02	0.3
Nitrate, NO_3-N	mg/L	<0.005	<0.005	<0.005	0.007	0.005	-
Nitrite, NO_2-N	mg/L	<0.001	<0.001	<0.001	0.002	0.001	-
Total Kjeldahl Nitrogen, TKN	mg/L	0.32	0.18	0.12	0.16	0.02	-
Ortho Phosphate as P	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	0.015
Total Phosphate as P	mg/L	0.027	0.019	0.015	0.017	0.005	-
Total Nitrogen	mg/L	0.32	0.18	0.12	0.17	0.02	-
Chlorine, Cl_2	mg/L	0.01	0.01	0.01	0.01	0.01	-
Microbiology							
Pathogens	MPN/100ml	< 1	< 1	< 1	< 1	1	Nil
Total Coliforms	MPN/100ml	< 1	14	< 1	6	1	1000

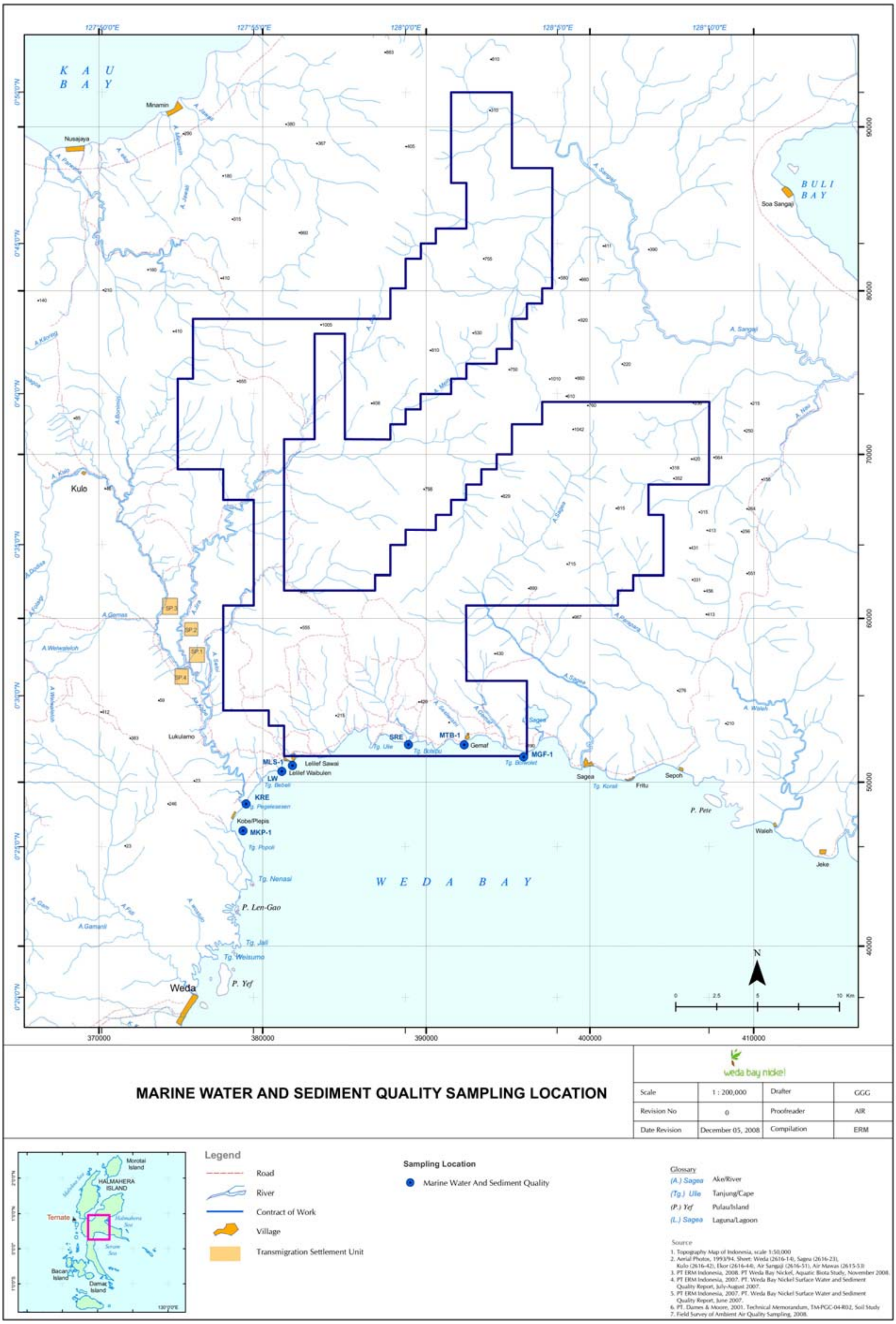
Sample I.D.		MKP 1	MLS 1	MGF 1	MTB 1	Laboratory Detection Limit	Regulation ME 51-2004 Attachment III
Date Sampled		31-Jul-08	31-Jul-08	31-Jul-08	31-Jul-08		
Time Sampled (WIT)		11.30	10.35	9.40	9.00		
Test Description	Unit	Results					
Organics							
BOD	mg/L	< 2	< 2	< 2	< 2	2	20
COD	mg/L	8	5	13	8	2	-
MBAS	mg/L	0.08	0.11	0.10	0.10	0.01	1.00
Oil & Grease	mg/L	<1	<1	<1	<1	1	1
Total Phenol	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	0.002
Dissolved Metals							
Aluminium, Al	mg/L	<0.05	<0.05	<0.05	<0.05	0.05	-
Arsenic, As	mg/L	<0.0005	<0.0005	<0.0005	0.0007	0.0005	0.012
Barium, Ba	mg/L	0.16	0.14	0.14	0.13	0.01	-
Boron, B	mg/L	7.0	2.6	7.6	6.7	0.1	-
Cadmium, Cd	mg/L	<0.005	<0.005	<0.005	<0.005	0.005	0.01
Calcium, Ca	mg/L	405	397	503	482	0.05	-
Chromium Hexavalent, Cr^{6+}	mg/L	<0.002	<0.002	<0.002	<0.002	0.002	0.005
Cobalt, Co	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	-
Copper, Cu	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	0.008
Iron, Fe	mg/L	0.006	0.010	<0.005	0.006	0.005	-
Lead, Pb	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	0.008
Magnesium, Mg	mg/L	1170	1280	1470	1330	0.05	-
Manganese, Mn	mg/L	0.004	0.007	0.004	< 0.001	0.001	-
Mercury, Hg	mg/L	0.00008	0.00012	0.00008	0.00009	0.00005	0.001
Nickel, Ni	mg/L	0.001	0.004	< 0.001	< 0.001	0.001	0.05
Potassium, K	mg/L	317	321	389	375	0.05	-
Selenium, Se	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	-
Sodium, Na	mg/L	8350	9290	11100	10300	0.05	-
Zinc, Zn	mg/L	<0.005	<0.005	<0.005	<0.005	0.005	0.05

Source : Intertek (2008); KAN-accredited laboratory.
Analysis of samples done in accordance with standard methods from the American Public Health Association (APHA).

Table 18 Analytical results of Sediment

Sample Code			MKP 1	MLS 1	MGF 1	MTB 1	LW	SRE	KRE
Sampling Date			31-Jul-08	31-Jul-08	31-Jul-08	31-Jul-08	2-Mar-09	2-Mar-09	2-Mar-09
Sampling Time			11:30	10:35	9:40	9:00	11:50	10:58	12:10
Metals	Unit	Technique	Results						
Arsenic, As	mg/dryKg	HVAAS	13.3	6.33	6.28	18.4	17.8	4.08	6.27
Barium, Ba	mg/dryKg	FAAS	8	16	5	7	61	5	15
Cadmium, Cd	mg/dryKg	FAAS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Chromium, Cr	mg/dryKg	FAAS	372	465	669	693	525	775	402
Cobalt, Co	mg/dryKg	FAAS	40.8	33.6	52.2	82.1	26.7	65.5	45
Copper, Cu	mg/dryKg	FAAS	36.7	14.9	18	11.9	4.9	12.3	35.5
Iron, Fe	mg/dryKg	FAAS	62500	36600	45400	52400	25900	41400	49500
Lead, Pb	mg/dryKg	FAAS	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Manganese, Mn	mg/dryKg	FAAS	390	262	501	447	306	484	665
Mercury, Hg	mg/dryKg	CVAAS	0.65	0.025	0.011	0.022	0.018	0.057	0.055
Nickel, Ni	mg/dryKg	FAAS	640	779	995	1680	719	1270	648
Selenium, Se	mg/dryKg	HVAAS	0.38	0.34	0.02	0.07	< 0.01	< 0.01	< 0.01
Silver, Ag	mg/dryKg	FAAS	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Zinc, Zn	mg/dryKg	FAAS	65.8	36.1	41.2	37.2	27.2	38.4	63.7

Source : Intertek (2008 and 2009); KAN Acredited Laboratory.



Map 13 Marine Water and Sediment Quality Sampling Location

14 SAGEA LAGOON

14.1 WATER QUALITY

Sagea Lagoon has a direct connection to the sea, as evidenced by its surface level which changes with the tides. The water of Sagea Lagoon is a mixture between sea water and fresh water, the latter derived from springs. At high tide, such as the one found during the March 2006 sampling period, sea water predominates, while at lower tide levels (such as at the December 2006 and August 2007 sampling periods) the salinity was much lower. Results of analyses of water samples from Sagea Lagoon for the three sampling periods are shown in **Table 19** for sampling location). For most parameters results of analyses were in compliance with the relevant standards as stipulated in the State Minister of Environment Decree No. 51, Year 2004, and Appendix III, which governs marine biota.

Exceptions, which are highlighted in red, were nitrate in the December 2006 and August 2007 samples; total phosphorous in the March 2006 sample; copper in the December 2006 sample; and zinc in the December 2006 and August 2007 samples.

Table 19 Sagea Lagoon Water Quality Analyses

Location	Unit	Ake Danau Sagea			State Minister of Environment No. 51 of 2004, Appendix III (marine biota)
Date Sampled		Aug-07	Dec-06	Mar-06	
Laboratory		ALS	ALS	ALS	
Physical Tests					
Color	TCU	14	<5	-	-
Hardness Total	mg/L	1330	3,170	-	-
pH	-		8	-	7-8.5
Total Dissolved Solids (TDS)	mg/L		20,200	35,700	-
Total Suspended Solids (TSS)	mg/L	3	1	117	-
Turbidity	NTU		1.3	-	5
Dissolved Anions					
Alkalinity ($CaCO_3$)	mg/L	132	141	-	-
Alkalinity-Bicarbonate ($CaCO_3$)	mg/L	132	141	-	-
Alkalinity-Carbonate ($CaCO_3$)	mg/L	<1	<1	-	-
Chloride (Cl^-)	mg/L	3210.9	9,290	21,600	-
Fluoride (F^-)	mg/L	0.21	0.48	1	-
Free Chlorine (Cl_2)	mg/L	ND	ND	ND	-
Silica (Si)	mg/L	16	4	-	-
Sulphate ($SO4^{2-}$)	mg/L	546	1,180	2,710	-
Sulphide (H_2S)	mg/L	ND	ND	ND	0.010
Nutrients					
Total Ammonia (T-NH_3)	mg/L	ND	ND	0.02	0.3
Nitrate (NNO_3)	mg/L	0.09	0.035	ND	0.008
Nitrite (NNO_2)	mg/L	ND	ND	ND	-
Total Phosphorus (T-PO_4)	mg/L	ND	0.009	2.59	0.015
Total Nitrogen (TKN+NO_3+NO_2)	mg/L	0.18	ND	-	-
Ortho Phosphate	mg/L		ND	-	-
Total Kjeldahl Nitrogen (TKN)	mg/L	0.09	ND	-	-
Total Cyanide	mg/L	ND			
Dissolved/ Total Metals		**Diss.**	**Diss.**	**Diss.**	
Aluminium (Al)	mg/L	ND	ND	-	-

Location	Unit	Ake Danau Sagea			State Minister of Environment No. 51 of 2004, Appendix III (marine biota)
Date Sampled		Aug-07	Dec-06	Mar-06	
Laboratory		ALS	ALS	ALS	
Arsenic (As)	mg/L	ND	0.0012	0.012	0.012
Barium (Ba)	mg/L	ND	ND	ND	-
Boron (B)	mg/L	ND	ND	35	-
Cadmium (Cd)	mg/L	ND	ND	ND	0.001
Calcium (Ca)	mg/L	4.23	226	-	-
Chromium (Cr)	mg/L	ND	ND	ND	-
Cobalt (Co)	mg/L	ND	ND	ND	-
Copper (Cu)	mg/L	ND	0.02	ND	0.008
Iron (Fe)	mg/L	ND	ND	ND	-
Lead (Pb)	mg/L	ND	ND	ND	0.008
Magnesium (Mg)	mg/L	321	594	-	-
Manganese (Mn)	mg/L	ND	ND	ND	-
Mercury (Hg)	mg/L	ND	ND	ND	0.001
Nickel (Ni)	mg/L	ND	ND	-	0.05
Potassium (K)	mg/L	105	197	-	-
Selenium (Se)	mg/L	ND	ND	ND	-
Sodium (Na)	mg/L	3,008	5,780	-	-
Zinc (Zn)	mg/L	0.074	0.051	ND	0.05
Bacteriology*					
Total Coliform Bacteria	MPN/100mL	>2420	980	>2420	1000
E.coli Bacteria	MPN/100mL	51	27	1730	-
Organics					
Biochemical Oxygen Demand (BOD_5)	mg/L		<5	<5	20
Chemical Oxygen Demand (COD)	mg/L		30	<10	-
Oil and Grease	mg/L		<5	<5	1
$KMnO_4$	mg/L	9			
Phenols	mg/L	<0.002	0.008	0.002	0.002
Surfactants (MBAS)	mg/L	0.1	0.14	0.08	1
Total Organic Carbons	mg/L	2	3.7	-	
Dissolved Organic Carbons	mg/L	1.4	3.7	-	-

Source : Analytical Results, ALS Indonesia, Bogor
Remarks:
Maximum quantifiable limit for coliforms is 2420 MPN.
- : Not analyzed, > : greater than
Value in red color is the value that does not meet the standard for the parameter.

14.2 BATHYMETRY OF SAGEA LAGOON

The Bathymetry of Sagea Lagoon was surveyed by recording water depths over a thirty meter by fifty meter grid. The results of the survey can be seen in Figure I6.

The Sagea Lagoon is roughly circular in shape with a width of 1,415 meters and length of 1,554 meters.

From the eastern bank, the lagoon floor slopes steeply to its maximum depth of 31.2 m. The lagoon floor then rises to a north-south tending ridge at a depth of 16 m. Then the floor slopes down again to a flat valley at a depth of 22 m. Subsequently, there is another steep slope in the lagoon floor followed by a shallow bench for approximately 25 meters. The lagoon floor then gently slopes up to the western bank.

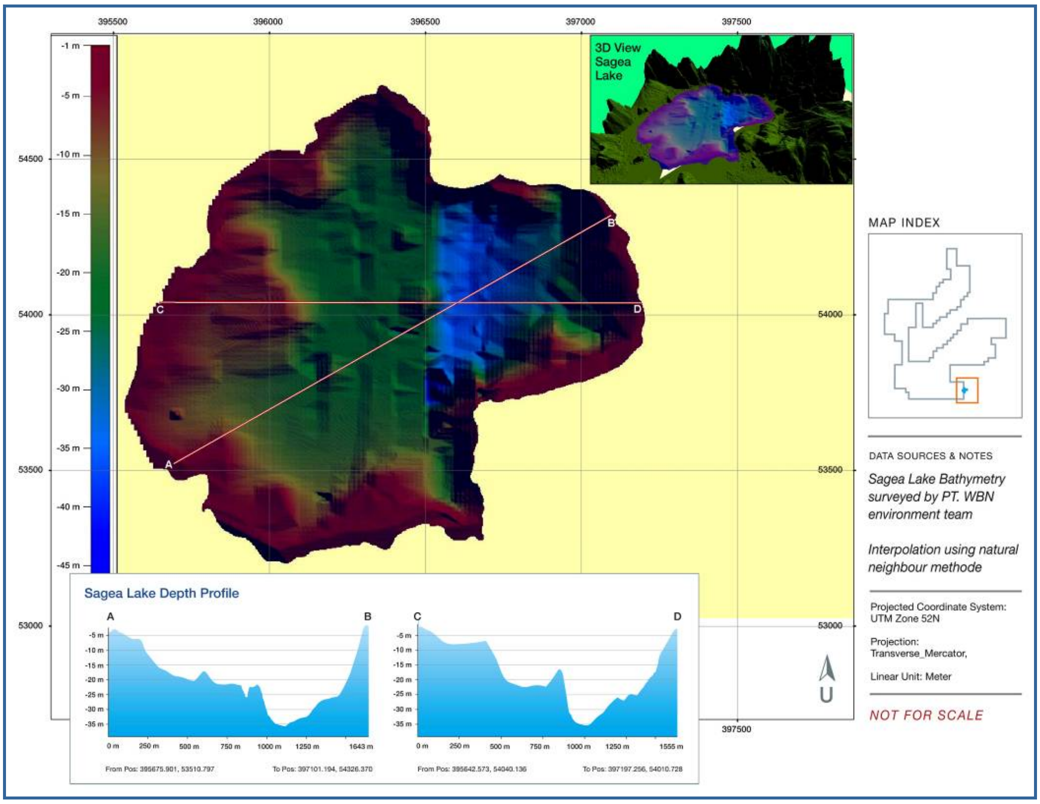


Figure 16 Sagea Lagoon Bathymetry

15 BIOLOGY

Baseline information on the biological environment is presented here; information relevant to the biodiversity issues and values in the project area (including protected, special status, and endemic species) presented in Section 6.

15.1 TERRESTRIAL FLORA AND FAUNA

15.1.1 Forest Area Status

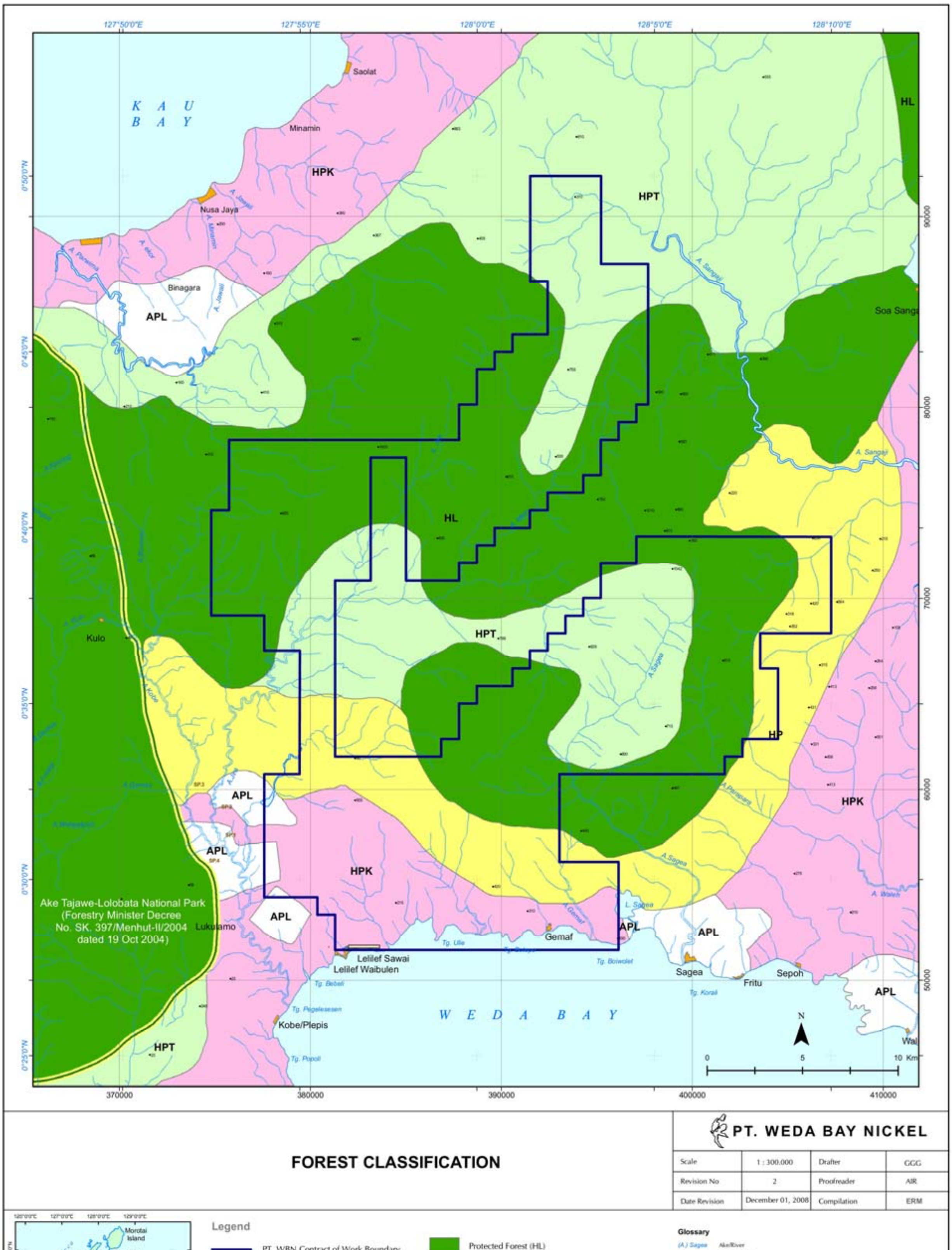
As described in Biodiversity and Sustainable Natural Resources Management section, forest areas in Indonesia are classified by the Ministry of Forestry through decree (SK Menhut). The determination of a forest region is based on the interests of the public, which include socio-economic development, education, religion and culture. According to Forestry Law No 41/1999, a forest region is divided into three main categories: Conservation, Protection and Production Forest. This section illustrates various forest classifications based on suchcategories. According to forestry data, Map 14 illustrates the area of study, which includes forests with various status: protection forest (HL); other use (APL); production forest (HP); limited production forest (HPT); and conversion production forest (HPK). The area of the forest at CoW is presented in Table 20.

Table 20 Area of Forest at COW

No	Forest Area	Area (Hectares)	Percentage (%)
1	Conversion Production Forest	8,650	16.1
2	Production Forest	6,807	12.7
3	Protection Forest	25,118	46.9
4	Limited Production Forest	13,026	24.3
	Total	**53,601**	**100.0**

Source: Forestry Department, (P.48/Menhut-II/2008 dated 10 July 2008)

The area of study is dominated by protection forest (46.9%) and limited production forest (24.3%).



Map 14 Forest Classification

15.1.1.1 *Flora*

Islands in the Maluku archipelago are clustered in the region, small in size and were formed in a relatively short geological time. Literature research indicates limited botanical knowledge of this unique area, as evidenced by poor existing data and botanical collection (van Balgooy *et al*., 1986). Whitmore et al (1989) reported that there were at least 76 tree families in Maluku consisting of 363 genera, although actual numbers are expected to be higher. Species richness refers to the number of species, while species diversity is determined by species richness and pattern of distribution. High number of species distributed evenly across the landscape in low densities result in high diversity. Poulsen *et al* (1999) classified 10 main habitat types and 21 vegetation types on the island of Halmahera. This classification is based on several factors including: the geology, elevation, rainfall, and the use of spatial data and satellite imaging. Using the Poulsen classification, the WBN COW contains the following habitat types:

- Mangrove and freshwater swamp forest;
- Lowland forest on Ultra Basic Soils;
- Lowland forest on Alluvial Soils;
- Lower montane forest; and
- Lowland forest on limestone (i.e. Karst).

Flora surveys have been conducted to establish baseline data of flora within the Project area, identify components of flora with special economic and/or ecological value and provide data of flora species to support future land rehabilitation. Flora surveys conducted within the WBN CoW are listed below:

- Terrestrial Ecology Studies, PT. Dames & Moore Indonesia (2001);
- Forest Inventory for the Test Pit Area and Study of Vegetation on Santa Monica (Bukit Limber), PT. Hatfield Indonesia (2007);
- Forestry Survey in Lowland Areas of PT Weda Bay Nickel's CoW, PT Hatfield Indonesia (2008);
- Forestry Survey in Lower Montane Areas of PT Weda Bay Nickel's CoW, PT Hatfield Indonesia (2008);
- Fauna and Supplementary Flora Survey in Lowland Areas of PT Weda Bay Nickel's Contract of Work, PT Hatfield Indonesia (2008); and
- Gunung Zohra Karst Biodiversity and Biogeography PT Weda Bay Nickel, PT ERM Indonesia (2008).

Lowland Flora

The flora survey in lowland areas was conducted between elevations of 0 and 500 meters above sea level (see Map 14 of flora and fauna survey locations). The survey collected data from the following habitat types:

- Mangrove and Freshwater Swamp Forests;
- Lowland Forests on Alluvial Soil; and
- Lowland Forests on Ultra Basic Soil.

Based on the analysis of a remote sensing data and site observation, transect locations were chosen to encompass all major vegetation types of the lowland area. A total of 15 transects were established to provide vegetation data on the ecosystem types. **Table 21** provides details for each transect. Transect dimensions varied from 20 m x 60 m to 500 m, depending on diversity of the vegetation and physical extent of the particular forest type. The transects were established perpendicular to environmental change gradient. To obtain additional information on the floristic diversity, general exploration was also carried out.

Table 21 UTM Coordinates and Conditions of Each Lowland Transect

Transect	Length	Habitat Type/Geology	Condition	Forest Status	East	North
TTR-01	160 m	Mangrove	High-salinity, seaward habitat	CPF	386263	52607
TTR-02	300 m	Mangrove + FW swamp	Inland mangrove association	CPF	389924	52680
TTR-03	360 m	Alluvium	Bush and early secondary	CPF	391513	52984
TTR-04	500 m	Alluvium	Mature secondary and primary	CPF	388151	52765
TTR-05	500 m	Alluvium	Secondary forest	CPF	386402	54104
TTR-06	500 m	Ultra basic	Disturbed primary forest	CPF	390169	55253
TTR-07	500 m	Ultra basic	Primary forest	CPF	387521	54382
TTR-08	500 m	Ultra basic	Primary forest	CPF	385155	55451
TTR-09	500 m	Ultra basic	Primary forest	PF	388164	57331
TTR-10	500 m	Ultra basic	Primary forest	PF	392944	55330
TTR-11	60 m	Ultra basic	Regenerating vegetation	PF	392901	55294
TTR-12	500 m	Ultra basic	Primary forest	CPF	391727	54172
TTR-13	380 m	Alluvium	Primary forest	CPF	384436	52413
TTR-14	260 m	Alluvium	Bush and early secondary	CPF	382660	51876
TTR-15	200 m	Alluvium	Primary forest	PF	380052	63293

Note CPF – Conversion Production Forest, PF- Production Forest

The Rubiaceae family had the highest number of species (29) and genus (16), followed by Euphorbiaceae (26 species, 16 genera) and Myrtaceae (26 species, 7 genera). The list of most abundant families is provided in **Figure 17**.

Reflecting the floristic diversity of Halmahera, there were at least 55 tree species (from the total of 317 species) represented by only one individual, including some important or protected species.

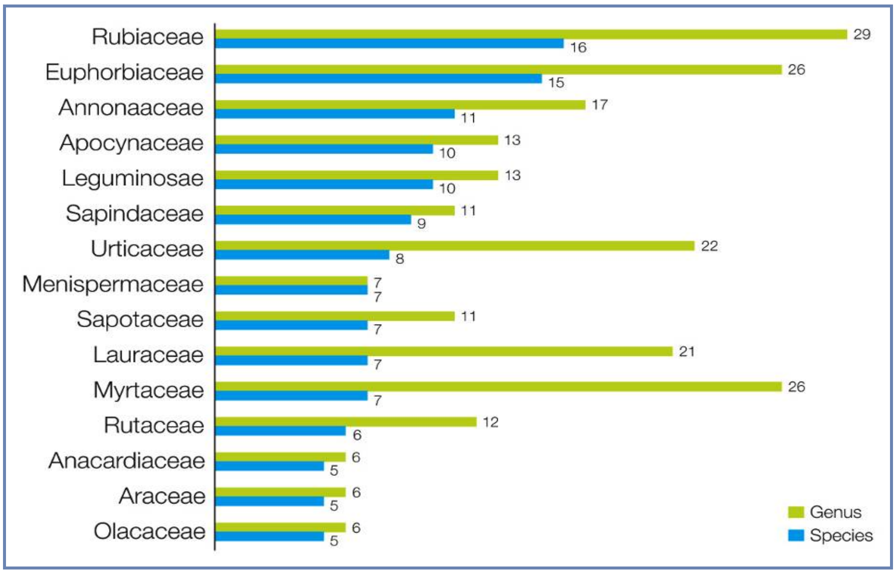


Figure 17 ***Most Abundant Families and Genera***

Some of the common species with relatively even distribution included *Vatica rassak, Canarium sylvestre and Syzygium fastigiatum*. On the other hand, abundant species with limited distribution were *Melochia umbellate* and *Piper aduncum*. Both are secondary forest species that require open areas for establishment.

Some species were not abundant but had wide distributions, e.g. *Kejilbergiodendron hylogeiton, Pometia pinnata, Mezzetia parviflora* and *Planchonela moluccana*. These species yield fruits that are well dispersed by animals (Ridley 1930; Pijl 1982).

Tree density can be used to gauge the health and succession status of forest ecosystems (**Figure 18**). The Mangrove (i.e. TTR-01) and the forest on ultra basic soils (i.e. TTR-06, TTR-08, TTR-09 and TTR-12) had the highest numbers of trees above 20 cm diameter, indicating their relatively undisturbed conditions. High density of poles in the forest on alluvial soil (i.e. TTR-05) reflects the secondary nature of this forest.

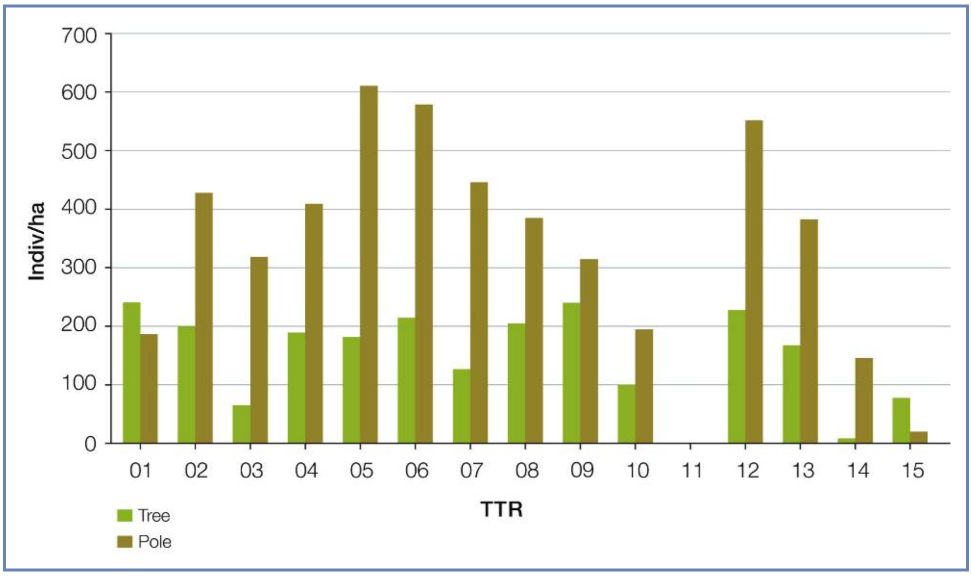


Figure 18 Density of Trees and Poles at Each Transect

Mangrove and Freshwater Swamp Forest

Mangrove forests in the study area are scattered along the coast at variable widths. Two transects were completed among the mangrove and freshwater swamp forest. TTR-01 represented a small and thin seaward mangrove community composed of three dominant species, i.e. Rhizophora appiculata, R. mucronata and Bruguiera gymnorrhiza. R. appiculata is typically dominant on soft muddy soils that are flooded by normal high tide. Only certain mangrove species are adapted to survive and develop on this kind of environment. In general, mangrove vegetation does not develop extensively in Maluku region (Monk et al 2000).

The inland mangrove at TTR-02, is a vegetation community associated with freshwater swamp showed more complexity. There were 59 species recorded as part of this mixed mangrove community. However, the dominant species remained to be *Rhizophora apiculata*, *R. mucronata* and *Bruguiera gymnorrhiza*. The common species of saline swamps were found only in the lowland transitional zone, with Inocarpus fagiferus and Dolichandrone spathacea being the most common. Some non-mangrove trees were found in low densities along the boundaries of dry terrestrial ecosystem.

R. apiculata was the only species consistently dominant at tree, pole, sapling and seedling stages. It is predicted *R. apiculata* will continue to be the main component of this mangrove community in the future.

In open areas, fern and woody liana species are abundant, e.g. Acrostichum aureum, Salacia macrophylla, Deris trifoliata, Lophopyxis maingayi, Pandanus polycephalus and Tylophora flexuosa. These species are also present along streams, indicating disturbed or damaged mangrove vegetation.

Lowland Forests on Alluvial Soil

Five transects were established in forests developed on alluvial soil. Vegetation at each transects displayed different species composition, indicating high species heterogeneity. Most genera were only represented by one or two species, except for the common genera of Calophyllum, Cryptocarya, Ficus, Garcinia and Syzygium.

Alluvial soils are generally fertile and support a diverse community of plants (Whitmore, 1990). However, alluvial forests are also prone to land conversion for agriculture and other human disturbances due to ease of access and the rich soils. This seems to have been the case at Halmahera as well. Characteristic plant families of undisturbed alluvial forests of Maluku are Myrtaceae, Burseraceae, Lauraceae, Lecythidaceae, Dipterocarpaceae and Ebenaceae.

In TTR-03 covering bush and secondary vegetation, Sterculia macrophylla (local: Kerbang Kubung) and Ficus variegate (local: Gondang Putih) were most dominant among the 19 species recorded at the tree stage, following by Polysias nodosa (local: Jaranan), Macaranga tanarius (local: Mara), Artocarpus teysmannii (local: Cempedak) and Pometia pinnata (Local: Matoa). At the pole stage, Polyscias nodosa and Jagera serrata were dominant. Sapling stage was the most diverse with 43 species recorded, with Jagera serrata, Gnetum gnemon (local: Melinjo), Champeria manillana and Piper aduncum (local: Kisereuh) being the most common. Dominant bush and herb species included Nephrolepis biserrata (local: Pakis Kelabang), Scleria purpurascens and Imperata cylindrical (local: alang-alang), while the common liana species were Tetracera nordtiana, Gnetum gnemonoides (local: Akar Bikat), Flagellaria indica (local: Owar) and Arenga pinnata (local: Aren).

TTR04 was located in primary and mature secondary forest. At the tree stage, important timber species of *Vatica rasak* (local: Resalkhiru) and Intsia palembanica (local: Merbau) were among the most dominant species. Vatica was also abundant in regeneration indicating that the species will continued to comprise a major component of this forest in the future barring human disturbance. The vegetation was quite diverse, with 45, 37 and 94 species recorded at tree, pole and sapling stages, respectively. *Anisoptera thurifera*, another timber species belonging to Dipterocarpaceae family, were scattered as trees but their regeneration was almost non-existent. Other prominent tree species included: *Artocarpus teisjmanniana*, *Canarium sylvestre*, *Pimelodendron amboinicum*, *Jagera serrata*, *Kjellbergiodendron hylogeiton*, *Gnetum gnemon* and *Pigafetta filaris*.

Vegetation at TTR-05 mostly consisted of secondary forest species. Some of the prominent species included: Gironniera subaequalis, Haplolobus celebicus, Macaranga tanarius, *Trichospermum morotaiense*, *Calophyllum soulattri*, Prunus arborea and Syzygium fastigiatum. Clear distinction from TTR-04 is the complete absence of Vatica and Intsia, which are apparently limited in their dispersal range and not able to colonize during early stages of forest succession. Rattan, Calamus holrungii, was also common.

TTR-13 consisted of mostly primary forest vegetation. Unique for this transect was the dominance by Buchanania amboinensis. Importance ranking and species composition varied from primary forest at TTR-04 transect, although many species (such as Vatica rassak, Artocarpus teysmannii and Lophopetalum javanicum) were shared between the two transects.

TTR-14 covering bush vegetation only contained three individuals of trees larger than 20 cm diameter. The species were Girroniera subaequalis, Planchonella oxyedr and Mezzettia parviflora. Pole, sapling and seedling stages were dominated by *Macaranga* spp., Timonius celebicus, Ficus amplelas, Trichospermum morotaiense and Planchonella spp. The area will naturally develop into a secondary forest composed of these early succession species.

TTR-15 located in Ake Djira shared many species in common with other lowland forests, although the species composition was distinct due to the distance from other alluvial transects.

Vatica rassak was overwhelmingly dominant at the tree (≥ 20 cm diameter) class and with Anisoptera thurifera, comprised 46% of the stand basal area. Canarium maluense, Syzygium racemosum and Payena lucida followed in importance values.

Pole stage trees were scarce, with a density of only 200 poles/ha. Of the nine species recorded, Vatica rassak, Diospyros ulo, Garcinia riedeliana and Payena lucida were the most dominant. At the sapling stage, Diospyros cf. truncate was the most important species, followed by Vatica rassak, Garcinia riedeliana and Syzygium racemosum. Seedling stage was dominated by Garcinia celebica, Anisoptera thurifera and Vatica rassak.

Lowland Forest on Ultra Basic Soil

Seven transects (TTR-06, TTR-07, TTR-08, TTR-09, TTR-10, TTR-11 and TTR-12) were located in forests on ultra basic soils which were generally not disturbed (except for TTR-07 and TTR-11).

The species composition of forests on ultra basic soil varied from site to site, and species richness averaged 108 species per ha. Forests on ultra basic soils are generally species poor due the unfavorable nutrient status and metal cation toxicity (e.g. Al, Mg, Fe and Ni). However, the survey found that highly diverse forests had developed on ultra basic soils in Halmahea, composed of vegetation communities that are tolerant of the prevailing conditions. The variation in species composition is likely due to differences in micro habitat conditions, such as slope, aspect and hydrology.

The common occurrence of *Gironniera subaequalis* and lack of commercial timber species indicate some level of human disturbance in this forest. *Garcinia, Calophyllum, Syzygium* and *Canarium* were some of the most common genus represented. *Dacrydium novoguinensis* was also common at the tree stage.

The typical primary forest species were dominant at TTR-07. High frequencies of *Vatica rassak, Anisoptera thurifera, Pometia pinnata* and *Artocarpus teysmannii* indicate that the forest in the area has not been disturbed. These species were also observed to be regenerating well. *Duabanga moluccana*, a protected species was abundant in this transect.

The species composition at TTR-08 was quite different from TTR-07. *Syzygium fastigiatum* was a dominant feature, along with *Drypetes microphyllus, Canarium maluense, Terminalia supitiana, Lophopetalum javanicum, Ardisia forstenii* and *Calophyllum persimile*. *Vatica* was less prominent in this transect.

Dominance by *Canarium sylvestre, Calophyllum spp., Castanopsis buruana, Syzygium fastigiatum, Vatica rassak* and *Diospyros ulo* characterized TTR-09. *Calophyllum suberosum, Diospyros rostrata, Semecarpus forstenii* and *Endiandra forbesii* were abundant at sapling and seedling stages.

Vatica rasak was clearly the dominant tree species on TTR-10. *Planchonella moluccana, Kjellbergiodendron hylogeiton, Diospyros ulo* and *Livistona rotundifolia* were also prominent. *Hopea papuana* and *H. dryobalanoides* were recorded at sapling and seedling stages but in low densities. *Timonius rufescens, Piper aduncum* and *Vatica rassak* were the dominant species in regeneration.

TTR-11 was located in a quarry area where early successional vegetation was starting to regenerate. As such, no trees above 10 cm diameter were recorded. On a few species have been able colonize the open site at this stage. *Melochia umbellata, Piper aduncum, Pipturus subinteger, Timonius rufescens, Macaranga tanarius* and *Paraserianthes falcataria* were among the most common. These are early pioneer species and will not be a long-term component of the regenerating forest, except for *P. falcataria* (rain tree) which can attain large sizes.

Hopea dryobalanoides, which was infrequent at other transects, was among the dominant tree species at TTR-12. *Vatica rassak, Drypetes microphyllus* and *Syzygium lineatum* also had high importance values as trees and poles. *Vatica* and *Hopea* were also dominant in regeneration, along with *Semecarpus forstenii, Gnetum gnemon* and *Haplolobus celebicus*.

Species Richness and Diversity. Species richness varied significantly among the transects, depending the forest type, geology, topography, micro habitat conditions and level of human disturbance. The number of species per transect ranged from three to 269 species, averaging 186 species per ha (as shown in **Figure 19**). When compared to terrestrial ecosystems on larger islands such as Papua, Kalimantan and Sumatra, plant species richness of the study area was relatively low. This is a typical phenomenon of the Halmahera island geography.

Primary forests on ultra basic soils (i.e. transects TTR-06, TTR-09 and TTR-12) had the highest species richness of the lowland forests. The high species richness is due to a combination of factors including habitat characteristics and disturbance history (or lack thereof). The Mangrove Forest (i.e. transects TTR-01 and TTR-02) recorded the lowest species richness. The Margalef Richness Indexes recorded in the mangrove area were R_{TTR-01}=0.13 and R_{TTR-02}=1.89, which ranked 12th and 14th in the transect results. Despite the high density of species in the mangrove transects (density values of 241 for TTR-01 and 198 for TTR-02), vegetation tended to be homogeneous and consisted of fewer numbers of species, yielding low diversity indexes (H'_{TTR-01}=1.08 and H'_{TTR-02}=0.96). These H' indexes ranked last out of the 14 transects (note that the H' range for ultra basic soils was 3.15-3.68 and H' range for alluvial complex was 1.09-3.28).

Species diversity is determined by species richness and pattern of distribution. High number of species distributed evenly across the landscape in low densities result in high diversity. The lowland forest on ultra basic soils, given its habitat characteristics and lack of disturbance, is home to the highest species richness (the R range was 8.7-11.0 compared to mangrove's R range of 0.36-1.89). TTR-06, TTR-08 and TTR-09) had the highest diversity values (H'_{TTR-06}=3.68 H'_{TTR-08}=3.47 and H'_{TTR-09}=3.46). This pattern positively correlated to the species richness trend (transects 06-12, corresponding to the ultra-basic soils, recorded the highest diversity and species richness indexes). In general, those transects with high diversity values represent relatively undisturbed stable forest communities.

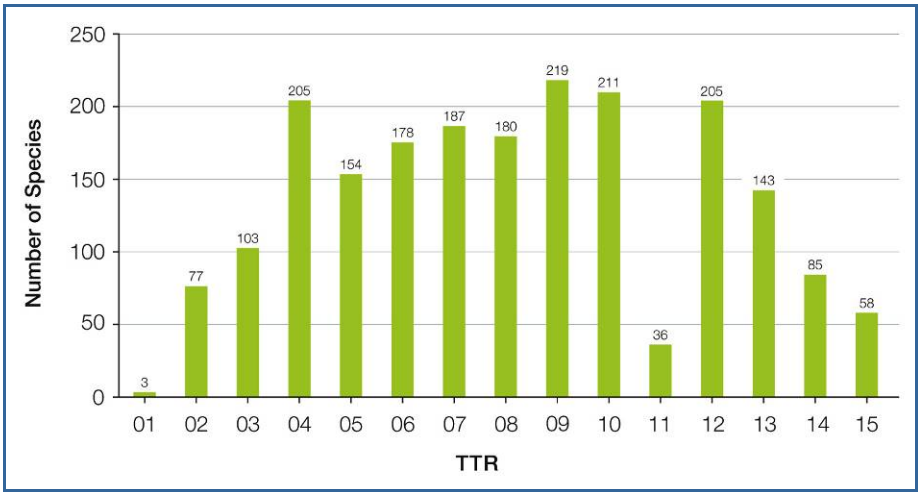


Figure 19 The number of species recorded in each transect.

Summary of Lowland Flora

Floristic richness and diversity values were high for the Maluku region, as seen in survey results for the Margalef richness index (R ranging 0-36-1.89 in mangroves to 8.51-11 in ultra-basic soils) and the Shannon-Wiener index (H' ranging 0.96-1.08 in mangroves to 3.15-3.68 in ultra-basic soils). The survey recorded 530 species from 311 genera and 117 families. The floristic composition varied significantly across and even within the forest types, which indicates the influence of micro-habitat characteristics.

The number of species per transect ranged from three to 269 species, averaging 186 species per ha. There were common species with relatively even distribution (Vatica rassak – 58 individuals in 32 sub-plots at six transects). There were abundant species with limited distribution (Melochia umbellate – 115 individuals in six sub-plots a one transect). Some species were not abundant but had wide distributions (Kejilbergiodendron hylogeiton – 13 individuals in 13 sub-plots at five transects). Some species were new records for North Maluku. There were at least 55 tree species (from the total of 317 species) represented by only one individual. Species richness and composition varied significantly, influenced by forest type, geology, topography, micro habitat conditions and level of human disturbance. Primary forests on ultra basic soils were the most diverse and species rich. Transects representing ultra-basic soils (TTR-06, TTR-08, TTR-09 and TTR-12) displayed the highest number of tress above 20cm in diameter.

Among the species recorded during survey, there were several species with significant economic and ecological importance. Three species protected under CITES Appendix II were found, namely gaharu (Aquilaria filarial and A. parvifolia) and ramin (Gonystylus macrophyllus). Valuable timber species of Intsia were scattered in low densities as were several species in the family Dipterocarpaceae. Of the Dipterocarpaceae family, which yield high-quality timber, only Vatica rasak was abundant.

The survey results highlight the ecological uniqueness of forest ecosystems in Halmahera, which is due to its geographical location, geology, variation in topography and isolation from other land masses (which drives the level of human disturbance). Floristic composition varied significantly across and within forest types (i.e., species density in alluvial complex ranged 6-168 and species richness index R ranged 1.12-8.38). The forests are apparently sensitive to human disturbance, as some primary forest species were not regenerating even in mature secondary forests.

Lower Montane Flora

The lower montane flora survey was conducted between elevation 700 m and 1,200 m above sea level. Based on the analysis of a remote sensing data and site observation, transect locations were chosen to encompass both secondary and primary vegetation of the lower montane area. A total of eight transects were established on lower montane forest, the details of which are shown in the Table 22. The number of transects were sufficient to capture the representative species composition of lower montane forest ecosystem.

Table 22 UTM Coordinates and Conditions of Each Lower Montane Transect

Transect Code	Elevation (m a.s.l.)	Geology	Forest Status	Land Cover	UTM Coordinates WGS 84	
					Easting	Northing
TTR-LM01	700	Ultra basic	PPF	Primary forest	388675.62	59488.12
TTR-LM02	900	Ultra basic	PPF	Primary forest	387783.64	60795.90
TTR-LM03	850	Ultra basic	PPF	Primary forest	387615.28	61040.68
TTR-LM04	900	Ultra basic	PPF	Primary forest	387340.18	61162.99
TTR-LM05	915	Ultra basic	PF	Primary forest	386088.45	60637.97
TTR-LM06	940	Ultra basic	PF	Primary forest	385944.71	60313.55
TTR-LM07	850	Ultra basic	PF	Primary forest	386545.43	58952.46
TTR-LM08	1,222	Ultra basic	PPF	Primary forest	390836.76	65054.27

Note PPF – Permanent Production Forest; PF- Production Forest

The lower montane forest is home to distinct species from nearby islands and from the lowland forest in Halmahera. Gymnosperm of Australian origin (Dacrydium novo-guineense in the Podocarpaceae family) was the most dominant canopy species with the highest overall basal area and importance value. Agathis celebica (Damar) was dominant in one transect (TTR-LM07) but mostly absent in all other transects. The reason for their clumped distribution may be anthropological but this could not be confirmed. Tree pandanus (Pandanus sp.) was also abundant and composed the lower canopy with other tree species.

The vegetation of the Lower Montane forest was dense and exhibited relatively high diversity for a montane ecosystem in the Maluku region (H' ranging 2.99-4.19 for seedlings, 4.41-4.78 for saplings, 3.00-4.26 for poles, and 4.38-4.91 for trees). The survey recorded 231 species from 129 genera and 53 families. Tree families represented by high numbers of species include: Myrtaceae, Rubiaceae, Clusiaceae, Euphorbiaceae, Lauraceae and Sapotaceae (Figure 20). Complete list of plant species recorded is presented in Appendix B-1.

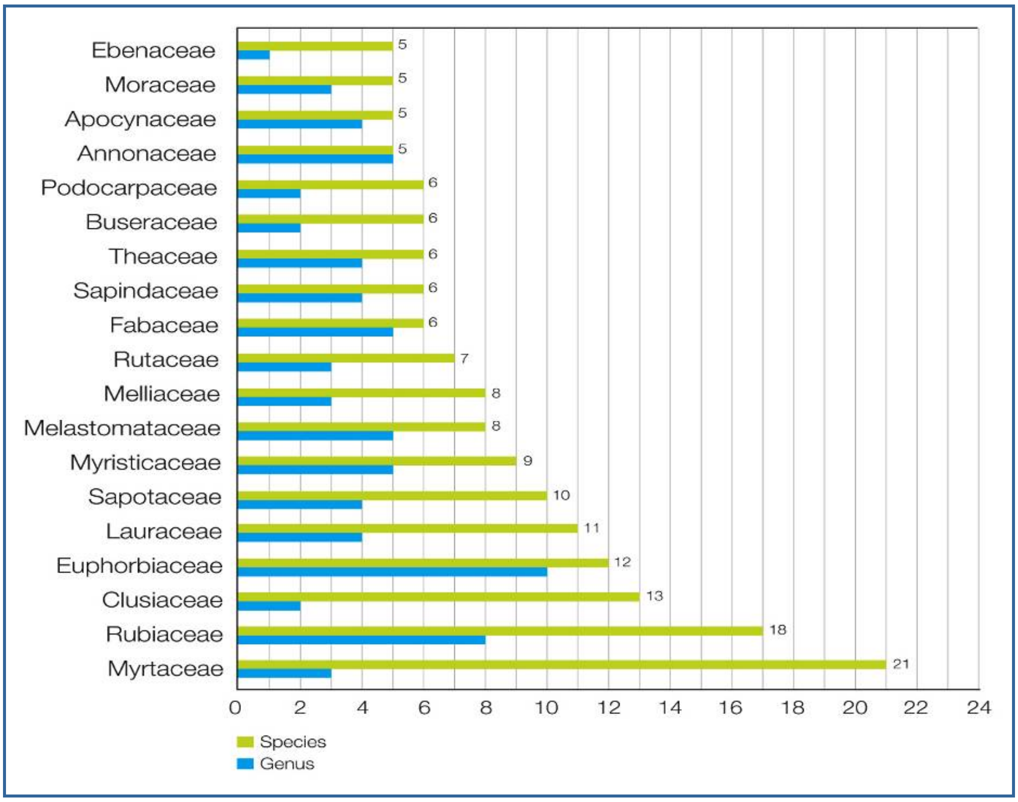


Figure 20 Most abundant tree families and genera.

Tree species at various growth stages with the highest Importance Value Index (IVI) are shown in **Table 23**. Many of the dominant canopy species are hardly represented as saplings. Only two species, *Calophyllum soulatri* (Bintangor hitam or kuning) and *Castanopsis acuminatissima* (Yoi) are consistently abundant at all three growth stages.

Dacrydium novo-guineense (Jewe nikolano), *Calophyllum* spp., *Garcinia celebica* (Bneng) and *Castanopsis accuminatissima* are dominant at the ≤20 cm diameter class. At the pole stage, the importance of *Dacrydium* declines, as *Gironniera subaequalis* (Manines), *Ploiarium sessile* and *Kibara kostermansii* become more abundant. Species composition changes again at the sapling stage, with species such as *Aglaia sylvestris*, *Symplocos cochinchinensis*, *Eurya accuminata*, *Timounius macrophyllus* and *Gordonia papuana* comprising prominent component of the community.

Calophyllum soulatri was the dominant species at the seedlings stage, having the highest importance values in all transects. Other species with generally high importance values include *Castanopsis acuminatissima, Garcinia microphylla* (Bneng), *Gordonia papuana* and *Syzygium tetrapterum* (Goglaw) (**Appendix B-1**). It should be noted that seedlings represent an ephemeral stock, a large percentage of which will not make it to the next growth stage.

Calophyllum soulatri continued to be the dominant species at the sapling stage, but the importance values are more spread out among a larger number of species. *Symplocos cochinchinensis, Gordonia papuana, Litsea firma* and *Gironniera subaequalis* were also among the prominent species as saplings (**Appendix B-1**).

Table 23 Top 10 most dominant tree species at each growth stage

Scientific Name	Local Name	IVI Value of Transect No:							
		1	2	3	4	5	6	7	8
Sapling									
Calophyllum soulatri	Baftong/bintangur kuning	4.2	6.76	5.29	9.43	8.97	5.72	12.98	19.68
Aglaia sylvestris		2.8	8.12	17.7	1.35	8.13	5.72	5.72	1.79
Symplocos cochinchinensis	Ai Fofo	11.2	9.46	16.4	NA	2.99	1.91	5.27	3.58
Eurya acuminate		2.8	4.06	1.76	14.81	5.98	NA	NA	8.95
Gironniera subaequalis	Manines	5.6	5.41	3.53	9.43	1.5	3.81	8.78	3.58
Pole									
Calophyllum persemile	Bintangur hitam	45.22	11.09	NA	NA	30.52	17.06	58.37	NA
Gironniera subaequalis	Manines	14.41	6.45	25.04	NA	42.68	11.66	13.57	NA
Castanopsis acuminatissima	Yoi	22.3	11.09	31.04	NA	4.18	11.66	26.24	37.66
Dacrydium novo-guineense	Jewe Nikolano	3.6	9.68	12.52	NA	18.56	17.48	NA	NA
Calophyllum soulatri	Baftong/bintangur kuning	13.66	20.36	8.35	NA	10.21	NA	6.79	36.1
Tree									
Dacrydium novo-guineense	Jewe Nikolano	83.52	66.73	73.81	NA	40.25	52.69	20.37	NA
Calophyllum soulatri	Baftong/bintangur kuning	41.22	12.51	20.19	NA	45.13	34.83	23.5	43.75
Garcinia celebica	Bneng	22.48	35.31	16.55	NA	39.44	30.89	NA	NA
Castanopsis acuminatissima	Yoi	13.99	2.52	43.34	NA	20.69	11.49	26.75	4.24
Calophyllum persemile	Bintangur hitam	37.07	16.08	28.16	NA	NA	22.15	12.46	3.96

Note: NA: Species was not available

At the pole stage, *Calophyllum persimile* had the highest overall importance value, followed by *Castanopsis acuminatissima*, *Calophyllum soulatri*, *Gironniera subaequalis* and *Dacrydium novo-guineense* (**Appendix B-1**).

The lower montane forest in Halmahera is characterized by the dominance in the forest canopy of *Dacrydium novo-guineense*. The species was infrequent at the seedling and sapling stages, indicating their limited seed production and/or requirement of open conditions for regeneration. Other dominant species at this stage were *Calophyllum soulatri, Calophyllum persimile*, *Garcinia celebica, Castanopsis acuminatissima, Campnosperma brevipetiolatum* (Malalong) and *Planchonella firma* (Ron) (**Appendix B-1**).

The most dominant species of herbaceous vegetation were *Nepenthes papuana* (pitcher plant) and *Tapeinidium amboinense* (terrestrial fern). Among the non-woody climbers, *Freycinetia amboinensis* (climbing pandanus) was dominant. Tree pandanus (only identified to genus, *Pandanus*) was also abundant and widely distributed. For woody lianas, *Hypserpa* sp*., Alyxia composite* and *Smilax amboinensis* were the most conspicuous (**Appendix B-1**). *Calamus* sp. (rattan) were scattered in low densities.

Species Richness and Diversity. Diversity indices were similar across all transects (H' values ranged 2.83-4.19 for seedlings; 4.41-4.81 for saplings; 3.00-426 for poles; and 4.38-4.91 for trees). The number of species of trees (≥ 20 cm diameter), poles and saplings per transect were fairly consistent, ranging from 21 to 28, 15 to 29 and 50 to 71, respectively (note that total number of species for Lowland Forestry displayed a higher range of records: 77-219 species per transect, with notable exceptions in TTR-01 and TTR-11).

Compared to lowland forest in Halmahera, species richness, which is a function of the number of species recorded in a given transect, was significantly lower in the lower montane forest due to its altitude (the range of species per transect was 77-219 in the Lowland compared to 21-70 in the Lower Montane). However, given that diversity is determined by species richness and pattern of distribution, the range of H' indexes for the Lower Montane (2.83-4.91) is higher than the range of H' indexes found in the Lowland forest (0.96-3.68).

Species diversity in the Lower Montane is lightly higher than those found in the Lowland Forest, indicating a well-balanced spatial distribution of various species.

Forest Stand Structure. Density of trees above 20 cm diameter was slightly higher on average than that of lowland primary forest in Halmahera, and similar across the all lower montane transects. Basal area was relatively consistent, with values significantly lower than intact lowland forests due to lesser frequency of large diameter trees. This is an expected phenomenon for forests at higher altitudes. TTR-LM08, located at the highest elevation (1,220 m), had the lowest basal area and density of trees above 20 cm diameter among all transects (excluding regenerating vegetation on TTR-LM04).

Summary of Lower Montane Flora

The Lower Montane forest was dense, relatively species rich and diverse, with intact structure and healthy dynamics, as seen in results of the Margalef richness index (R) and the Shannon-Wiener index (H'). The survey recorded 231 species from 129 genera and 53 families, including two species suspected to be new discoveries.

The forest was also abundant in epiphytes. Trees species of economic and ecological importance include: Agathis celebica (dammar), Aquilaria filaria (gaharu) and Dacrydium spp. Aquilaria is protected under CITES Appendix II, as are all species of Nepenthes (pitcher plant) and orchid family. Conifer of Podocarpaceae family (Dacrydium novo-guineense) was the most dominant canopy species, followed by Calophyllum spp. (Bintangor), Castanopsis acuminatissima and Garcinia celebica. Epiphytes, climbing pandanus (Freycinetia amboinensis), tree pandanus (Pandanus sp.), Nepenthes (pitcher plant) and fern (Tapeinidium amboinense) were abundant among the non-tree vegetation.

A. Karst Flora

Literature reviews suggest that not many studies on karst flora have been conducted in Indonesia, including no recent publication on karst vegetation in Halmahera. Plants growing on limestone face many limitations such as shallow soils with high calcium and magnesium content, free draining rock substrate, exposure to full sunlight, severe water stress and high temperatures during dry periods. Such conditions have the potential to create unique vegetation communities, and as such a specific survey of flora in the Karst formation with the Weda Bay Contract of Work has been conducted.

The karst flora survey was conducted in the Zohra Mountain region between the elevations 50 m to 175 m above sea level. Zohra Mountain is located in the karst formation directly west of Sagea Lagoon and in the area identified as a limestone resource.

The survey investigated flora composition in the east and the west of the karst. Vegetation plots were surveyed using transects with systematic sampling design of size 20 m x 200 m (Figure A1-3). A total of 10 transects were established, five in the eastern Karst and five in the western Karst, as detailed in **Table 24** below (Source: Gunung Zohra Karst Biodiversity and Biogeography, ERM November 2008).

Table 24 UTM Coordinates and Conditions for Each Karst Transect

Transect Code	Elevation (m a.s.l.)	Geology	Forest Status	Land Cover	UTM Coordinates WGS 84	
					Easting	Northing
TKE-1	115	Chalky Lime stone	CPF	Secondary Forest	395020.27	53338.04
TKE-2	115	Chalky Lime stone	CPF	Secondary Forest	394837.91	53534.59
TKE-3	80	Chalky Lime stone	CPF	Secondary Forest	394847.19	53614.43
TKE-4	80	Chalky Lime stone	CPF	Secondary Forest	394859.57	53718.83
TKE-5	70	Chalky Lime stone	CPF	Secondary Forest	394884.09	52186.55
TKW-1	175	Chalky Lime stone	CPF	Secondary Forest	394664.86	54013.64
TKW-2	170	Chalky Lime stone	CPF	Secondary Forest	394723.59	53930.73
TKW-3	140	Chalky Lime stone	CPF	Secondary Forest	394751.40	53841.67
TKW-4	115	Chalky Lime stone	CPF	Secondary Forest	394794.66	53764.90
TKW-5	100	Chalky Lime stone	CPF	Secondary Forest	394850.29	53663.56

Note: CPP: Conversion Production Forest

The survey recorded 113 species from 54 families. Families with the high number species include Euphorbiaceae (9 species), Rubiaceae (7 species), Arecaceae (6 species), Annonaceae (5 species) and Lauraceae (5 species). These families are similar to the families with high species abundance found in other lowland forest types (i.e. lowland forest on alluvial and ultrabasic soils). A complete list of species found in the Karst Forest is presented in **Appendix B-1**).

Species Dominance (Importance Value). Tree species with the highest Importance Value Index (IVI) at various growth stages for the eastern karst area are shown in Table 25. These results demonstrate that species Polyalthia glauca is the most dominant for all growth stages within the eastern part of Gunung Zohra area. In addition Diospyros ferrea and Manilkara sp. are also dominant in eastern karst area. This result indicates that, in general, that forest regeneration is stable.

Table 25 Top 5 most dominant tree species at each growth stage on Southern Karst Area

No.	Scientific Name	Local Name	IVI (%)
	Sapling		
1	*Polyalthia glauca*	Kayu Bulan	20,30
2	*Diospyros ferrea*	Kayu Coromandel	19,63
3	*Mallotus peltatus*	Tofa	13,48
4	*Manilkara* sp.	Sawo	11,48
5	*Aglaia lowii*		11,31
	Pole		
1	*Polyalthia glauca*	Kayu Bulan	58,35
2	*Diospyros ferrea*	Kayu Coromandel	28,42
3	*Gulibia costata*		27,70
4	*Manilkara* sp.	Sawo	15,60
5	*Mallotus peltatus*	Tofa	14,74
	Tree		
1	*Manilkara kanoensis*	Kayu Torem	52,24
2	*Manilkara* sp.	Sawo	38,43
3	*Polyalthia glauca*	Kayu Bulan	32,30
4	*Kjelbergiodendron celebicum*		21,72
5	*Diospyros ferrea*	Kayu Coromandel	18,97

Tree species with the highest IVI values at various growth stages for the western karst area are shown in Table 26. The results show that the western part of Gunung Zohra is dominated by *Manilkara* sp. (ron) and *Manilkara kanoensis* (lalon) trees species, from family Sapotaceae, once again implying a stable and healthy process of forest regeneration.

Table 26 Top 5 most dominant tree species at each growth stage on northern Karst Area

No.	Scientific Name	Local Name	IVI (%)
	Sapling		
1	*Manilkara* sp.	Sawo	20,21
2	*Actinodaphne multiflora*		17,86
3	*Kjelbergiodendron celebicum*		13,95
4	*Polyalthia glauca Boerl.*	Kayu Bulan	12,85
5	*Aglaia lowii*		11,59
	Pole		
1	*Mallotus peltatus*	Tofa	26,60
2	*Polyalthia glauca*	Kayu Bulan	10,49
3	*Manilkara* sp.	Sawo	6,14
4	*Gulibia costata*		11,00
5	Lalingen	Lalingen	8,95
	Tree		
1	*Manilkara* sp	Sawo	67,88
2	*Manilkara kanoensis*	Kayu Torem	52.24
3	*Pometia pinnata*	matoa	34,45
4	*Polyalthia glauca*	Kayu Bulan	26,58
5	*Hopea nodosa*	Wiriku (papua)	22,39

Note: Lalingen is the local name as this species has not been identified

The dominant vegetation compositions for Gunung Zohra Karst demonstrate that both locations, i.e. the eastern and western, have similar dominant species although with various IVI ranks for each growth stage (vegetation structure). Generally, the eastern part is dominated by *Polyalthia glauca* and the western part is dominated by *Manilkara* sp.

In general, the species found in Gunung Zohra Karst seem to grow in non-karst areas as well (meaning their distribution is not restricted to karst). For instance, a 2001 LIPI study indicates that *Alstonia scholaris* (Pulai), *Macaranga involucrate* (Aigemen) and *Arcangelisa flava* (Tali Kuning) are widely found outside Halmahera. Pulai is a high tree of the Apocynaceae family, with a height of 25 m and diameter of 40-60 cm, widely distributed in Sumatra, Kalimantan, Sulawesi and Papua (Heyne 1987). Aigemen is a plant originated from Maluku and well distributed in Ambon, North Halmahera and Ternate (Heyne 1987). Tali Kuning is a climber plant of the Menispermaceae family, with a heath reaching 20 meters and widely found in Sumatra, Java, Ambon and North Halmahera (Heyne 1987).

The eastern and western parts of the karst display similar Evenness ($E_{eastern}$ = 0.80 and $E_{western}$ = 0.74) and Diversity indexes ($H'_{eastern}$=3.03 and $H'_{western}$ = 2.64). The November 2008 ERM study reported H'= 3.20 and E = 0.87 for a control non-karst area. Such figures indicate that apart from the high number of flora species in the Gunung Zohra Karst, none are endemic to the specific karst area (based on the distribution of species found).

Species Richness and Diversity. It was found that the eastern part of Gunung Zohra is relatively richer (Margalef index = 7.50) and more diverse (H'=3.03) in species than the western part (Margalef index = 5.36 and H'=2.64). In addition, species richness and diversity of Gunung Zohra is considered less than that of the lowland forest on alluvial and ultra basic soils but greater than the freshwater swamp and mangrove forest. As discussed in previous sections, the value of species richness is influenced by the number of individuals found, thus locations with similar number of species, but with different number of individuals, will produce different species richness. Areas with higher number of individuals will usually produce lower species richness.

Forest Stand Structure. Density of vegetation in karst area is 190 individuals/ha which is which is comparable with lowland forest. Diameter distribution of trees at both karst locations show reverse-J curve relationship (see Figure 21 and Figure 22) indicating the vegetation condition is normal and regeneration is undergoing.

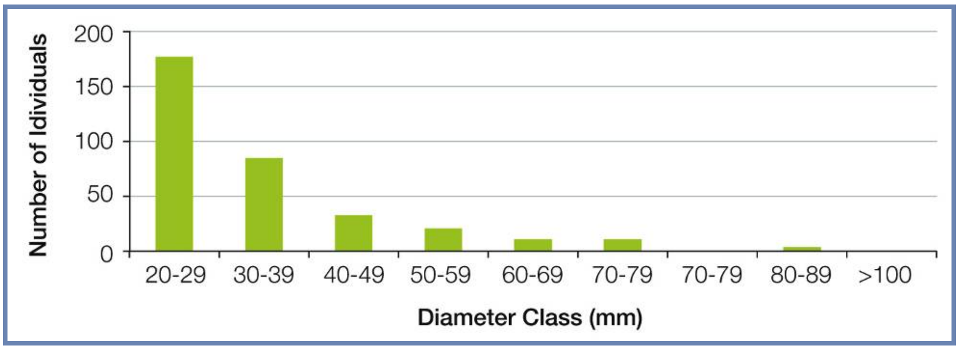


Figure 21 *Distribution of Tree Diameter Class for the Eastern Part of Gunung Zohra Karst*

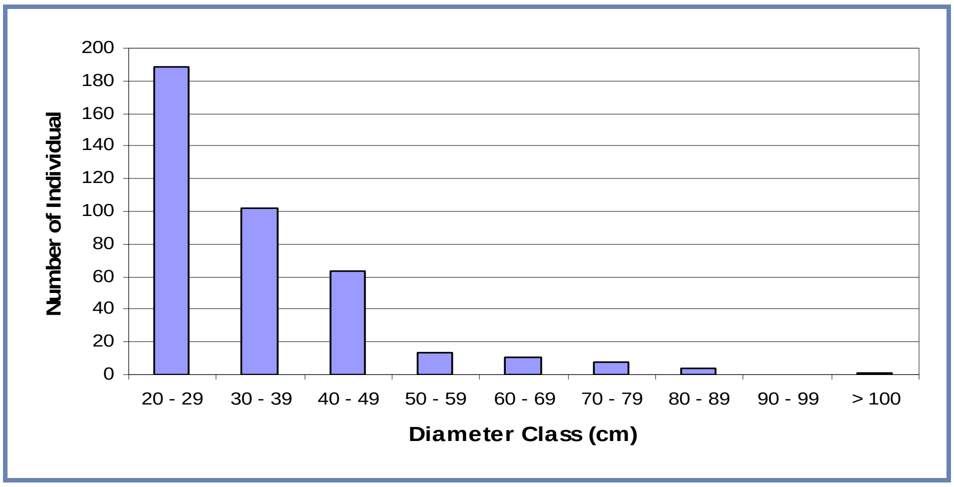


Figure 22 *Distribution of Tree Diameter Class for the Western Part of Gunung Zohra Karst*

Summary of Karst Flora

The vegetation structure of the study areas, the karst forest is dominated by small diameter trees. This implies a condition of normal habitat, meaning that regeneration is well taking place. Vegetation in the other lowland forests types is denser and higher in number than those in karst. Overall, there is no significant difference between species dominating the eastern and western part of the karst, although the Important Value Index (IVI) Ranks for the species showed different order.

The Shannon Diversity Index (H') for the Eastern Karst is 3.03 and its Evenness Index (E) is 0.80. For the Western Karst, H' is 2.64 and E is 0.74. These values indicate medium level of flora diversity. Furthermore, The East karst had a species richness value (Margalef Index D_{mg}) of 7.50 and the West Karst has a D_{mg} of 5.36. This indicates that the eastern part of Gunung Zohra is relatively richer in species than the western part (note that locations with similar number of species but with different number of individuals will produce different species richness).

Based on the vegetation structure, the eastern part of Gunung Zohra is dominated by *Polyalthia glauca* and the western part of Gunung Zohra is dominated by *Manilkara* sp. On the other hand, there is a significant difference in dominating species between karst and other lowland forest areas. The dominant species for the western part of Gunung Zohra Karst is Sapotaceae, for the eastern part of Gunung Zohra Karst are Annonaceae, Euphorbiaceae and Sapotaceae.

Out of all the species collected, one species is endemic to Maluku, i.e. *Macaranga involucrata* (Roxb.) Baill. (Aigemen) of Family Euphorbiaceae (karst). Two species found during the Karst survey have protection status *Arenga pinnata* (Aren), found on the eastern part of Gunung Zohra Karst was the only species protected by the Indonesian Government (***Ministry of Agricultural Decree No.54/Kpts/Um/2/1972*)**, due to its multipurpose function. *Alstonia Scholaris* (Pulai) is register on the ICUN Red List as lower risk.

Important Plant Species

Important Plant Species in the Weda Bay Nickel CoW are classified as those that have economic or ecological significance. This includes species which are covered directly by the Indonesian Government laws and regulations, species which have been identified in international treaties signed by the Indonesian Government and species which provide a special function for the local people (i.e. economic, medicinal, cultural etc). Descriptions of the first two groups are presented in Section 6: Biodiversity and Conservation of Natural Resources.

Local people only use species from the lowland and karst forest types due to difficulty in access to the lower montane forest. ***Table 27*** below present plant species found in the WBN CoW which are considered to have value for local communities.

Table 27 Plants Utilized by Local People

No	Local Name	Scientific Name	Family	Form of Utilization
1	Akar kuning	*Arcangelisia flava*	Menispermaceae	Medicine
2	Pulai	*Alstonia scholaris*	Apocynaceae	Medicine
3	Pugut-pugut	*Lunasia amara*	Rutaceae	Medicine
4	Hatebesi	*Flacourtia inermis*	Flacourtiaceae	Medicine
5	Kayu lawang	*Cinnamomum iners*	Lauraceae	Medicine
6	Kyase	*Gnetum gnemon*	Gnetaceae	Vegetable
7	Pala	*Myristica holrungii*	Myristicaceae	Spice
8	Panand dr	*Panandus tectorius*	Panandaceae	Rug material
9	halus	*Manilkara kanoensis*	Sapotaceae	Construction
10	Lalon	*Manilkara sp.*	Sapotaceae	material
11	Ron	*Salacia sp.*	Celastraceae	Construction
12	Aiwale	*Dillenia spp.*	Dilleniaceae	material
13	Barudapa	*Calophyllum spp.*	Clusiaceae	Construction
14	Bintangor	*Pometia pinnata*	Sapindaceae	material
		Octomeles sumatrana		

No	Local Name	Scientific Name	Family	Form of Utilization
15 16 17 18 19 20 21 22 23 24 25	Magame Benuang Benzoet Pus Plismetet Nyatoh merah Beneng Goglau Ainongu Kalmareh Badenga Bajelak	*Haplolobus floribundus* *Aglaia elliptica* *Terminalia microcarpa* *Palaquium obovatum* *Garcinia riedeliana* *Kjelbergiodendron celebicum* *Parastemon versteghii* *Psychotria celebica* *Sysygium rubiginosum* *Diospyros sp.*	Datistaceae Burseraceae Meliaceae Combretaceae Sapotaceae Clusiaceae Myrtaceae Chrysobalanaceae Rubiaceae Myrtaceae Ebenaceae	Construction material Construction material Construction material Construction material Construction material Construction material Construction material Construction material Firewood Firewood Firewood Firewood Bridge pole Bridge pole

15.1.1.2 Terrestrial Fauna

Available literature on the vertebrate fauna (particularly the herpetofauna) of Halmahera is fragmented, difficult to access, and in many cases, erroneous. The Dames and Moore report (*Terrestrial Ecology,* 2001) conducted a thorough review of the most recent literature on reptile, birds and mammals of Halmahera in order to compile a comprehensive list of vertebrate fauna of the island. Subsequent studies have been added to this list, which indicates knowledge gaps on fauna biodiversity still exist.

With respect to other vertebrate fauna, Halmahera Island has a high bird diversity. The Island is known as a home for a number of high value bird species including Wallace's Standardwing *(Semioptera Wallace)*, White Cockatoo (*Cacatua alba*) and Chattering Lory (*Lorius garrulous*).

Halmahera Island is home to several spectacular reptile species such as the Sail fin Lizard (*Hydrosaurus ambionensis*), Halmahera Giant Gecko (*Gehyra vorax*), Blue Pinspot Monitor (*Varanus caerulivirens*), Tricolor Monitor (*Varanus yuwonoi*) and Halmahera Scrub Python (*Morelia tracyae*). However, very little is known about the amphibians on the island.

Bat species dominate mammal fauna diversity on the island. Non-flying mammal fauna is dominated by introduced species such as wild boar (*Sus scrofa*), Timor Deer (*Cervus timorensis*), Malayan civet (*Viverra tangalunga*), the Asian House Rat (*Rattus tanezumi*), Polynesian Rat (*Rattus exulans*) and the House Shrew (*Suncus murinus*). Only four species of non-flying mammal are considered native to Halmahera: two marsupials - the Ornate Cuscus

(*Phalanger ornatus*), the Sugar Glider (*Petaurus breviceps)*, and two rodents – Red Tree Rat (*Melomys fulgens*) and Moluccan Pehensile-tailed Rat (*Rattus morotaiensis*).

Fauna studies conducted in the WBN COW include:

- *Terrestrial Ecology Studies*, PT. Dames & Moore Indonesia (2001);
- Forestry Survey in Lower Montane Areas of PT Weda Bay Nickel's COW, PT Hatfield (2008);
- Fauna and Supplementary Flora Survey in Lowland Areas of PT Weda Bay Nickel's Contract of Work, PT Hatfield (2008);
- Gunung Zohra Karst Biodiversity and Biogeography PT Weda Bay Nickel, PT ERM Indonesia (2008); and
- Birdlife Survey 2007.
- The following sections build on the original 2001 Dames & Moore survey, by supplementing fauna data compiled in 2007-08 by various reputable institutions. **Table 28** capture all species found in the CoW from surveys of the past 10 years in terms of habitat, protection status and endemism.

Standard methodology for data collections for the fauna surveys included:

- Direct counting using binoculars;
- Indirect counting through observation of footprints, feces or dung, nests, calls, scent, wildlife remains (hair, feather, bone, scratches, etc.), and interviews with local guides; and
- Capture and release method for small mammals and birds through mist nets and live traps.

Data analysis is similar to methods used in the flora survey and includes calculations for density, relative density, frequency, relative frequency, abundance, relative abundance and importance value index (IVI). These calculations are then used to determine the Margalef richness index (R) and Shannon-Wiener index (H') for diversity. For more detail refer to section 3.2.2.1 A Lowland Forest Survey.

Table 28 Bird species found on WBN during survey, their protection status and endemism

Scientific Name	English Name	Local Name	Habitat			Protection		Endemism
			Karst Area	Lowland	Lower Montane	National	International	
Ardeidae								
1. Egretta garzetta*	Little Egret	Kuntul kecil				AB		
2..Bubulcus ibis*	Cattle Egret	Kuntul kerbau		x	x	AB		
3. Egretta intermedia	Intermediate Egret	Kuntul Perak			x	AB		
4. Egretta sacra	Reef Egret	Kuntul Karang		x		AB		
5. Ardea sumatrana	Great-billed heron	cangak laut		x		AB		
6. Nycticorax caledonicus	Nankeen night-heron	Kowak Merah		x	x	AB		
7. Ixobrychus flavicollis	Black bittern	Bambangan Hitam		x	x			
8. Ixobrychus sinensis	Yellow bittern	Bambangan Kuning		x	x			
Accipitridae								
1. Haliastur indus*	Brahminy Kite	Elang bondol	x	x	x	AB	II	
2. Accipiter henicogrammus*	Moluccan Goshawk	Elang-alap halmahera	x	x	x	AB	II	NM
3. Accipiter meyerianus*	Meyers Goshawk	Elang-alap meyer	x			AB	II	
4. Aquila gurneyi*	Gurney's Eagle	Rajawali kuskus	x			AB	II, NT	
5. Haliaeetus leucogaster	White-bellied Sea-eagle	Elang-laut siput [perut-			x	AB	II	
6. Aviceda subcristata	Pacific baza	putih]		x	x	AB	II	
7. Aviceda novaehollandiae	Grey goshawk	kuayang			x	AB	II	
8. Accipiter novaehollandiae		Elang alap kelabu			x			
Falconidae								
1.Falco severus*	Oriental hobby	Alap alap macan			x	AB	II	
2. Falco moluccensis	Spotted Kestrel	Alap alap sapi		x	x	AB	II	
3. Falco cenchroides	Australian kestrel	Alap-alap laying		x	x	AB	II	
Anatidae								
Tadorna radja	White-headed Shelduck	Umukia raja		x	x			
Dendrocygna guttata	Spotted whistling-duck	Belibis tutul		x	x			
Megapodiidae								
1. Megapodius freycinet*	Dusky Scrubfowl	Gosong kelam		x	x	AB	LC	
2. Eulipoa wallacei	Moluccan scrub-fowl	Gosong Maluku		x	x	AB	VU	
Columbidae								
1. Streptopelia chinensis	Spotted Dove	Tekukur biasa		x				
2.Macropygia amboinensis	Slender-billed Cuckoo-	Uncal ambon	x	x	x			
3.Chalcophaps indica	dove	Delimukan zamrud	x	x	x			
4. Ptilinopus bernsteinii	Emerald Dove	Walik dada-merah	x					NM
5. Ptilinopus monacha	Scarlet-breasted Fruit-dove	Walik topi-biru	x				NT	NM
6. Ptilinopus hyogastra	Blue-capped Fruit-dove	Walik kepala-kelabu	x	x	x		LC	NM
7. Ptilinopus superbus	Grey-headed Fruit-dove	Walik raja	x	x	x			

Scientific Name	English Name	Local Name	Habitat			Protection		Endemism
			Karst Area	Lowland	Lower Montane	National	International	
8. Ducula perspicillata	Superb Fruit-dove	Pergam mata-putih	x	x	x			
9. Ducula basilica	White-eye Imperial Pigeon	Pergam boke	x					NM
10. Ducula bicolor	Cinnamon-bellied Imperial	Pergam laut	x					
	Pigeon							
	Pied Imperial Pigeon							
Psittacidae								
1.Eos squamata	Violet-necked Lory	Nuri kalung-ungu		x	x		II	NM
2.Trichoglosus haematodus	Rainbow Lorikeet	Perkici pelangi	x				II	
3.Charmosyna placentis	Red-flanked Lorikeet	Perkici dagu-merah		x	x		II	
4.Cacatua alba	White Cockatoo	Kakatua putih		x	x		II, VU	NM
5. Eclectus roratus*	Eclectus Parrot	Nuri bayan	x	x	x	AB	II, LC	
6. Geoffroyus geoffroyi	Red-cheeked Parrot	Nuri pipi-merah	x	x	x		II, LC	
7.Tanygnathus	Great –billed Parrot	Betet-kelapa paruh besar	x				II	
megalorhynchos	Moluccan King Parrot	Nuri-raja ambon	x				II	
8. Alisterus amboinensis	Moluccan Hanging-parrot	Serindit maluku	x	x	x		II	NM, B
9. Loriculus amabilis	Chattering Lory	Kasturi Ternate		x	x		EN	NM
10. Lorius garrulous								
Cuculidae								
1. Cacomantis variolosus	Brush Cuckoo	Wiwik rimba	x	x	x			
2. Centropus goliath	Goliath Coucal	Bubut goliath	x	x	x		LC	NM
3. Cacomantis heinrichi	Moluccan Cuckoo	Wiwik Maluku					NT	NM
4. Eudynamys scolopacea	Asian Koel	Tuwur Asia			x		LC	
5. Centropus bengalensis	Lesser Coucal	Bubut alang-alang		x	x		LC	
6. Cuculus pallidus	Pallid cuckoo	Kongkok pucat		x	x			
7. Chrysococcyx crassirostris	Pied bruonze cuckoo	Kedasi belang		x	x			
Apodidae								
1. Collocalia esculenta	Glossy Swiftlet	Walet sapi		x	x			
2. Collocalia vanikorensis	Uniform Swiftlet	Walet polos	x					
3. Collocalia infuscata	Moluccan swiftlet	Walet Maluku		x	x			
Alcediniidae								
1. Tanysiptera galatea*	Common Paradise-	Cekakak-pita biasa		x		AB		
2. Halcyon diops*	kingfisher	Cekakak biru-putih		x		AB		NM
3. Halcyon saurophaga*	Blue-and-white Kingfisher	Cekakak pantai		x		AB		
4. Halcyon sancta*	Beach Kingfisher	Cekakak suci		x		AB		
5. Alcedo azurea*	Sacred Kingfisher	Raja-udang biru-langit	x			AB		
6. Halcyon funebris	Azure Kingfisher	Cekakak murung		x		AB	VU	H

Scientific Name	English Name	Local Name	Habitat			Protection		Endemism
			Karst Area	Lowland	Lower Montane	National	International	
7. Halcyon chloris 8. Ceix Lepidus 9. Alcedo atthis	Sombre Kingfisher Collared Kingfisher Variable-dwarf kingfisher Common kingfisher	Cekakak Sungai Udang Merah Kerdil Raja udang erasia		x x x		AB AB AB	LC	
Meropidae 1. Merops ornatus	 Rainbow Bee-eater	 Kirik-kirik australia	 x	 X			 LC	
Coraciidae 1. Eurystomus azurea 2. Eurystomus orientalis	 Purple Dollarbird Common Dollarbird	 Tiong-lampu ungu Tiong-lampu cek-cek		 x x			 NT LC	 NM
Bucerotidae 1. Rhyticeros plicatus*	 Blyth's Hornbill	 Julang irian	 x	 X		 AB	 II	
Hirundinidae 1. Hirundo tahitica	 Pacific Swallow	 Layang batu		 X				
Campephagidae 1. Coracina atriceps 2. Coracina parvula 3. Coracina papuensis 4. Lalage aurea	 Moluccan Cuckoo-shrike Halmahera Cuckoo-shrike White-billied Cuckoo-shrike Rufous-bellied Triller	 Kepudang-sungu maluku Kepudang-sungu halmahera Kepudang-sungu kartula Kapasan halmahera	 x x x	 x x x x	 x x x x			 H NM
Pycnonotidae Ixos affinis	 Golden Bulbul	 Brinji emas	 x	 X	 x			
Dicruridae 1. Dicrurus bracteatus	 Spangled Drongo	 Srigunting lencana	 x	 X	 x			
Oriolidae 1. Oriolus phaeochromus	 Dusky Oriole	 Kepodang halmahera	 x	 X	 x		 LC	 H
Corvidae Corvus validus Corvus orru	 Long-billed Crow Torresian crow	 Gagak Halmahera Gagak koru	 x	 x x	 x x		 LC	 NM
Paradisaeidae 1. Semioptera wallacei* 2. Lycocorax pyrrhopterus*	 Wallace's Standardwing Paradise Crow	 Bidadari halmahera Gagak cendrawasih	 x	 X		 AB AB	 II II	 NM NM
Rhipiduridae 1. Rhipidura leucophrys 2. Rhipidura rufifrons	 Willie Wagtail Rufous Fantail	 Kipasan kebun Kipasan [sibeko] dada-hitam			 x x			
Pachycephalidae								

Scientific Name	English Name	Local Name	Habitat			Protection		Endemism
			Karst Area	Lowland	Lower Montane	National	International	
1. Pachycephala pectoralis 2. Pachycephala griseonota	Common Golden Whistler Drab Whistler	Kancilan emas Kancilan tunawarna	 x	X 	x 		LC 	
Sturnidae 1. Aplonis mysolensis 2. Aplonis metallica	 Mollucan Starling Metallic Starling	 Perling Maluku Perling (Narit; Gesser)		 X 	 x x		 LC	
Meliphagidae 1.Melitograis gilolensis* 2. Myzomela obscura* 3. Philemon fuscicapillus	 White-streaked Friarbird Dusky Myzomela Dusky Friarbird	 Cikukua halmahera Myzomela remang Cikukua (hitam)	 x x 	 x x x	 x x x	 AB AB AB	 LC VU	 NM NM
Nectariniidae 1. Leptocoma sericea* 2. Nectarinia solaris* 3. Nectarinia jugularis 4. Nectarinia aspasia	 Black Sunbird Flame-breasted Sunbird Olive-backed Sunbird Black sunbird	 Burung-madu hitam Burung Madu Matari Burung-madu sriganti Burung Madu	 x x	 x x	 x x x	 AB AB AB AB		
Dicaeidae 1. Dicaeum erythrothorax	 Flame-breasted Flowerpecker	 Cabai dada-api	 x	 X	 x			 NM
Zosteropidae 1. Zosterops atriceps	 Cream-throated White-eyes	 Kacamata halmahera	 x	 X				 NM
Estrildidae 1. Lonchura molucca	 Black-faced Munia	 Bondol taruk		 X				
Fragatidae 1. Fregata ariel	 Lesser Frigatebird	 Cikalang Kecil		 X		 -	 LC	
Sulidae 1. Sula leucogaster	 Brown bobby	 Angsa-batu coklat			 x	 AB	 -	
Pandionidae 1. Pandion haliaetus	 Osprey	 Elang Tiram		 X	 x	 AB	 II	
Charadriidae 1. Pluvialis fulva	 Pacific Golden Plover	 Cerek kernyut [kliit]			 x	 -		
Scolopacidae 1. Actitis hypoleucos	 Common Sandpiper	 Trinil pantai [laut]		 X		 -	 LC	
Sternidae 1. Actitis hypoleucos 2. Sterna albifrons 3. Sterna bergii 4. Anous stolidus	 Common Tern Little Tern Great Crested Tern Brown noody	 Dara laut Dara laut kecil Dara laut berjambul Camar angguk coklat		 x x x x		 AB AB AB AB	 LC	

Scientific Name	English Name	Local Name	Habitat			Protection		Endemism
			Karst Area	Lowland	Lower Montane	National	International	
Hemiprocnidae 1. Hemiprocne mystacea	Moustached Tree-swift	Tepekong kumis		X	x		LC	
Pittidae 1. Pitta maxima 2. Pitta erythrogaster	Ivory-breasted Pitta Red-bellied pitta	Paok Halmahera Burung Paok		x x		AB AB	 II	NM
Hirundinidae 1. Hirundo tahitica	Pacific Swallow	Layang-layang batu			x			
Motacillidae 1. Motacilla cinerea	Grey Wagtail	Kicuit batu			x			
Monarchidae 1. Monarcha pileatus	White-naped Monarch	Kehicap [tengkuk-putih]		X				
Artamidae 1. Artamus leucorynchus	White-breasted Wood-swallow	Kekep babi [pulau; kapeh-kapeh]		X	x			
Recurvirostridae 1. Himantopus himantopus	Black-winged stilt	Trulek lidi		X		AB		
Threskiornithidae 1. Plegadis falcinellus	Glossy ibis	Ibis rook-roko		X		AB		
Phalacrocoracidae Phalacrocorax sulcirostris	Little black cormorant	Pecuk Padi Hitam		X	x			
Turnicidae Coturnix chinensis	Blue-breasted quail	Puyuh batu		X	x			
Rallidae 1. Gallirallus philippensis 2. Rallina fasciata 3. Habroptila wallacii 4. Gymnocrex plumbeiventris 5. Amaurornis olivaceus	Buff-banded rail Red-legged crake Drummer rail Bare-eyed rail Common bush-hen	Mandar padi kalung kuning Tikusan Ceruling Mandar gendang Mandar Maluku Koreo Zaitun		x x x x x	x x x x x			H NM
Strigidae Otus magicus Ninox squamipila	Moluccan scopsowl Moluccan boobook	Celepuk Maluku Punggok maluku		x x	x x			
Caprimulgidae 1. Caprimulgus macrurus	Large-tailed nightjar	Cabak Maling		X	x			
Sylviidae Orthotomus cuculatus Phylloscopus poliocephalus	Mountain tailorbird Island leaf-warbler	Cinenen Gunung Cikrak Pulau		 X	x x			

Scientific Name	English Name	Local Name	Habitat			Protection		Endemism
			Karst Area	Lowland	Lower Montane	National	International	
Muscicapidae								
Ficedula hyperythra	Snowy-browed flycatcher	Sikatan Bodong	x	x	x			
Monarcha pileatus	White-naped monarch	Kehicap Tengkuk putih		x	x			
Monarcha trivirgatus	Spectacled monarch	Kehicap kacamata		x	x			
Myiagra galeata	Dark-grey flycatcher	Sikatan kelabu		x	x			
Rhipidura leucophrys	Willie-wagtail	Kipasan kebun	x	x	x			
Procellariidae								
1. Bulweria bulwerii				X				

Note;

NM=North Maluku, H=Halmahera; B= Banggai Island; II = CITES Appendix II; Red List Book IUCN: EN=Endangered, LC = Least Concern, VU= Venerable, NT= Near Threatened, AB= Protected under Government

A. Birds

Previous studies on Halmahera and the surrounding islands of North Maluku have identified 232 bird species, including 28 endemic and 72 protected species (Coates & Bishop, 2000; Noerdjito & Maryanto, 2007).

In total the bird survey of Weda Bay Nickel's Contract of Work recorded 130 species from 50 families as shown the Table 29. Of the total number of species, 48 are protected under Indonesian Law, 24 species are protected under the CITES Appendix II, 27 species are registered under IUCN Red List. The bird survey also found 27 species endemic to either Halmahera or North Maluku.

Table 29 summarizes the bird diversity, protected status and endemicity in relation to the forest ecosystem types. The table clearly show the lowland forest have not only the greatest diversity but also the highest number of protected species. The most likely reason for this is that the lowland forest covers a broad range of habitats including mangrove, freshwater swamp, plantations, primary and secondary forest on alluvial and ultrabasic soils.

Table 29 Number of Birds Species Found for Each Ecosystem Type in WBN

Forest Ecosystem Type	*Number of Species*	*Protected species*	*Endemicity*
Karst Forest	43	23	15
Lowland Forest	99	47	22
Lower Montane Forest	83	35	16

Note: Protected species include those species classified under Indonesian Law, CITES and IUCN
Endemicity refers to North Maluku or Halmahera.

The karst forest was dominated by 14 species as follows: Blyth's Hornbill (*Rhyticeros plycatus*), Spangled Drongo (*Dicrurus brachteatus*), Golden Bulbul (*Thapsinillas affinis*), Cinnamon Bellied Imperial Pigeon (*Ducula basilica*), Grey Headed Fruit Dove (*Ptilinopus hyogastra*), Uniform Swiftlet (*Collocalia vanikorensis*), Black Sunbird (*Leptocoma aspasia*), Goliath Coucal (*Centropus goliath*), Red Cheeked Parrot (*Geoffroyus geoffroyii*), Eclectus Parrot (*Eclectus roratus*), Superb Fruit-dove (*Ptilinopus superbus*), Blue-capped Fruit-dove (*Ptilinopus monacha*), White Cockatoo (*Cacatua alba*) and Halmahera Cuckoo Shrike (*Coracina parvula*).

The bird community of the lowland forest was dominated by 13 species as follows: Rufous-bellied triller (*Lalage aurea*); Glossy swiftlet (*Collocalia esculenta*); Lesser fregatebird (*Fregata ariel*); Moustached tree-swift (*Hemiprocne mystacea*); Moluccan hanging parrot (*Loriculus amabilis*); Black-faced munia (*Lonchura molucca*); Brahminy kite (*Haliastur indus*); Cream-throated white-eye (*Zosterops atriceps*); Island leaf-warbler (*Phylloscopus poliocephalus*); Flame-breasted flowerpecker (*Dicaeum erythrothorax*); White-eyed pigeon (*Ducula perspicillata*); Australian pratincole (*Stiltia isabella*); and Pacific swallow (*Hirundo tahitica*).

The bird community of lower montane forest was dominated by 14 species as follows: Violet-necked Lory (*Eos squamata),* Eclectus Parrot *(Eclectus roratus),* Red-flanked Lorikeet *(Charmosyna plasentis),* Red-cheeked Parrot (*Geoffroyus geoffroyi)* and Mollucan Hanging-parrot (*Loriculus amabilis);* Emerald Pigeon (*Chalcophaps indica*), Superb Fruit-dove *(Ptilinopus superbus)*; Mollucan Cuckoo-shrike (*Coracina atriceps*), Halmahera Cuckoo-shrike *(Coracina parvula); Common Kingfisher (Alcedo atthis);* Flame-breasted Flower-pecker (*Dicaeum erythrothorax); Pacific* Swallow (*Hirundo tahitica);* Moluccan Starling (*Aplonis mysolensis*); and Dusky Friarbird (*Philemon fuscicapillus*).

B. Herpetofauna

McGuire et al (2000) recorded 53 species of herpetofauna (i.e. reptiles) on Halmahera, with 5 species considered endemic to the island and 5 protected species. It should be noted that the Dames & Moore study raised concerns about taxanomy issues and errors of this and other herpetofauna studies.

The various surveys conducted in the WBN CoW recorded a total of 16 amphibian species and 33 reptile species. Table 30 presents the list of complete herpetofauna encounter in the fauna surveys, along with the habitats and the protected status and endemicity.

A greater number of amphibian species were recorded in the lower montane forest (9 species) as compare to karst and lowland (6 species each). Given the wet and humid climate of all forest types and subsequent microclimates, it is unlikely that this difference in amphibian diversity is significant. However, it is significant that the Dames and Moore Survey (2001) identified only 2 species of amphibian in field survey and 9 species from literature whilst recent fauna surveys in the Contract of Work identified 15 species. This further highlights the lack of fauna data on Halmahera.

Table 30 Herpetofauna Species Found in Fauna Surveys, Their Protection Status and Endemism

Name Species	Kasrt Area	Lowland Forest	Lower Montane Forest	Protection		Endemism
				National	International	
AMPHIBIANS						
Hylidae						
Litoria amboinensis	x				LC	
Litoria infrafrenata		x			LC	NM
Nyctimystes rueppelli		x			VU	
Microhylidae						
Hylophorbus boettgerri	x					
Oreophryne senckenbergiana			x			
Xenobatrachus bidens	x				LC	
Ranidae						
Platymantis papuensis	x	x	x		LC	
Platymantis dorsalis			x			
Rana Celebensis			x		LC	
Rana grisea	x				LC	
Rana moluccana		x			LC	NM

Name Species	*Kasrt Area*	*Lowland Forest*	*Lower Montane Forest*	*Protection*		*Endemism*
				National	*International*	
Rana papua	x		x		LC	
Limnonectes inflatus		x	x			
Limnonectes grunniens			x			H
Litoria infrafrenata		x	x			
Litoria sp			x			
REPTILES						
• **Lizards**						
Agamidae						
Bronchocela cristatella	x	x	x			
Hydrosaurus amboinensis		x	x	AB		
Gekkonidae						
Gehyra mutilate		x				
Gehyra vorax		x				
Gekko vittatus	x		x			
Hemidactylus frenatus		x	x			
Scincidae						
Carlia fusca		x				
Emoia atrostostata		x				
Emoia kuekenthali	x	x	x			
Emoia jakati			x			
Emoia sorex	x		x			
Emoia cf. baudini		x	x		II	
Lamprolepis smaragdinum	x	x				
Lipinia noctua		x				
Lygosoma consobrinum			x			
Mabuya multifasciata			x			
Sphenomorphus consobrinum			x			NM
Sphenomorphus cf. textum			x			
Tiliqua gigas			x			
Varanidae						
Varanus indicus		x			II	
Varanus salvator		x			II	
Varanus yuwonoi		x			II	H
• **Snakes**						
Boidae						
Candoia carinata			x			
Candoia paulsoni		x			II	
Colubridae						
Boiga irreguralis	x	x				
Dendrelaphis modestus	x					NM
Dendrelaphis calligastra		x				
Stegonotus batjanensis		x				
Rhabdophis chrysargos		x				
Pythonidae						
Morelia tracyae		x			II	H
Python reticulatus		x			II	
Morelia amethistina		x			II	
• **Turtoise**						
Geoemydidae						
Cuora amboinensis		x			VU	

Note;

NM=North Maluku, H=Halmahera; II = CITES Appendix II; Red List Book IUCN: VU= Venerable, NT= Near Threatened, LC=Least Concerned; AB= Protected under Government

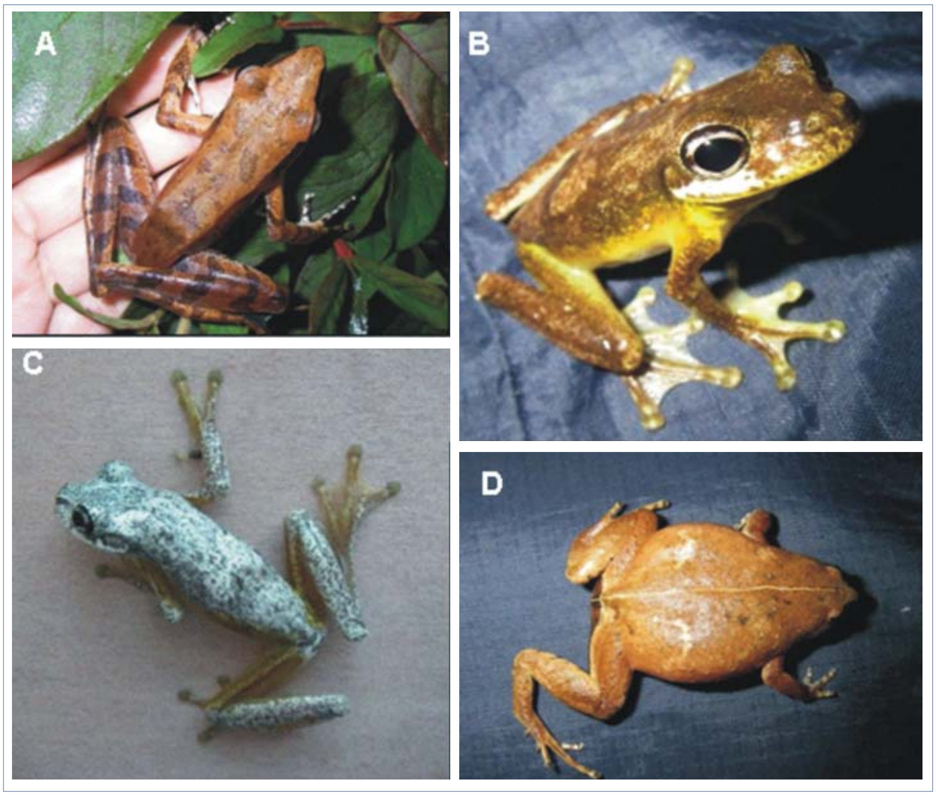


Figure 23 Examples of amphibians found during survey*: (a) Rana grisea, (d) Litoria amboinensis* during night time *(b) Platymantis papuensis, (c) Litoria amboinensis* during daytime, and *(e) Oreophryne senckenbergiana,*

Based on **Table 30**, lowland forest had greater reptile species (23) than karst (7 species) and lower montane (14 species). Reptile, being cold blooded species, will be more likely to occur in the warmer climate of the karst and lowland forest. Skinks and lizards appear to be more adapted to the colder temperature of the lowland montane forest than snakes.

The fauna survey found that the dominant reptile species in all forest types were either skinks or geckos. In the Karst forest*, Emoia kuekenthali* (a species of skink) seems to dominate, however, this species was mainly recorded in disturbed areas. The most dominant reptile for both the lowland forest and the lower montane forest were found to be *Emoia cf. baudini* (a species of skink) and *Hemidactylus frenatus* (house gecko; see **Figure 24**).

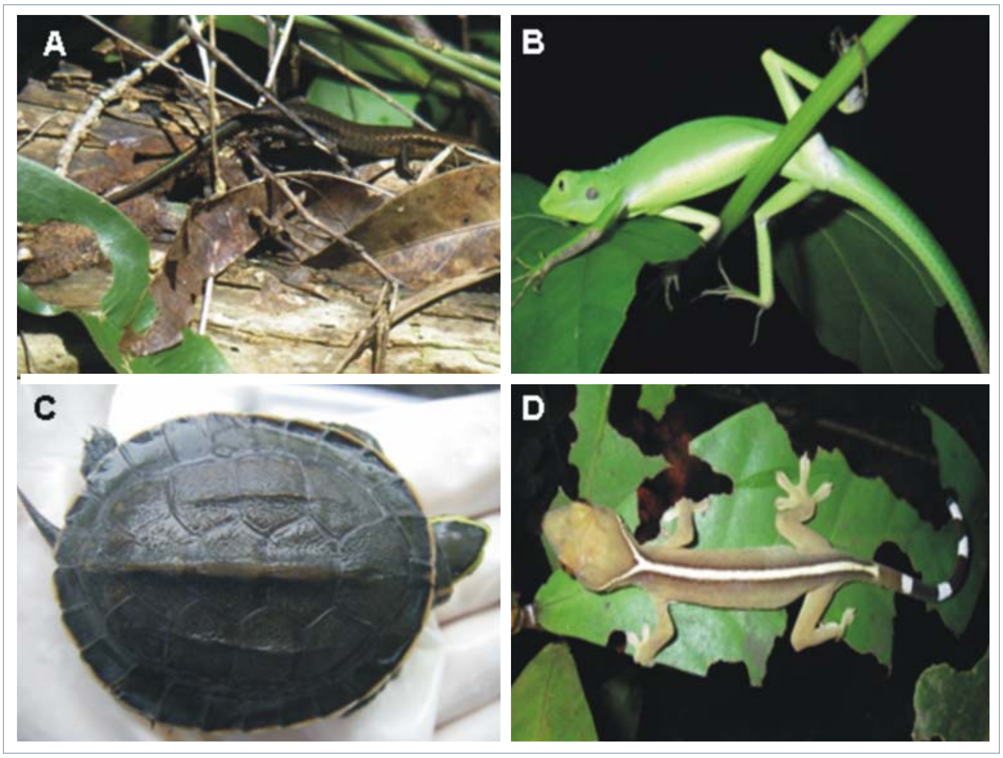


Figure 24 *Examples of reptiles found during survey: (A) Emoia kuekenthali, (B) Broncochela cristatella, (C) Cuora amboinensis, and (D) Gekko vittatus*

C. Mammals

Previous studies of mammals in the Maluku region have recorded 120 species of which 28 species are endemic and 14 species protected. Studies on Halmahera Island have recorded only 44 mammal species (Suyanto et al., 2002, Noerdjito & Maryanto, 2007) suggesting a poor diversity of mammal species in relation to the surrounding islands.

A total of 22 species bat have been recorded on Halmahera including three full species and two sub-species which are endemic to North Maluku and two endemic sub-species of Horseshoe-bat.

The various surveys conducted in the WBN COW recorded a total of 10 non-flying and 12 flying mammal species. Table 30 presents the complete list of mammal species encounter in the fauna surveys, along with the habitats and the endemic and protected status.

In the karst, there were no dominant non-flying mammals recorded. Due to the availability of caves in the karst, two species of bats were found to be dominant i.e. Raffrays Sheath tail-Bat (Emballonura raffrayana) and Fawn Hourseshoe-Bat (Hipposideros cervinus). In both the lowland and lower montane forest, the dominant species recorded were Wild Boar (Sus scrofa) and Wild Rat (Rattus sp.). Both species are not native to Halmahera. Of the 10 species of fruit bats (Pteropodidae family) identified on Halmahera

(Dames and Moore 2001), nine species were recorded in the lower montane forest (Figure 25).

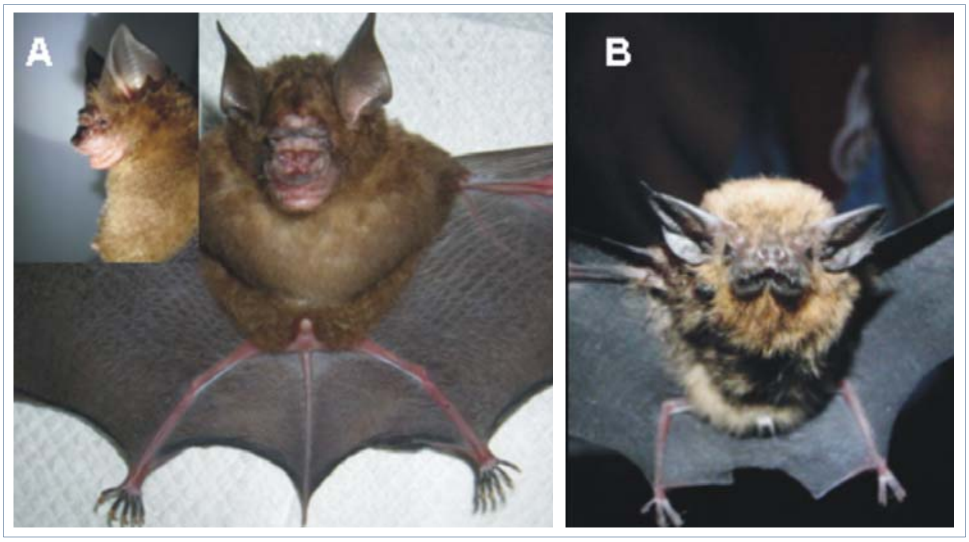


Figure 25 ***Two dominant bat species found in caves. (A)*** *Fawn Horseshoe-Bat (Hipposideros cervinus Gould, 1854)**, (B**) Raffray's Sheathtail-Bat (Emballonura raffrayana Dobson, 1876)*

The Ornate Cuscus (*Phalanger ornatus)* was the only mammal, native to the island, recorded in the survey that protected under Indonesian Law. The Timor Deer (*Cervus timorensis*), which was recorded as widespread but in low density in all forest type, is also protected under Indonesian Law. Of the 10 mammal species register on the ICUN Red List, only the Lesser Tube-nosed Bat (*Nyctimene minutus*) is vulnerable.

Two species of mammals recorded in the survey are endemic to the region. The Moluccan Prehensile-tailed Rat (*Rattus morotaiensis)* is endemic to North Maluku. The Brown Eyed form of the Ornate Cuscus (as shown in Figure 26 which is only found in Halmahera and Bacan is a subspecies of the Ornate Cuscus of North Maluku.

Figure 26 *Ornate Cuscus (Phalanger ornatus) subspecies endemic to Halmahera and Bacan*

D. Insects (Butterfly)

Little is known regarding butterfly species of Halmahera. Previous studies on butterflies by Sutrisno (1995) in North Halmahera resulted in 20 species from 7 families. A total of 46 species of Butterfly were recorded during the fauna survey of Weda Bay Nickel Contract of work, from 6 families (as shown Figure 27). Thus, the fauna survey of Weda Bay Nickel's Contract of Work identifies a significant increase in the butterfly species diversity than previously published surveys.

Figure 27 *Several butterfly species found in the study area*

The Karst forest had the greatest diversity, with 37 species identified, whilst the lowland and Lower Montane forest recording 13 species each. Six butterfly species were most dominant in the Karst: *Jamides* sp., *Vagrans* sp., *Andaus* sp., *Andis* sp., *Terias* sp. and *Papilio* sp. Four butterfly species were the most dominant in the lowland forest: Idea sp.; *Ideopsis* sp.; *Zizina* sp.; *Papilio* sp.; and *Catopsilia* sp. Seven butterfly species were commonly observed in the Lower Montae forest: *Euchrysops* sp., *Eurema* sp., *Hypolimnas* sp., *Jamides* sp., *Junonia* sp., *Mycalesis* sp. and *Zizina* sp.

A review of the CITES and IUCN Red List database found that none of the butterfly species recorded in the Weda Bay Nickel Contract of Work were protected under international treaty. No butterfly species recorded during the fauna survey are protected under Indonesian Law (Government Regulation No 7, 1999 regarding Preservation of Plants and Animals).

E. Cave Fauna

The Karst formations found in and around the Weda Bay Nickel Contract of Work provide ideal locations for the formation of Caves. Caves are a passage small enough to be entered by human (human size passages) and are mostly developed in limestone. The limiting factors in microclimate condition, such as low light stable temperature and humidity and limited food supply, provide the circumstances for the development of cave fauna that is unique, rare and endemic. Morphologically, cave fauna have depigmented, transparent, reduced eye sight and increased ability to regulate water in their bodies. The universal character for subterranean ecosystem is the absence of light. Six new caves were identified during the karst survey.

Generally caves can be divided into the following 4 zones:

- Twilight zone – near the cave entrance, where light intensity, humidity and temperature vary and a diverse fauna can be found.
- Transition zone – zone of complete darkness but still variable humidity and temperature, where a number of common species live, some of which make sorties to the outside world.
- Deep zone – zone of complete darkness and almost constant 100% humidity and constant temperature, which is the home of fully cave-adapted species that never venture outside the cave.
- Stagnant zone – zone of complete darkness and 100% humidity, where there is little air exchange and carbon dioxide concentrations may become high.

The survey caves only focus on 2 zone i.e. twilight and transition zone. Dominating fauna are cave crickets and spiders. The complete list of cave fauna species recorded during the survey is presented on Table 31 and Figure 28.

Table 31 Cave fauna species found during cave survey

Cave name	*Species*	
	Scientific Name	*Common Name*
Wesley (WS) Cave	- Rana sp. - Varanus sp eggs - *Rhapidophora sp* - Heteropoda sp.	- Frog - Varanus sp - Cave cricket - Huntsman Spider
S. Cave 1	- *Emballonura raffrayana*	- Bat
S. Cave 2	- *Charon grayi* - *Rhapidophora sp*	- Amblypygi - Cave cricket

Cave name	*Species*	
	Scientific Name	*Common Name*
	- Heteropoda sp. - Olios sp.	- Huntsman Spider - Small spider
Cave A	- *Rhapidophora sp*	- Cave Cricket
Cave B	- *Rhapidophora sp* - *Olios* sp. - *Heteropoda* sp. - *Hipposideros cervinus Gould*	- Cave Cricket - Small spider - Huntsman Spider - Bat
Cave C	- *Rhapidophora sp* - *Helminthoglypta tudiculata*	- *Cave Cricket* - *Snail*
Cave D	- *Rhapidophora sp* - *Spider*	- *Cave Cricket* - *Spider*
Cave E (spring)	- *Hipposideros cervinus Gould* - *Shrimp (unidentified)* - *Spider* - *Hemigrapsus nudus*	- *Bat* - *Shrimp* - *Spider* - *Crab*
Cave F	- *Rhapidaiphora sp* - *Heteropoda sp.* - *Olios sp.* - *Hipposideros cervinus Gould, 1854*	- *Cave Cricket* - *Huntsman Spider* - *Small spider* - *Bat*
Cangcungelo (Sagea River Cave)	- *Ceutophilus maculatus* - *Aselliscus tricuspidatus Temminck, 1835* - *Seramba sp.* - *Hemigrapsus nudus* - *Charon grayi* - *Phalangodidae*	- *Small cricket* - *Bat* - *Long-tailed Spider* - *Crab* - *Amblyphygi* - *Spider*
Boki Maruru (Batu Lubang Cave)	- *Scolopendra gigantea* - *Bat (several species-unidentified)* - *Charon grayi* - *Hemigrapsus nudus* - *Heteropoda sp* - *Rhapidophora sp*	- *Giant Centipede* - *Bat* - *Amblyphygi* - *Crab* - *Huntsman Spider* - *Cave Cricket*

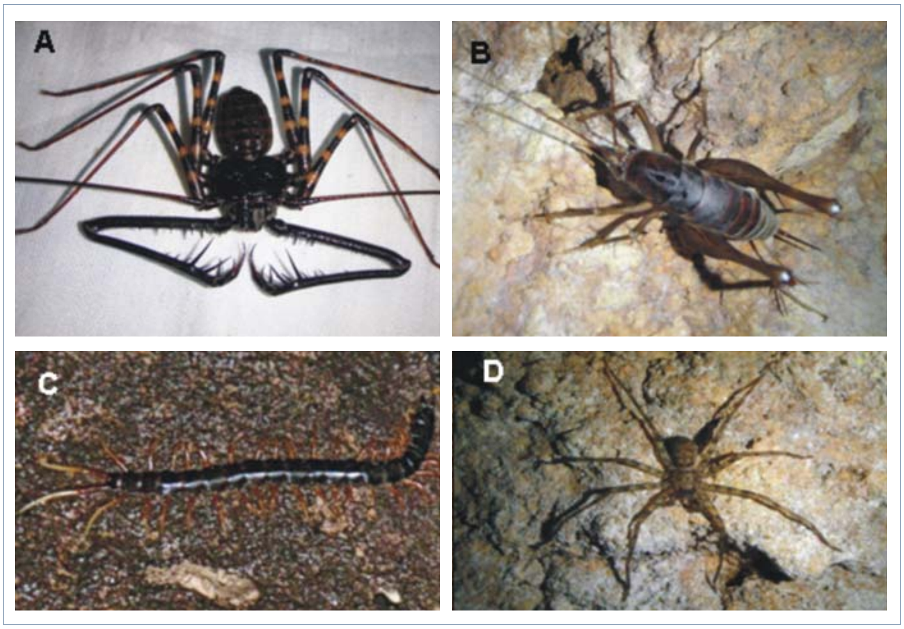


Figure 28 ***Some cave arthropods found during survey. (A) Amblypygi Charon grayi Gervais, 1842, (B) Cave cricket Rhapidophora sp, (C) Giant centipede Scolopendra gigantean, (D) Huntsman Spider Heteropoda sp***

All cave fauna recorded in the survey are categorized as trogloxene. Trogloxene fauna is cave fauna that either enter caves for refuge but normally return to the outside environment to feed (e.g. bats) or accidentally wander into caves. No protected cave fauna species were recorded during the survey.

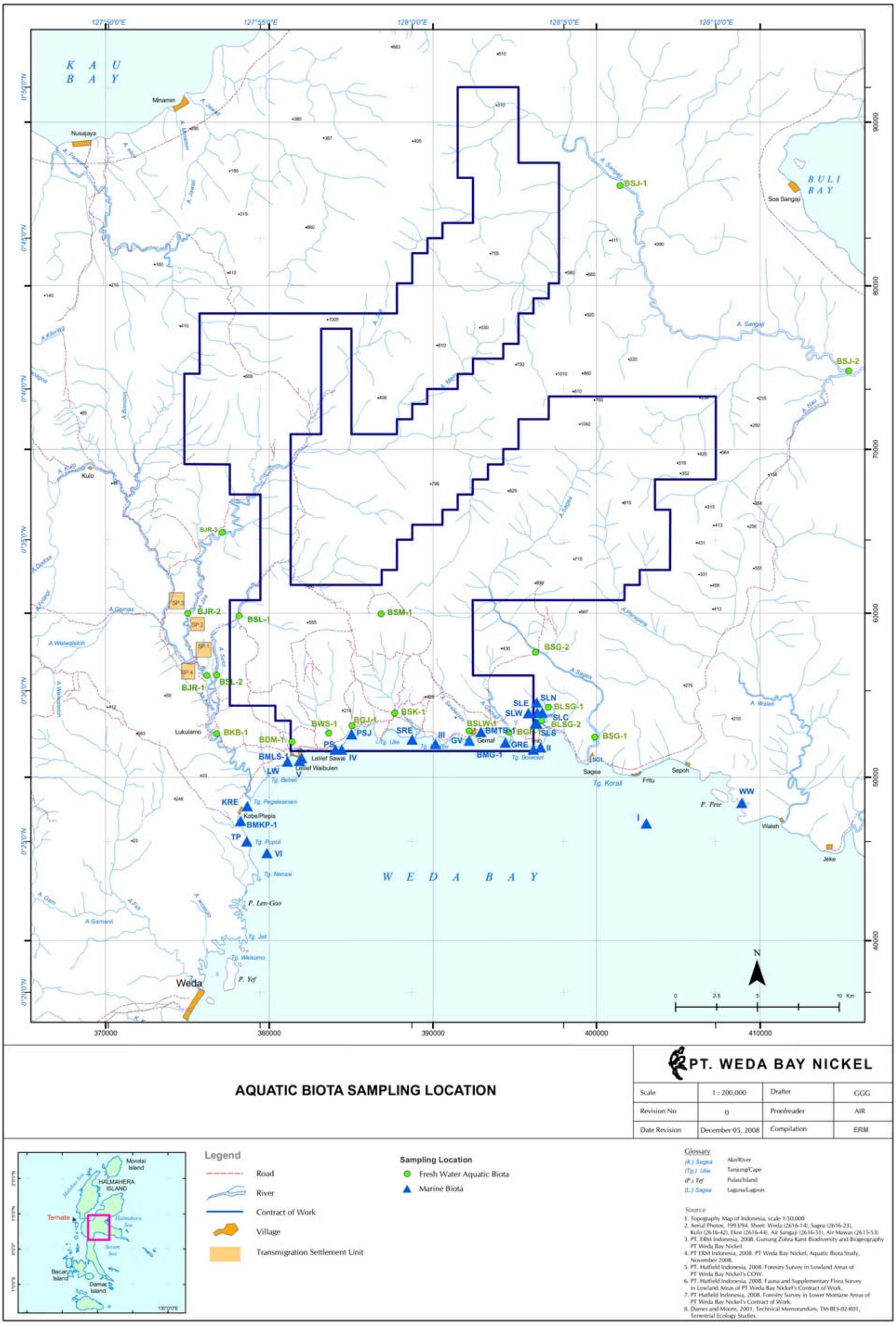
Fresh Water Aquatic Biota

The presence of aquatic biota in a water body depends on the condition of the water. For example, the supply of both dissolved oxygen and food sources are important on providing an adequate habitat for the aquatic biota. Sampling was conducted at eighteen locations to analyze and assess the type and number of plankton, benthos and nekton in water bodies on the project area. The sampling locations are in Central Halmahera Regency (17 locations) and East Halmahera Regency (2 locations) (see **Map 15**).

15.1.1.3 Plankton

Plankton is a group of microscopic organisms that live in water and drift passively with water currents. The study of plankton included both phytoplankton and zooplankton.

Based on the feeding method, plankton is divided into two groups, which are phytoplankton and zooplankton. Phytoplankton has a significant role in the transfer of energy, sustaining the life of other organisms in the water body. Phytoplanktons obtain energy by photosynthesis; therefore their ideal habitat is in the well-lit surface layer. They are also dependent on the availability of nutrients for their growth, such as nitrate or phosphate. Phytoplankton's cumulative energy fixation in carbon compounds is the basis of their function as primary producer in the food chain of water ecosystem. Phytoplankton is a direct food supplier for zooplankton and several types of juvenile fish, thus its abundance and diversity directly impacts on higher life forms such as zooplankton. The existence of phytoplankton is used an indicator of the quality of an aquatic ecosystem.



Map 15 Aquatic Biota Sampling Locations

Zooplankton are the heterotrophic component of plankton, which require organic substrates to get carbon for their growth and development, whereas phytoplankton are the autotrophic component, which produce complex organic compounds from simple inorganic molecules and an external energy source.

The discussion of freshwater aquatic biota survey includes the characterization of phytoplankton, zooplankton, and benthos in terms of four widely used, internationally acceptable indices: dominance (scaled is 0-10), diversity (scale is 0-10), evenness (scale is 0-10) and abundance (0-100%). The relative values of these indices are employed to baseline aquatic biota.

Phytoplankton

The amount of phytoplankton species that live and phytoplankton dominance in a water body can give information of the actual water body condition. Results of statistical parameters used to measure phytoplankton status are presented in **Table 32**.

In general, the composition of phytoplankton species found in each sampling location were relatively similar, although several species were only found in one sampling locations. This is a result of the relatively similar physical environment conditions of the waterways studied, such as the riverbed composition, the current flow, pH and dissolved oxygen (DO) levels.

The survey found 23 phytoplankton species form the following 4 classes: Bacilariophyceae class (15 species), Chlorophyceae (4 species), Cyanophyceae (3 species), and Dinophyceae (only 1 species).

According to Sachlan (1973), the high species composition of Bacillariophyceae (Chrysophyta) is related to its characteristic as a cosmopolite, resisting to extreme conditions (including the temperature), its ability to adapt, and it's very fast reproduction cycle. The pH value of the water body also plays an important role in the development phase of Bacillariophyceae. The high pH value (up to 8.9) of a most of the waterways was a key factor for supporting optimal growth of the Bacillariophyceae.

Cyanophyceae, represented by the *Lyngbia sp*., was only found at BJR-3 (Ake Jira Upstream) where the water body has the following physical and chemical characteristics:

- A relative slow current;
- Warm water temperature; and
- High concentration of organic matter.

Table 32 List of Phytoplankton Species, Total Number of (Individual/m³), Diversity Index, Evenness Index and Dominancy Index at Sampling Locations

ORGANISME	SAMPLING LOCATIONS												
	BJR-1	BJR-2	BJR-3	BSL-1	BSL-2	BKB-1	BDM-1	BWS-1	BSG-1	BSG-2	BSK-1	BSLW-1	BGF-1
BACILLARIOPHYCEAE :													
Nitzschia sp.	-	-	-	33,216	-	-	4,402	4,402	4,402	-	-	-	4,402
Navicula sp.	-	-	-	6,603	2,201	-	-	-	-	-	35,216	1,101	-
Amphora sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Achnantes sp.	-	-	-	-	-	-	-	-	-	-	4,402	-	-
Bacillaria sp.	1,101	-	4,404	6,603	-	-	-	-	-	-	-	-	-
Fragillaria sp.	11,010	-	4,404	55,025	2,201	6,606	15,407	-	6,603	4,402	8,804	-	8,804
Pinnularia sp.	1,101	-	-	2,201	-	-	-		-	-	-	-	-
Cymbella sp.	1,101	-	-	4,402	2,201	2,201	-	-	4,402	-	-	-	-
Surirella sp.	2,202	-	-	4,402	-	1,101	2,201	-	-	-	-	1,101	-
Melosira sp.	2,202	-	-	-	-	-	-	-	-	-	-	-	-
Eunotia sp.	-	-	-	2,201	2,201	-	-	-	-	-	-	-	-
Diatoma sp.	-	-	-	17,608	4,402	8,808	-	-	4,402	6,603	4,402	-	-
Ghomphonema sp.	1,101	-	-	2,201	2,201	-	-	-	2,201	-	-	-	-
Ephitemia sp.	-	-	-	-	4,402	-	-	-	-	-	-	-	-
Cocconeis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
CHLOROPHYCEAE :													
Spirogyra sp.	48,444	71,565	563,456	116,653	15,407	-	-	121,055	6,603	15,407	4,402	-	-
Mougeotia sp.	4,404	-	-	-	-	-	-	-	-	-	-	-	-
Ankistrodesmus sp.	-	-	-	8,804	-	-	24,211	4,402	4,402	4,402	35,216	-	6,603
Ulothrix sp.	-	-	-	-	-	-	-	11,005	28,613	26,412	96,844	-	39,618
CYANOPHYCEAE :													
Phormidium sp.	17,616	-	26,412	-	-	-	-	-	2,201	-	-	1,101	4,402
Lyngbya sp.	-	-	8,804	-	-	-	-	-	-	-	-	-	-
Anabaena sp.	-	-	-	-	-	-	-	-	-	6,603	-	-	-
Microscystis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
DINOPHYCEAE :													
Ceratium sp.	-	-	-	-	1,101	-	-	2,201	-	-	-	-	-
Amount of Taxa	**10**	**1**	**5**	**12**	**9**	**4**	**4**	**5**	**9**	**6**	**7**	**3**	**5**

Abundance (Ind/m³)	**90,282**	**71,565**	**607,480**	**259,919**	**36,317**	**18,716**	**46,221**	**143,065**	**63,829**	**63,829**	**189,286**	**3,303**	**63,829**
Diversity Index (H')	**1.45**	**0**	**0.34**	**1.82**	**1.83**	**1.14**	**1.07**	**0.61**	**1.79**	**1.54**	**1.37**	**1.10**	**1.17**
Evenness Index (E)	**0.63**	**-**	**0.21**	**0.73**	**0.83**	**0.82**	**0.77**	**0.38**	**0.81**	**0.86**	**0.70**	**1.00**	**0.73**
Dominancy Index (D)	**0.34**	**1.00**	**0.86**	**0.25**	**0.18**	**0.36**	**0.38**	**0.71**	**0.25**	**0.25**	**0.33**	**0.33**	**0.40**

Source: Aquatic Biota Study at Weda Bay Area, 2008 - ERM
Note: Calculation used Ln (Nats)
Remark: BJR-1 : Ake Jira Downstream
BJR-2 : Ake Jira middle
BJR-3 : Ake Jira Upstream
BSL-1 : Ake Seloi Downstream
BSL-2 : Ake Seloi Upstream
BKB-1 : Ake Kobe
BDM-1 : Ake Doma
BWS-1 : Ake Wosea
BSG-1 : Ake Sagea Upstream
BSG-2 : Ake Sagea Downstream
BSK-1 : Ake Sake
BSLW-1 : Ake Sisliwisini
BGF-1 : Ake Gemaf
BGJ-1 : Ake Gojemli
BSM-1 : Ake Bukit Limber
BSJ-1 : Ake Sangaji Upstream
BSJ-2 : Ake Sangaji Downstream

The presence of Cyanophyceae in the water body can be used as an organic pollution indicator since they can survive in the highly polluted environments. Although very high occurrence of Cyanophyta in the water body will cause the water to become smelly (Davis, 1955), results from Ake Jira Upstream were well below the levels required for this to occur.

Dinophyceae, represented only by Ceratium sp., was found at BSL-2 (Ake Seloi Upstream) and BWS-1 (Ake Wosea). Dinophyceae is an important component in phytoplankton composition of sea waters, salty waters and fresh waters. Besides producing food by photosynthesis, the members of this class can get food in a heterotrophic, saprophytic, parasitic, symbiotic, and holozoic way. This Dinophyceaee may cause water body to become very poisonous for fish if their abundance is very high. This phenomenon is known as a red tide. Levels in the Ake Seloi Upstream and Ake Wosea were well below those required for a red tide to occur.

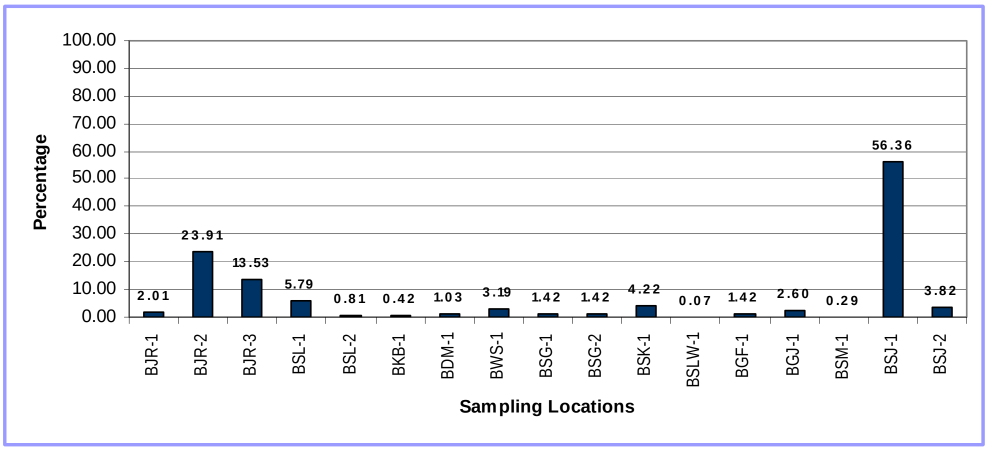


Figure 29 Percentage Abundance of Phytoplankton from 17 Sampling Locations

Not surprisingly, the Bacilariophyceae Class had the highest abundance percentage when compared to other classes. Cyanophyceae and Dinophyceae had a lowest abundance percentage in the water body of the studied area (see Figure 30). The low abundance percentage of Cyanophytceae and Dinophyceae indicates that the organic matter content in these waters is very low.

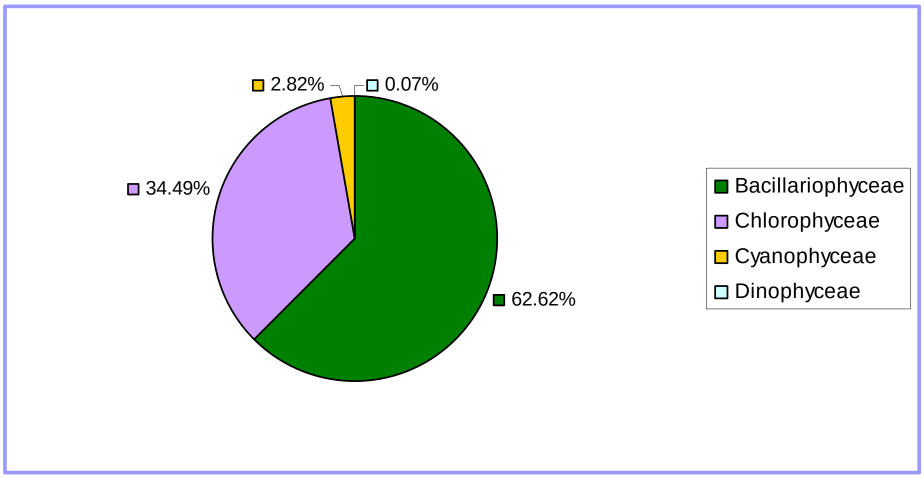


Figure 30 Phytoplankton Abundance in 17 Sampling Locations

The ANDAL for WBN contains statistical analyses of plankton diversity, evenness, abundance, and dominance. The plots of these are omitted in this baseline description for brevity. The diversity index calculation results of the observed phytoplankton in each location were generally under the range of H value < 3.0, which according to Wilhelm's criteria (1975) shows low diversity and community stability.

Upper Ake Sangaji BSJ-1) had the highest diversity index, once again highlighting the generally good condition of this water body. Ake Jira Middle had a zero diversity index, indicating the dominance of one species and the fact that this location has been impacted by upstream activities (most notably the construction of the Transmigration weir and irrigation system). The evenness value of 1 obtained at BSLW-1 (Ake Sesliwisini) indicates that the phytoplankton species populations in the river were spread evenly, with no dominance by one species. The low evenness value of 0 obtained from BJR-2 (Ake Jira River Middle) showed the existence of a one dominant phytoplankton species (i.e. *Spirogyra* sp). This confirms the conclusions of the result from the Diversity Index. The abundance or density of phytoplankton in the studied area ranged between 3,303 – 2,529,862 individual/m3. The highest abundance percentage was found at BSJ-1 (Ake Sangaji Upstream) 56.36%. The Ake Sangaji Upstream location is a fast flowing stream with a significantly large, relatively undisturbed catchment. Lowest abundance percentage was found at BSLW-1 (Ake Sesliwisini) 0.07%. Ake Sesliwisini is a small catchment, close to the Gemaf village and thus heavily disturbed by agricultural and domestic activities. Phytoplankton species with high abundance percentage include *Bacillaria* sp (24,31%), *Eunotia* sp (16,07%), *Gyrosigma* sp (7,57%), and *Mougeotia* sp (6,72%). Plankton conditions in the middle Ake Jira are susceptible to changes in water quality. Phytoplankton dominance index of the 17 collected samples at WBN area range ranging from 0.18 to 1.00; this indicated that the water body has predominance to dominance condition.

A. Zooplankton

In the aquatic ecosystem, zooplankton is placed in the second layer of tropic level after phytoplankton, and its existence depends on phytoplankton existence. Zooplankton serves the function of transferring energy from primary producers (phytoplankton) to living creatures at higher levels in the food chain, such as nekton.

Relative to phytoplankton, the number of species of zooplankton is usually lower. Phytoplankton has a shorter lifecycle and higher turn-over than zooplankton; and hence the reproduction rate of zooplankton is lower, and it requires a longer time to reach maximum population (Tait, 1981). Therefore, there will always be a food supply for zooplankton, provided conditions are good for phytoplankton.

The results of the zooplankton analyses of the collected samples are presented in **Table 33.**

The identification of phytoplankton in the river water body showed 10 species were found from three genera (as shown in Figure 31**)**.

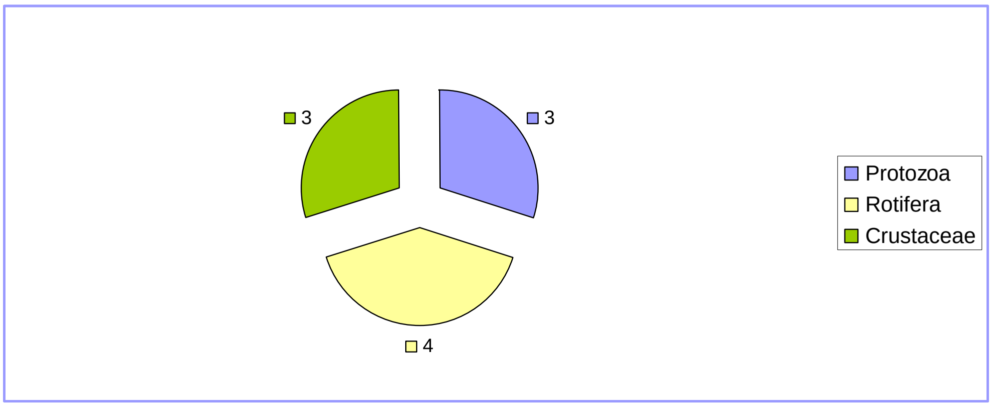


Figure 31 Zooplankton Species Composition at the Study Area

The species composition is even distributed across the three classes. This condition is caused by the relatively similar physical environment of the sampling sites. The abundance of individual zooplankton the collected during the survey ranged between 1,101 and 321,346 ind/m^3.The highest abundance percentage was recorded at BSJ-1 (Ake Sangaji Upstream). This result is unsurprising given the high abundance of phytoplankton at this location. The lowest abundance percentage was found at BSLW-1 (Ake Sesliwisini), which also had the lowest abundance of phytoplankton. Interestingly all other locations recorded low abundance percentages, despite some locations, such as Ake Jira Middle, having reasonable phytoplankton abundance. The zooplankton diversity index at all sampling location was ranged from 0.00 to 1.38. According to the criteria established by Wilhm (1975), if the diversity index of zooplankton is less than 3, it is classified as low to medium.

Table 33 List of Zooplankton Species, Total Number (Individual/m³), Diversity Index, Evenness Index and Dominance Index at 17 Sampling Locations

ORGANISMS	*SAMPLING LOCATIONS*															
	BJR-1	*BJR-2*	*BJR-3*	*BSL-1*	*BSL-2*	*BKB-1*	*BDM-1*	*BWS-1*	*BSG-1*	*BSG-2*	*BSK-1*	*BSLW-1*	*BGJ-1*	*BSM-1*	*BSJ-1*	*BSJ-2*
PROTOZOA :																
Arcella sp.	1,101	-	-	-	-	2,201	-	-	-	-	-	1,101	-	-	-	-
Centropyxis sp.	1,101	1,101	2,201	2,201	2,201	-	-	-	2,201	-	2,201	-	-	2,201	-	-
Difflugia sp.	-	-	-	-	4,402	-	-	-	2,201	-	2,201	1,101	-	2,201	2,201	-
ROTIFERA :																
Notolca sp.	1,101	-	-	-	-	-	2,201	1,101	2,201	2,201	4,402	1,101	-	4,402	2,201	8,804
Squatinella sp.	-	-	-	-	-	1,101	-	-	-	-	-	-	-	-	-	-
Brachionus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	316,944	-
Monostylla sp.	-	-	-	-	-	-	-	-	2,201	-	-	-	-	-	-	-
CRUSTACEAE :																
Nauplius (stadia)	-	1,101	-	2,201	-	1,101	-	-	-	4,402	-	-	2,201	-	-	-
Cyclops sp.	-	-	-	-	-	-	-	-	-	2,201	-	-	-	-	-	-
Oithona sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chydorus sp.	1,101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amount of Taxa	**4**	**2**	**1**	**2**	**2**	**3**	**1**	**1**	**4**	**3**	**3**	**3**	**1**	**3**	**2**	**1**
Abundance (Ind/m³)	**4,404**	**2,202**	**2,201**	**4,402**	**6,603**	**4,403**	**2,201**	**1,101**	**8,804**	**8,804**	**8,804**	**3,303**	**2,201**	**8,804**	**321,346**	**8,804**
Diversity Index (H')	**1.38**	**0.69**	**0**	**0.69**	**0.63**	**1.04**	**0**	**0**	**1.38**	**1.04**	**1.04**	**1.10**	**0**	**1.04**	**0.69**	**0**
Evenness Index (E)	**1.00**	**1.00**	**0**	**1.00**	**0.91**	**0.94**	**0**	**0**	**1.00**	**0.94**	**0.94**	**1.00**	**0**	**0.94**	**1.00**	**0**
Dominancy Index (D)	**0.25**	**0.50**	**1.00**	**0.50**	**0.55**	**0.37**	**1.00**	**1.00**	**0.25**	**0.37**	**0.37**	**0.33**	**1.00**	**0.37**	**0.50**	**1.00**

Source: Aquatic Biota Study at Weda Bay Area, 2008 - ERM
Note: Calculation used Ln (Nats)
Remark: BJR-1 : Ake Jira Downstream
BJR-2 : Ake Jira middle
BJR-3 : Ake Jira Upstream
BSL-1 : Ake Seloi Downstream
BSL-2 : Ake Seloi Upstream
BKB-1 : Ake Kobe
BDM-1 : Ake Doma
BWS-1 : Ake Wosea
BSG-1 : Ake Sagea Upstream
BSG-2 : Ake Sagea Downstream
BSK-1 : Ake Sake
BSLW-1 : Ake Sisliwisini
BGF-1 : Ake Gemaf
BGJ-1 : Ake Gojemli
BSM-1 : Ake Bukit Limber
BSJ-1 : Ake Sangaji Upstream
BSJ-2 : Ake Sangaji Downstream

The higher the value of organism's diversity index, the more diverse the organisms existed in the ecosystem. In general the diversity of zooplankton is low as a result of the low diversity of phytoplankton at all sampling locations. Several locations recorded a Diversity Index of 0 (i.e. Ake Jira Upstream, Ake Doma, Ake Wosea, Ake Gojemli and Ake Sangaji Downstream). This indicates only one species of zooplankton present. Based on evenness index calculation results of the zooplankton observed in sampling location ranged from 0.00 - 1.00. This value showed that zooplankton in the studied area indicated low to high evenness. All sampling locations with two species of zooplankton present had a high evenness index, implying that populations of zooplankton species are evenly spread and there is no dominance. Sampling locations with an Evenness Index of 0 (i.e. Ake Jira Upstream, Ake Doma, Ake Wosea, Ake Gojemliand Ake Sangaji Downstream), indicated dominance by one species. Dominance Index of zooplankton of the 17 collected samples at WBN area ranged from 0.25 to 1.0, indicated the area have predominance to dominance zooplankton condition. Those locations with a high dominance have already been identified as having 0 Evenness Index. The species found to be dominant varied across sampling locations. Of note is the Seloi Downstream and Upstream had Dominance, and also a high evenness index. The reason for this was the low population of individuals. No sampling locations recorded a condition on Not Predominance, indicating that all water bodies were moving towards (or all ready at) a condition of Dominance. Dominance of zooplankton at the sampling locations implies that the environmental conditions are periodically changing, as a result of natural fluctuations or human activities.

Benthos

Benthos is macroscopic animal existing on, in or near river beds or lake beds. The existence of benthos at the bottom of the water column is affected by the soil substrate type and condition, muddiness of the water, water currents, chemical and biological factors. Benthos interacts with other organisms in the aquatic ecosystem, either as a food competitor or as a predator. Therefore, the populations and types of benthos existing in a water body can be used as a significant determining factor of the biological conditions at the bottom of the water column.

Results of benthos identification and data analysis are presented in **Table 34.**

Table 34 List of Benthos Species, Total Number (Individual/m³), Diversity Index, Evenness Index and Dominance Index at 17 Sampling Locations

ORGANISMS	SAMPLING LOCATIONS																
	BJR-1	BJR-2	BJR-3	BSL-1	BSL-2	BKB-1	BDM-1	BWS-1	BSG-1	BSG-2	BSK-1	BSLW-1	BGF-1	BGJ-1	BSM-1	BSJ-1	BSJ-2
ODONATA :																	
Cordulegaster sp.	-	-	-	8	4	-	-	-	4	-	-	-	-	-	-	-	-
Helocordulia sp.	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
Lester sp.	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tachopterix sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
EPHEMEROPTERA :									-	-	-	-	-	-	-		-
Ephemerella sp.	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudocloeon sp.	-	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ametropus sp.	-	24	-	-	4	4	4	16	72	-	160	-	-	-	32	44	8
Caenis sp.	-	4	-	4	-	-	-	4	12	-	12	4	-	-	-	12	4
Habroplebia sp.	-	-	-	-	4	-	-	-	-	-	-	16	-	-	-	-	-
Basiaesna sp.	-	-	-	-	-	-	-	-	4	-	-	4	-	-	-	-	-
Paraleptoplebia sp.	-	-	-	-	-	-	-	20	40	-	44	-	-	-	-	4	-
Erythemis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
MALACOSTRACA :	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Atylus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euphausid sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanaidae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA :			-	-	-		-	-	-	-	-	-		-	-	-	
Melanoides sp.	4	-	-	-	-	4	-	-	-	-	-	-	52	-	-	20	4
Thiara sp.	48	4	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-
Clithon sp.	4	12	-	-	-	-	4	-	-	28	-	-	-	-	-	-	-
Campeloma sp.	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nerita sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AMPIPODA :	-	-	-	-	-	-	-	-	-	-		-	-			-	-
Gammarus sp.	-	-	-	-	-	-	-	-	-	-	4	-	-	28	-	-	-
BIVALVIA :	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
Modiulus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinctada sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRICHOPTERA :	-		-	-	-	-	-	-		-			-	-	-	-	-
Hydropsyche sp.	-	8	-	-	-	-	-	-	48	-	24	4	-	-	-	-	-
Neureclypsis sp.	-	-	-	-	24	-	-	-	-	-	8	-	-	-	4	-	-
DIPTERA :	-	-	-	-			-	-	-	-	-	-	-	-		-	-
Chironomus sp.	-	-	-	-	-	128	-	-	-	-	-	-	-	-	-	-	-
Atherix sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brilia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
Spinosa sp.	4	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-
Megalopa sp.	28	-	96	-	-	-	-	72	-	-	200	-	-	-	-	-	4
Palaemonetes sp.	24	-	-	-	-	16	264	-	-	12	8	56	204	40	-	12	-
Potamon sp.	8	-	8	-	-	-	-	-	-	-	-	8	-	20	-	-	-
Lymnodrilus sp.	-	4	-	-	-	8	-	-	-	-	-	-	-	-	-	4	-
Branchiura sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereis sp.	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
Dendronereis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phylodoce sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polydora sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syllis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
sp. 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium sp.	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Amount of Taxa	9	8	2	2	4	6	4	5	7	2	9	7	2	4	3	8	4

ORGANISMS	SAMPLING LOCATIONS																
	BJR-1	BJR-2	BJR-3	BSL-1	BSL-2	BKB-1	BDM-1	BWS-1	BSG-1	BSG-2	BSK-1	BSLW-1	BGF-1	BGJ-1	BSM-1	BSJ-1	BSJ-2
Density (Ind/m²)	128	84	104	12	36	164	292	116	192	40	464	96	256	96	40	104	20
Diversity Index (H')	1.72	1.79	0.27	0.63	1.00	0.84	0.39	1.10	1.55	0.61	1.42	1.35	0.50	1.26	0.64	1.68	1.33
Evenness Index (E)	0.78	0.86	0.39	0.92	0.72	0.47	0.28	0.69	0.79	0.88	0.65	0.69	0.73	0.91	0.58	0.81	0.96
Dominancy Index	0.23	0.20	0.86	0.55	0.48	0.62	0.82	0.44	0.26	0.58	0.31	0.38	0.68	0.31	0.66	0.25	0.28

Source: Aquatic Biota Study at Weda Bay Area, 2008

Note: Calculation used Ln (Nats)

Remark : BJR-1 : Ake Jira Downstream
BJR-2 : Ake Jira middle
BJR-3 : Ake Jira Upstream
BSL-1 : Ake Seloi Downstream
BSL-2 : Ake Seloi Upstream
BKB-1 : Ake Kobe
BDM-1 : Ake Doma
BWS-1 : Ake Wosea
BSG-1: Ake Sagea Upstream
BSG-2 : Ake Sagea Downstream
BSK-1 : Ake Sake
BSLW-1 : Ake Sisliwisini
BGF-1 : Ake Gemaf
BGJ-1 : Ake Gojemli
BSM-1 : Ake Bukit Limber
BSJ-1 : Ake Sangaji Upstream
BSJ-2 : Ake Sangaji Downstream

Density of Benthos

Composition of benthos organisms in an aquatic ecosystem depends on the habitat condition and other environmental factors within the ecosystem, including water depth, turbulance, physical and chemical water quality, food quality, interaction between benthitic species and predator-prey cycles.

The number of benthos genera (taxa) from the 17 sample location at WBN area ranged between 2 and 9, with the total number of individual benthos ranging from 12 to 464 ind/m². Benthos density values in all the sampling location are presented in Figure 32.

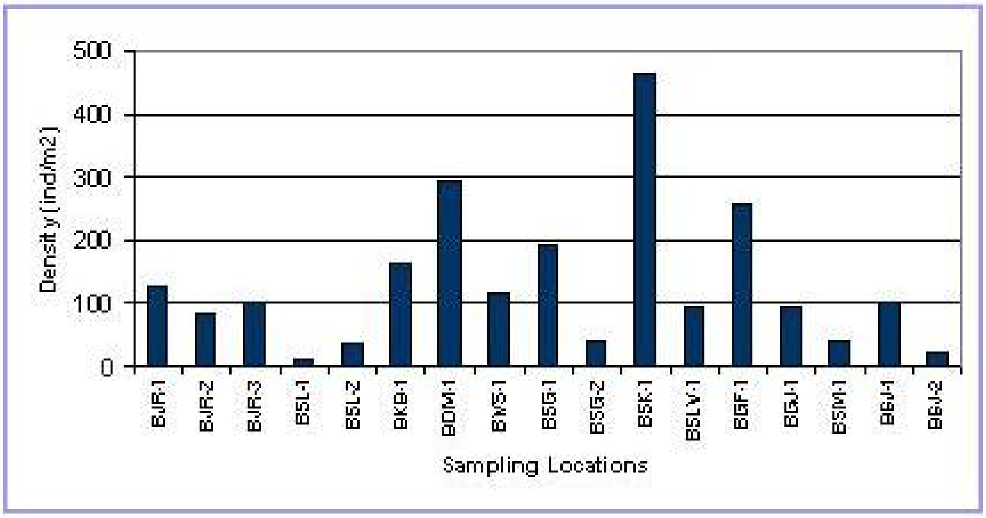


Figure 32 Benthos Density (ind/m²) of the Studied Area

As shown in the Figure 32, Ake Sake, Ake Gemaf, and Ake Doma, with the highest abundance, are all smaller catchments when compared with Ake Jira, Ake Sagea and Ake Sangaji.

Diversity of Benthos

The Diversity Index (H') values of benthos, for the 17 samples collected at WBN the area range from 0.27 to 1.79. According to criteria from Wilhm (1975) this result shows a low value of diversity and community stability in the study area. The low benthos diversity follows similar results for diversity of zooplankton and phytoplankton. The low diversity of benthos cannot be directly related to the diversity of zooplankton (and phytoplankton). However, it can be said that environmental factors in the study area have a significant influence on all forms of aquatic biota. The Evenness Index (E') of benthos organism range from 0.28 to 0.96 for the sampling location at WBN project area. In general, there is a high evenness of benthos in the study area, suggesting that an even distribution of populations of benthos species at most sampling locations. Only Ake Jira Upstream and Ake Doma recorded a low Evenness Index. These two locations also recorded the lowest diversity for Benthos. Dominance Index of benthos for 17 sampling locations at WBN project area range from 0.2 to 0.86, indicating the waters have predominance to dominance. As expected, upper Ake Jira and Ake Doma were found to be in a dominance condition. This is likely to be due to these locations being dominant in one species of zooplankton, and thus one food source.

The following points summarize the results of the freshwater aquatic biota study:

- The low diversity and the trend towards Dominance of phytoplankton, zooplankton and benthos indicate that the conditions of the water bodies in the study area (i.e. water quality, river bed substrate, current) are continuously changing.
- The diversity of aquatic biota in Ake Jira increased from upstream to downstream, whilst the diversity in Ake Sagea had the reverse relationship. Ake Jira is subject to more intensive agriculture as a result of the Transmigration community, and as such the increase in diversity is most likely due to the run-off of fertilizer. Downstream Ake Sagea is subject to much less intensive agriculture (i.e. primarily coconut plantation) with little or no fertilizer use.
- The high abundance and moderate diversity of aquatic biota at Ake Sangaji Upstream is a direct reflection of the relatively undisturbed condition of this large catchment. Ake Sangaji Downstream recorded much lower abundance and a similar diversity of aquatic biota, which is possibly a result of the human activities in this location.
- Apart from low abundance for phytoplankton and zooplankton, significant variation in aquatic biota existed in the smaller catchments of the study area. The variation in results is due to different characteristics of each catchment (i.e. river bed substrate, level of human activity, stream morphology).

15.1.1.4 Fish

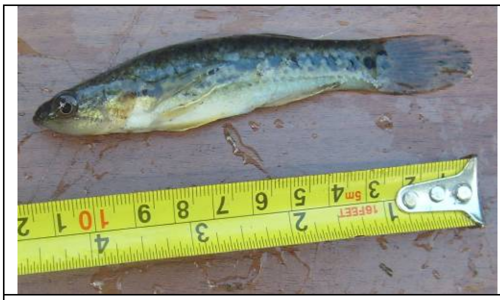
A. Fish Species

During survey of freshwater aquatic biota, 6 species of freshwater fish, one species of shrimp were found at the sampling locations. Table 35 and Figure 33 showed nekton (fish and shrimp) caught during the study.

Table 35 Nekton and Mollusk Species Found at Aquatic Biota Sampling Locations

Local name	Scientific Name	Location	Number of biota
Udang (shrimp)	*Macrobrachium sp.*	Ake Sagea-upstream	7 shrimps
Lalaimon		Ake Sagea-downstream	2 fishes
Lalaimon		Ake Sake	2 fishes
Udang (shrimp)	*Macrobrachium sp.*	Ake Sake	5 shrimps
Kobos (snakehead murrel)	*Channa sriata*	Ake Sake	2 fishes
Kobos (snakehead murrel)	*Channa sriata*	Ake Jira downstream	3 fishes
Kobos (snakehead murrel)	*Channa sriata*	Ake Jira Middle	1 fish
Bulanak (blue spot mullet)	*Valamugil seheli*	Ake Jira Upstream	10 fishes
Lalaimon		Ake Jira Upstream	2 fishes
Kobos (snakehead murrel)	*Channa sriata*	Ake Gemaf	2 fishes
Kobos (snakehead murrel)	*Channa sriata*	Ake Sangaji upstream	1 fish
Kobos (snakehead murrel)	*Channa sriata*	Ake Sangaji Downstream	1 fish
Udang (shrimp)	*Macrobrachium sp.*	Ake Sangaji Downstream	5 shrimps
Lalaimon		Ake Doma	5 fishes
Bulanak blue spot mullet)	*Valamugil seheli*	Ake Gojemli	1 fish
Bubara (white trevally)	*Pseudocaranx dentex*	Ake Gojemli	1 fish
Gete-Gete (climbing perch)	*Anabas testudines*	Ake Gojemli	1 fish
Somasi (black bass)	*Micropterus sp.*	Ake Gojemli	1 fish

Source: Aquatic Biota Study at Weda Bay Area, 2008 – ERM

	
Kobos (snakehead murrel) *Channa sriata*	Bulanak (Blue spot mullet) *Valamugil seheli*

	
Bubara (white trevally) *Pseudocaranx dentex*	Gete-Gete (climbing perch) *Anabas testudines*
	
Somasi (black bass) *Micropterus sp.*	Udang (shrimp) *Macrobrachium sp*

Figure 33 Fresh water nekton (fish and shrimp) found in the study area

B. Metals in Fish Tissue

Fish tissue has the ability to accumulate heavy metals, and therefore can be used as one of the aquatic biota indicators of water quality. If the fish tissue contains a high level of heavy metals or other pollutants, it can be considered as an indication of a polluted environment. According to Anand, 1978, the content of heavy metals in fish tissue is closely related to waste disposal in surrounding area of the fish habitat, such as ponds, rivers, lakes and the sea. The amount of heavy metals absorbed and distributed in the fish tissue depends on the form and concentration of the pollutant, the activity of micro-organisms, the substrate of water bed sediments, and the fish species inhabiting the environment.

Trace metals can be absorbed by fish and accumulated in its tissue. Many studies have focused trace metals of fishes which will be consumed by humans. The allowable level of trace metals in food is stipulated in the Decree of Directorate General of Drug and Food Control, Department of Health of Indonesia No. 03725/B/SK/VII/89 regarding Allowable Level of Metals Contaminant in Food. Out of 10 metals analyzed in this study, only 5 metals are listed in the above mentioned regulation. Those metals are Arsenic, Copper, Lead, Mercury and Zinc. Cobalt, Chromium, Cadmium, and Nickel have been selected as they are found in naturally associated with the ore body. Selenium has a similar bio-cycle as Arsenic and Mercury, and can be accumulated in fish tissue. It therefore has the capacity to be used as a control for natural accumulation of metals in fish tissue.

Table 36 Results of Tissue Analyses of Fish Samples Collected from freshwater at the WBN Area

Sample I.D. Surface Water				BSG 1	BSG 2	BMG 1	BMG 1	BSK 1	BSK 1	BSK 1	BJR 1	BJR 2	BJR 3	B
Sample Description				Udang Macro Branchium	Lalaimon	Lakuriha	Porobibi	Lalaimon	Udang Macro Branchium	Kobos	Gabus/ Kobos	Kobos	Bulanak	Lal
Date Sampled				2-Aug-08	2-Aug-08	31-Jul-08	31-Jul-08	2-Aug-08	2-Aug-08	2-Aug-08	1-Aug-08	31-Jul-08	1-Aug-08	1-A
Time Sampled (WIT)				7.30	16.55	9.40	9.40	11.30	11.30	11.30	13.15	15.00	10.45	1
No.	**Metals**	**Unit**	**Technique**	**Results**										
1	Arsenic, As	mg/wet.kg	GFAAS	< 0.01	< 0.01	0.27	3.27	0.04	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<
2	Cadmium, Cd	mg/wet.kg	GFAAS	0.021	0.004	0.014	0.05	0.002	0.163	0.002	0.003	0.003	0.001	0
3	Copper, Cu	mg/wet.kg	GFAAS	14.2	0.36	0.25	0.34	0.32	4.66	0.25	0.21	0.20	0.27	0
4	Chromium, Cr	mg/wet.kg	GFAAS	2.25	0.4	0.11	0.04	0.03	0.75	0.02	0.04	0.01	0.02	0
5	Cobalt, Co	mg/wet.kg	GFAAS	0.03	<0.01	0.01	0.01	0.06	<0.01	0.53	0.15	0.07	0.11	0
6	Lead, Pb	mg/wet.kg	GFAAS	0.16	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<
7	Mercury, Hg	mg/wet.kg	CVAAS	0.013	0.052	0.03	0.025	0.013	0.004	0.017	0.047	0.059	0.046	0
8	Nickel, Ni	mg/wet.kg	GFAAS	0.20	0.06	0.06	0.04	0.13	0.03	1.48	0.22	0.10	0.16	0
9	Selenium, Se	mg/wet.kg	GFAAS	0.05	0.20	2.39	0.12	0.29	0.10	0.12	0.14	0.31	< 0.01	0
10	Zinc, Zn	mg/wet.kg	FAAS	14.2	11.5	9.5	16.0	29.4	26.9	5.36	8.39	7.71	18.2	9

Sample I.D. Surface Water			BGF 1	AJS 1	ASJ 2	ASJ 2	BDM	BGJ 1	BGJ 1	BGJ 1	BGJ 1	Regulation
Sample Description			Kobos	Kobos	Kobos	Udang	Lalaimon	Bulanak Kobos Jeke	Bubara	Gete-gete	Somasi	BPOM Decree
Date Sampled			2-Aug-08	5-Aug-08	5-Aug-08	5-Aug-08	1-Aug-08	2-Aug-08	2-Aug-08	2-Aug-08	2-Aug-08	No. 0375-1989
Time Sampled (WIT)			14.00	9.40	10.40	10.40	15.30	10.40	10.40	10.40	10.40	
Metals	**Unit**	**Technique**										
Arsenic, As	mg/wet.kg	GFAAS	0.25	< 0.01	< 0.01	0.17	< 0.01	< 0.01	< 0.01	< 0.01	2.07	1
Cadmium, Cd	mg/wet.kg	GFAAS	0.006	0.003	0.010	0.125	0.002	0.002	0.008	0.003	0.003	-
Copper, Cu	mg/wet.kg	GFAAS	0.17	0.18	0.17	8.71	0.30	0.27	0.46	0.21	0.21	20
Chromium, Cr	mg/wet.kg	GFAAS	0.03	0.02	0.07	0.31	0.02	0.03	0.03	0.03	0.01	-
Cobalt, Co	mg/wet.kg	GFAAS	0.01	0.03	0.01	0.01	<0.01	0.07	<0.01	<0.01	<0.01	-
Lead, Pb	mg/wet.kg	GFAAS	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2
Mercury, Hg	mg/wet.kg	CVAAS	0.031	0.064	0.037	0.008	0.027	0.014	0.010	0.020	0.037	0.5
Nickel, Ni	mg/wet.kg	GFAAS	0.05	0.09	0.11	0.07	0.03	0.22	0.05	0.08	0.03	-
Selenium, Se	mg/wet.kg	GFAAS	0.24	0.31	0.18	0.26	0.38	0.11	0.10	0.23	0.21	-

Sample I.D. Surface Water			BGF 1	AJS 1	ASJ 2	ASJ 2	BDM	BGJ 1	BGJ 1	BGJ 1	BGJ 1	Regulation
Sample Description			Kobos	Kobos	Kobos	Udang	Lalaimon	Bulanak Kobos Jeke	Bubara	Gete-gete	Somasi	BPOM Decree
Date Sampled			2-Aug-08	5-Aug-08	5-Aug-08	5-Aug-08	1-Aug-08	2-Aug-08	2-Aug-08	2-Aug-08	2-Aug-08	No. 0375-1989
Time Sampled (WIT)			14.00	9.40	10.40	10.40	15.30	10.40	10.40	10.40	10.40	
Zinc, Zn	mg/wet.kg	FAAS	9.15	7.09	12.8	11.8	11.2	6.42	10.4	11.3	3.37	100

Source: Aquatic Biota Study at Weda Bay Area, 2008

Remarks:

BJR-1 : Ake Jira Downstream
BJR-2 : Ake Jira middle
BJR-3 : Ake Jira Upstream
BSL-1 : Ake Seloi Downstream
BSL-2 : Ake Seloi Upstream
BKB-1 : Ake Kobe
BDM-1 : Ake Doma
BWS-1 : Ake Wosea
BSG-1 : Ake Sagea Upstream
BSG-2 : Ake Sagea Downstream
BSK-1 : Ake Sake
BSLW-1 : Ake Sisliwisini
BGF-1 : Ake Gemaf
BGJ-1 : Ake Gojemli
BSM-1 : Ake Santa Monica
BSJ-1 : Ake Sangaji Upstream
BSJ-2 : Ake Sangaji Downstream

Results of tissue analyses of fish samples collected from the studied area are presented in **Table 36**. The metals concentration of the collected samples were all well below the maximum allowable threshold limit stipulated in the Decree of Directorate General of Drug and Food Control, indicated the fish are not contaminated by the metals.

16 MARINE AQUATIC BIOTA

16.1 PLANKTON

- *Phytoplankton*

Results of Study in 2008

In the marine ecosystem, phytoplankton plays an important role in determining the existence of biological resources. Fluctuation in the environment conditions in the coastal area (i.e. such as light, temperature, salinity, and nutrients (Odum, 1971)) mean only some phytoplankton species can survive and make use of abundant nutrients, despite of the, especially the extreme salinity fluctuation (Nybakken, 1992).

Light plays important role in the phytoplankton photosynthesis process. This condition relates to phytoplankton productivity. Only phytoplankton in the upper column of water body has sufficient light to carry out the photosynthesis process. This makes this phytoplankton more productive than other phytoplankton in the lower level of water column (Nybakken, 1992).

The water temperature has a direct effect on phytoplankton photosynthesis rate. Moreover the temperature also takes part in the metabolism and reproduction process of aquatic organisms (Nontji, 1987). The temperature also has a indirect influence to carbon dioxide solubility in the photosynthesis process. The carbon dioxide solubility will increase as the temperature increases, and subsequently increase the photosynthesis rate. Each phytoplankton species has its own optimum temperature and also very depends on living media and other factors. Generally the optimal temperature range for phytoplankton growth is 29˚ – 30˚C.

The water salinity influences the life of various phytoplankton species due to the changes of specific gravity and the changes in osmosis pressure of the sea water. The sea water specific gravity will increase with the increase in salinity (Nybakken, 1988). According to Chua (1970) in coastal waters, coastal salinity has a great influence in phytoplankton succession. There are some phytoplankton species that can only live in a narrow salinity range/stenohalin area but there are also some species that live in the wide salinity range/euryhalin area.

Generally the salinity in phytoplankton cell tends to be the same/isotonic as the average salinity of the sea water. When these organisms live in lower than average salinity, the cell fluids will be hypertonic and will allow the sea water to flow into the cells. Phytoplankton that cannot overcome this situation will die (Raymont, 1963 in Koesoebiono, 1980).

Nutrients were used by phytoplankton for growth. Inorganic nutrients (i.e. carbon, hydrogen, sulphur, potassium, phosphorus, calcium and magnesium) are needed in a sufficient amount) (Davis, 1955). The main inorganic nutrients required by phytoplankton, and which often become the growth limiting factors, are N and P (Nybakken, 1992).

Sampling of phytoplankton was conducted at four coastal locations. A total of 87 phytoplankton species (see Table 37) represented by 3 classes were recorded. Bacillariophyceae was the most diverse class with 12 species, followed by Dinophyeceae (2 species) and Chyanophyceae (1 species).

Table 37 List of Phytoplankton Species, Total Number of (Individual/m³), Diversity Index, Evenness Index and Dominancy Index of Marine Biota

ORGANISMS	*STATION*			
	BMTB-1	*BMG-1*	*BMLS-1*	*BMKP-1*
BACILLARIOPHYCEAE :				
Chaetoceros sp.	66,012	22,004	258,547	99,018
Coscinodiscus sp.	22,004	11,002	16,503	16,503
Rhizosolenia sp.	55,010	11,002	-	5,501
Stephanopyxis sp.	-	22,004	-	-
Leptocylindrus sp.	33,006	-	11,002	-
Nitzschia sp.	33,006	16,503	27,505	5,501
Navicula sp.	-	-	5,501	5,501
Amphora sp.	5,501	-	5,501	5,501
Triceratium sp.	5,501	-	-	-
Asterionella sp.	-	-	5,501	-
Gyrosigma sp.	-	-	-	5,501
Surirella sp.	-	5,501	-	-
CYANOPHYCEAE :				
Trichodesmium sp.	33,006	5,501	5,501	2,204
DINOPHYCEAE :				
Ceratium sp.	11,002	5,501	33,006	16,503
Peridinium sp.	22,004	-	55,010	27,505
Amount of Taxa	10	8	10	10
Abundance (Ind/m³)	286,052	99,018	423,577	189,238
Diversity Index (H')	2.07	1.93	1.39	1.61
Evenness Index (E)	0.90	0.93	0.60	0.70
Dominancy Index (D)	0.14	0.15	0.34	0.31

Source: Aquatic Biota Study at Weda Bay Area, 2008
Note: Calculation used Ln (Nats)
Remarks: BMTB-1 : Marine at Tanjung Boiwalet
BMG-1 : Marine at Gemaf
BMLS-1 : Marine at Lelilef Sawai
BMKP-1 : Marine at Kobe Pelpis

Abundance of Phytoplankton

The abundance or the density of phytoplankton from marine location was ranged from 99,018 – 423,577 individual/m3. The highest abundance percentage was found at BMLS-1 (Lelilef Sawai) with the value of 42.57%. The lowest was found at BMG-1 (Gemaf) with the abundance percentage of 9.06%. More information of abundance percentage of marine biota is showed in Figure 34.

Phytoplankton species that were recorded in high abundance are as follows: *Bacillaria* sp., *Eunotia* sp, *Gyrosigma* sp, *Mougeotia* sp and *Ankistrodesmus* sp.

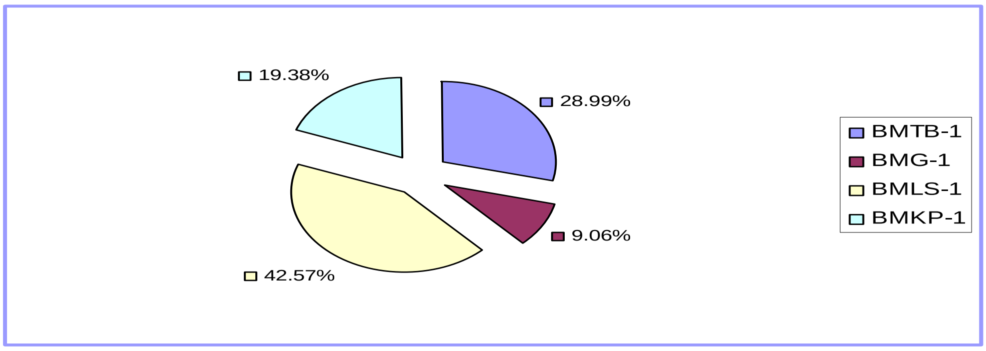


Figure 34 ***Phytoplankton Abundance Percentage of Marine Sampling Locations***

Marine biota samples analysis showed that Bacilariophyceae was possessed the highest relative abundance percentage of more than 80%. Cyanophyceae and Dinophyceae were had the lowest relative abundance percentage (see Figure 35).

According to Sachlan (1972), Bacillariophyta species are most likely to dominate in waters with salinity above 20%. Yudilasmono (1996) in Arsil (1999) stated that Bacillariophyta or Bacillariophyceae can adapt easily to their surrounding environment and are also more likely to be consumed by the fish and the prawn's larva.

The low relative abundance percentage of Cyanophytceae and Dinophyceae is due to their requirement for organic matter as source of food. From this it can be concluded that organic matter content in these waters is very low. This condition was also confirmed by water quality test result of organic matter which was relatively low.

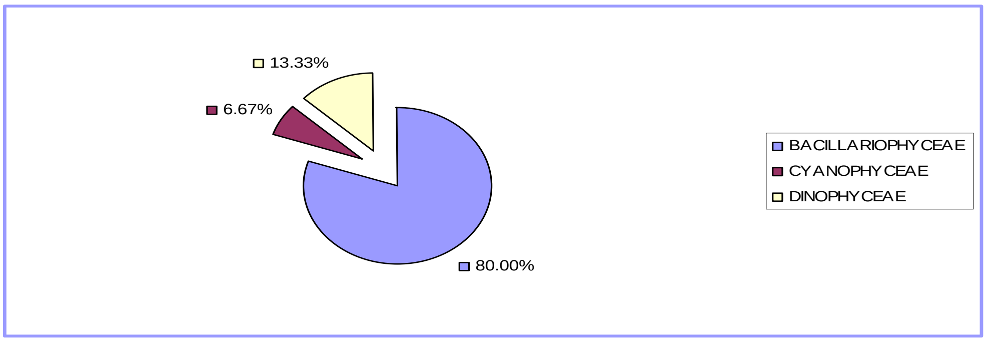


Figure 35 The Abundance of Phytoplankton Based on Class in 4 Sampling locations

The diversity index calculation results of phytoplankton from marine sampling location ranged from 1.39 to 2.07. According to Wilhm criteria, the marine samples showed a moderate diversity and moderate community stability. The Evenness Index calculation result of phytoplankton species found at the marine locations was ranged from 0.60. to 0.93. The value showed that the populations were spread evenly and there is no trend of single species dominance. Dominance Index of phytoplankton of the 4 samples collected from marine waters at WBN the area ranged from 0.14 to 0.34. This value showed that generally there was not one dominant plankton species, meaning that the potential for eutrophication to occur is very low. The loss of dominant species, according to Odum (1971), will cause important changes, not only to the biotic ecosystem, but also to the surrounding physical environment.

<u>Results of Study in 2009</u>

PT. WBN in cooperation with RCO LIPI had undertaken Phytoplankton sampling from 22 February to 7 March 2009 in Weda Bay.

The sampling locations were Project Site (PS); Port Site (PSJ); Sake River Estuary (SRE), Gemaf Village (GV), Gemaf River Estuary (GRE); Tanjung Propoli (TP); Kobe River Estuary (KRE), Lelilef Waibulen Village (LW); and West Waleh (WW). The sampling is triplicate at each sampling location.

Further description is presented below:

There are 29 phytoplankton species found in Weda Bay, which include 20 genuses of diatoms and 9 genus of Dinoflagellata. Three dominant species of phytoplankton in Weda Bay are *Chaetoceros sp, Nitzschia sp,* and *Rhizosolenia sp*. In average, the phytoplankton abundance ranges between 12,291 and 231,965 cell/m^3. The most abundance of phytoplankton is at PSJ station whereas the least abundance is at GV station. More complete data of Phytoplankton is presented in **Appendix B**.

Phytoplankton abundant (e.g. *Chaetoceros* sp) indicated that the water of Weda Bay contains rich nutrient needed by this group of organism. However, the abundant of *Chaetoceros* sp also threaten Weda Bay as blooming of this species is able to generate toxic for other biota (e.g. for fishes which is as phytoplankton predator).

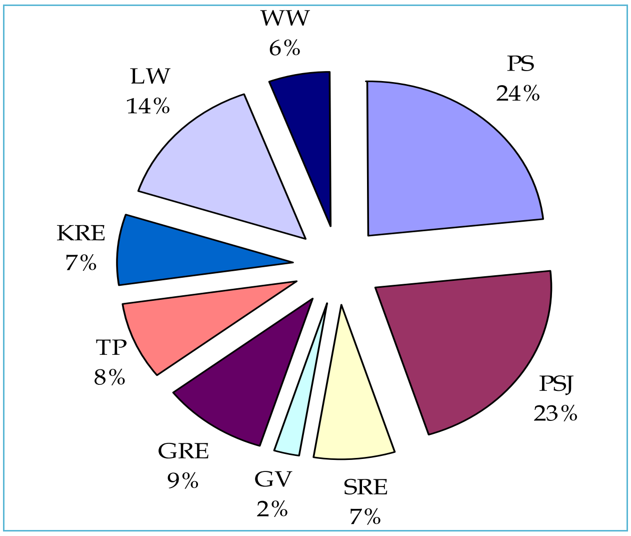


Figure 36 ***Phytoplankton Abundance Average at Each Sampling Location***

Average phytoplankton diversity index in Weda Bay ranged from 1.09 to 2.02. The lowest diversity was at PS station, whereas the highest was at GRE. In general the diversity of phytoplankton in Weda Bay was moderate. In average, the evenness index of phytoplankton in Weda Bay ranged from 0.43 to 0.43 as shown in Figure 36. The lowest evenness index was found at PS whereas the highest was found at GV. The evenness indexes in Weda Bay were identified within moderate and high level. Locations with the highest species richness average was PSJ whereas the lowest was TP. The range of species richness average ranged between 0.77 and 1.11.

B. Zooplankton

Results of Study in 2008

In the aquatic ecosystem, zooplankton is in the second tropic level and its existence depends on phytoplankton existence. Zooplankton serves the function of transferring energy from primary producers (phytoplankton) to living creatures at higher levels of the food chain, such as varieties of nekton.

The results of the zooplankton analyses from the collected marine samples are presented in Table 38.

Table 38 List of Zooplankton Species, Total Number (Individual/m³), Diversity Index, Evenness Index and Dominance Index at 4 Sampling Locations

ORGANISMS	*Sampling Locations*			
	BMTB-1	*BMG-1*	*BMLS-1*	*BMKP-1*
PROTOZOA :				
Codonella sp.	4,402	4,402	127,658	44,020
Rabdonella sp.	2,201	2,201	-	-
Favella sp.	-	-	11,005	-
Vorticella sp.	-	-	563,456	17,608
CRUSTACEAE :				
Nauplius (stadia)	28,613	13,206	24,211	48,422
Calanus sp.	2,201	6,603	2,201	4,402
Corycaeus sp.	4,402	-	2,201	17,608
Cyclops sp.	-	-	-	-
Oithona sp.	2,201	1,101	13,206	2,201
Microsetella sp.	1,101	-	-	11,005
Eucalanus sp.	-	1,101	-	-
COPELLATA :				
Oikopleura sp.	-	2,203	1,101	-
Larva Of Gastropoda (Sp.1)	-	-	6,603	-
Larva Of Pelecypoda (Sp.1)	-	-	2,201	-
Larva Of Polychaeta (Sp.1)	2,201	-	-	-
Amount of Taxa	**8**	**7**	**8**	**9**
Abundance (Ind/m³)	**47,322**	**30,817**	**753,843**	**145,266**
Diversity Index (H')	**1.45**	**1.77**	**0.80**	**1.76**
Evenness Index (E)	**0.55**	**0.91**	**0.38**	**0.80**
Dominancy Index (D)	**0.37**	**0.25**	**0.60**	**0.20**

Source: Aquatic Biota Study at Weda Bay Area, 2008
Note: Calculation used Ln (Nats)
Remarks: BMTB-1 : Marine at Tanjung Boiwalet
BMG-1 : Marine at Gemaf
BMLS-1 : Marine at Lelilef Sawai
BMKP-1 : Marine at Kobe Pelpis

Abundance of Zooplankton

The number of zooplankton genera (taxa) of the collected samples at WBN area ranged between 7 and 9 and the abundance of individual zooplankton ranged between 1,101 and 563,456 ind/m³. The species with the highest abundance percentage at a particular location was *Vorticella* sp (59.46%) found at BMLS-1 (Lelilef Sawai). The species with the lowest abundance percentage was *Eucalanus* sp (0.11%) found at BMG-1 (Sagea).

The abundance percentage calculation result is presented in **Figure 37.**

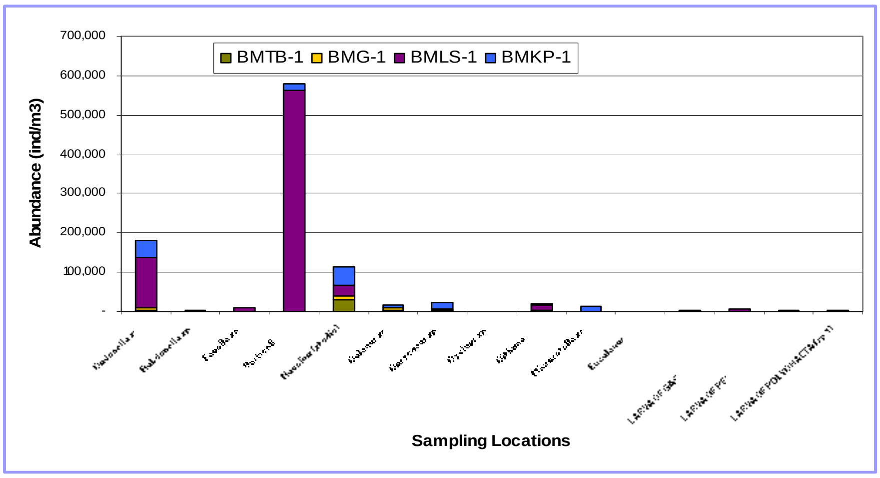


Figure 37 Abundance of Zooplankton from Marine Locations

The diversity index calculation result of zooplankton species found on the sampling locations ranged from 0.80 to 1.77, which is considered low to moderate. The results of the diversity index for zooplankton were inversely proportional with the existence of phytoplankton that served as the food source for zooplankton. The Evenness Index calculation result for zooplankton species found at marine sampling locations ranged from 0.38. to 0.91. This value showed that zooplankton in the studied area showed low to high in evenness. The evenness value of 0.91 in BMG-1 (Gemaf) showed that the population spread was even and no trend of dominance of a single species existed. The lowest evenness value of 0.38 in BMLS-1 (Lelilef Sawai) showed a trend of species dominance. This was confirmed by the abundance percentage of *Vorticella* sp (59.46%). Zooplankton Dominance Index of 4 samples collected at WBN area ranged from 0.20 to 0.60, indicated the waters have the condition Predominance to Dominance for zooplankton. As identified in the Similarity Index, the Lelilef Sawai sampling location had one dominant species, *Vorticella* sp. Some species of *Vorticella* are known to be abundant in the treatment of domestic wastewater. It is possible that the abundance of this species is due to the organic load from the village of Lelilef Sawai.

<u>Results of Study in 2009</u>

Zooplankton sampling was undertaken from 22 February to 7 March 2009 in order to update and to comprehend previous zooplankton data. The zooplankton sampling was carried out by plankton net with mesh size 180 μm.

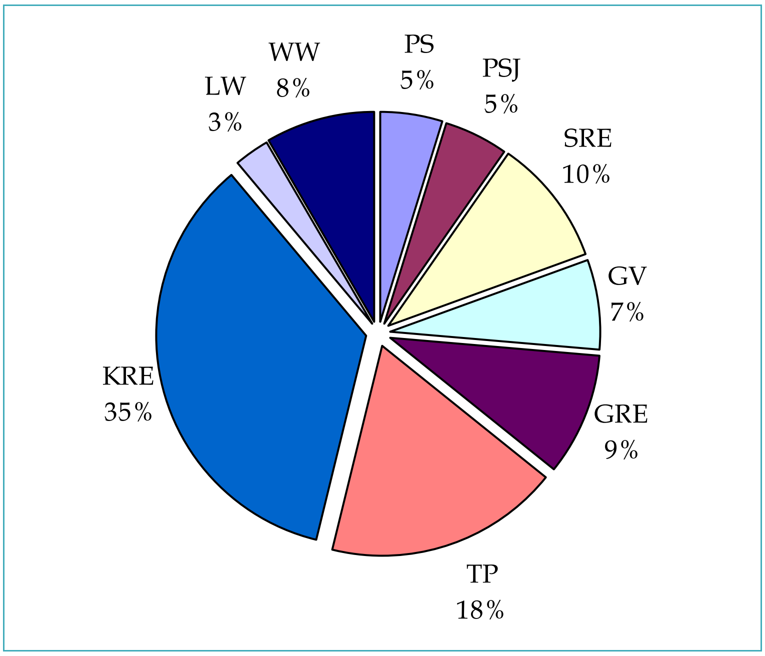
The zooplankton sampling, which was part of plankton sampling was conducted at the same sampling locations as phytoplankton sampling, i.e. Project Site (PS); Port Site (PSJ); Sake River Estuary (SRE), Gemaf Village

(GV), Gemaf River Estuary (GRE); Tanjung Propoli (TP); Kobe River Estuary (KRE), Lelilef Waibulen Village (LW); and West Waleh (WW).

There were four zooplankton groups found in Weda Bay i.e. Calanoida, Cyclopoida, Oikopleura and Luciferida. Of the groups, Calanoida and Cyclopoida were the most frequent species found in the study area. The complete zooplankton data is presented in **Appendix B**.

Zooplankton Abundance

The average of zooplankton abundance was between 327 and 4,005 Ind./m^3. The highest abundance of zooplankton was found at KRE station whereas the lowest was at LW station..



PS	535	**GV**	794	**KRE**	4,005
PSJ	590	**GRE**	1,078	**LW**	327
SRE	1,090	**TP**	2,063	**WW**	955

Unit: Ind./m^3

Figure 38 Zooplankton Abundance in Weda Bay

Zooplankton diversity index in Weda Bay ranged from 1.29 to 1.82. The lowest diversity index was found in KRE station whereas the highest was at PS station. In general, the zooplankton diversity in Weda Bay was within moderate level. The average of evenness index in Weda Bay was between 0.41 and 0.60. The lowest evenness index was found at KRE station whereas the highest was at PS station. In general the evenness of zooplankton index was at a moderate level. The location with the highest species richness of zooplankton was at PSJ whereas the lowest was at TP station. The species richness Index was between 0.77 and 1.11.

16.1.1.1 *Benthos*

<u>Results of Study in 2008</u>

Marine benthoses are macroscopic organisms which perform the same biotic function as freshwater benthos (see Section 3.2.3.2).

Results of benthos identification and data analysis from marine samples are presented in Table 39.

Table 39 List of Benthos Species, Total Number (Individual/m³), Diversity Index, Evenness Index and Dominance Index at 4 Sampling Locations

ORGANISMS	Sampling Locations			
	BMTB-1	BMG-1	BMLS-1	BMKP-1
MALACOSTRACA :				
Photis sp.	-	-	105	-
Euphausid sp.	-	-	15	-
Grapsidae sp.	-	-	-	15
sp. 1	-	-	15	-
GASTROPODA :				
Conus sp.	15	-	-	-
Oliva sp.	30	-	-	-
CRUSTACEAE :				
Trachypeneus sp.	-	4	-	-
POLYCHAETA :				
Nereis sp.	-	4	-	-
Notomastus sp.	-	4	-	-
Lumbrineris sp.	-	-	-	15
Cossura sp.	-	-	-	15
Glycera sp.	45	-	-	-
Platynereis sp.	15	-	-	-
sp. 1	-	-	30	30
sp. 2	-	8	-	-
NEMERTINA :				
Tubulanus sp.	-	4	-	-
SCAPOPODA :				
Dentalium sp.	-	4	-	-
Amount of Taxa	**4**	**6**	**4**	**4**
Density (Ind/m²)	**133**	**193**	**240**	**75**
Diversity Index (H')	**1.84**	**2.52**	**1.49**	**1.92**
Evenness Index (E)	**0.92**	**0.98**	**0.74**	**0.96**
Dominancy Index	**0.30**	**0.18**	**0.45**	**0.28**

Source: Aquatic Biota Study at Weda Bay Area, 2008
Note: Calculation used Ln (Nats)
Remarks: BMTB-1 : Marine at Tanjung Boiwalet
BMG-1 : Marine at Gemaf
BMLS-1 : Marine at Lelilef Sawai
BMKP-1 : Marine at Kobe Pelpis

The total number of individual benthos collected from the 4 samples at WBN area ranged between 4 to 105 ind/m2, and coming from 6 genera (taxa). The species with the highest density percentage was *Photis* sp (28.2%) found at Lelilef Sawai. The species' with the lowest percentage were *Trachypeneus* sp , *Nereis* sp, *Notomastus* sp, *Tubulanus* sp, and *Dentalium* sp. (all 1.10%). Density values for Benthos at the 4 marine locations is presented in **Figure 39.** The Diversity Index (H') of benthos from the 4 marine sampling locations ranged from 1.49 to 2.52. According to Wilhm criteria, the value showed moderate diversity and moderate community stability. The condition means that environmental factors have a significant influence with regards to the existence of benthos organisms in the studied area. The Evenness Index (E') of benthos organisms ranged from 0.74 and 0.98 for the 4 marine sample locations. The results indicate an even distribution of benthos populations at all sampling locations. The Dominance Index of benthos for the 4 marine sampling locations ranged from 0.18 to 0.45, indicated the locations have a Predominance condition for benthos.

The following points summarize the results of the marine aquatic biota study:

- In general, little variation exists between sampling locations, except for the high abundance of aquatic biota at the Lelilef Sawai location. The cause of this result is not clear; however it may be connected with human activities of the Lelilef Sawai village.
- In general, all locations recorded moderate diversity, high evenness and a Predominance condition. This indicates stable environmental conditions for the support of aquatic life.

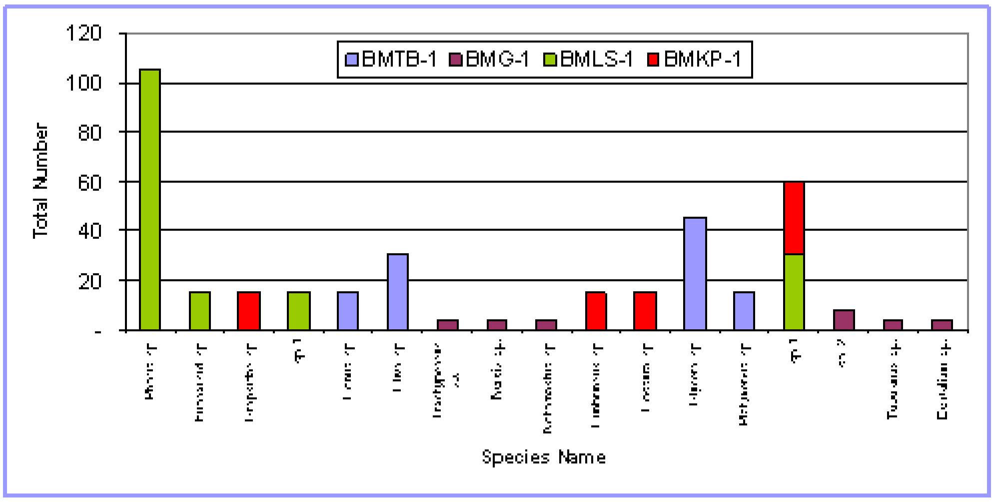


Figure 39 Density (ind/m2) of Benthos from Marine Sampling Locations

Results of Study in 2009

Benthic sampling was carried out from 22 February and 7 March 2009. The samples were collected by 0.5 m^2 Smith McIntyre Grab.

Locations of benthos sampling include Project Site (PS); Port Site (PSJ); Sake River Estuary (SRE), Gemaf Village (GV), Gemaf River Estuary (GRE); Tanjung Propoli (TP); Kobe River Estuary (KRE), Lelilef Waibulen Village (LW); and West Waleh (WW). . In general, the average of benthic diversity index in Weda Bay is high. The evenness of benthic organisms in Weda Bay are also high. The location with the highest species richness was found at TP station whereas the lowest was found at WW.

Coral Reefs and Reef Fishes

Survey activities coral reefs and reef fishes at Weda Bay area were conduct 2001. Results of survey of coral reefs and reef fishes are described below:

A. Coral Reef Biota

A survey of coral reef and reef fishes in the vicinity of the Weda Bay Nickel Contract of work was conducted by PT Dames and Moore Indonesia in 2001. The survey included an investigation of the coral species and reef fish species distribution and abundance.

The survey included six sampling points along the coast adjacent to the Weda Bay Nickel Contract of Work, as shown in Table 40. Each location established transects 50 meters in length, at 3 meters and 10 meters in depth.

Table 40 Sampling points for Coral Reef and Reef Fishes survey

Station	Location	Coordinate
I	Small atoll, south of Fritu	47160N, 403049E
II	River mouth of Sagea Lagoon	52041N, 396416E
III	Botepu Cape	52020N, 390157E
IV	Ulie Cape/Wosea	51894N, 384185E
V	Lelilef	50982N, 381847E
VI (control site)	Tanjung Pegelessesen	45346N, 379868E

Results of the survey are presented below:

Coral Reefs

The average percentage coverage of hard coral in the 6 studied areas is 33.50%. This suggests that the condition of coral reef in Weda Cape Bay lies within the damaged category (Sukarno, 1993). Threats to the coral-reef ecosystem in Weda Bay include the past use of explosives for fishing and the presence of the crown-of-thorn starfish (Acanthaster plancii) in the area. The presence of this type of starfish is commonly used as an indicator of an unbalanced ecosystem.

The percentage of coverage of the sea floor at 3m depth and 10m depth for all six locations is presented in Table 41.

Table 41 The percentage of coverage of the sea floor

Percent Coverage	I		II		III		IV		V		VI	
	3m	10m	3m	10m	3m	10m	3m	10m	3m	10m	3m	10m
Acropora	5.30	5.96	1.38	0.00	3.96	0.76	1.60	2.58	0.12	6.52	9.98	2.22
Non-Acropora	29.76	35.40	57.36	47.20	20.18	6.86	24.88	9.48	29.62	43.32	22.50	32.14
Dead Scleractinia	6.32	4.96	0.68	6.00	24.52	2.42	4.20	7.20	0.00	11.14	0.98	0.00
Algea	2.70	11.98	26.60	7.54	28.72	23.30	23.60	41.10	16.20	8.74	24.34	23.64
Other Fauna	23.96	17.62	6.66	36.56	11.60	5.94	36.72	8.82	52.68	16.12	42.20	28.56
Abiotic	31.96	19.38	6.90	2.30	11.02	60.72	8.68	31.48	0.00	14.80	0.00	11.92

Note: Acropora and Non-Acopora are both hard coral types

Dead Scleractinia includes dead corals and those dead corals with an agal covering.

Other Fauna includes Soft Corals, sponges, Zoanthids and other fauna

Abiotic includes sand, silt, rocks and rubble.

Key observations from the survey are as follows:

The Non-Acropora coral type was found to dominate hard coral coverage at both depths for all locations. In some cases this hard coral type was the dominant form of coverage types (i.e. 3m and 10m depth at the mouth of the Sagea Lagoon estuary).

The Non-Acropora coral type was found to be in very good condition at both depths at Ulie Cape/Wosea and at 3m depth at Lelilef location.

The Acropora coral type was sparsely represented across all stations at both depths.

The high percentage of abiotic coverage at Botepu Cape, 10m depth, is due to rubble, indicating a high degree of damage to hard corals. This condition, along with the high percent of Dead Scerlactinia at 3m depth, is presumed to relate to land activities causing high turbidity of some waters at this location.

In general, other fauna at both depths for all locations is dominated by the presences of soft corals, with the highest coverage at 3m depth at Lelilef (52.30%). Sponges represent a small percentage of the total coverage, with the highest coverage at 10m depth at the small atoll to the south of Fritu (6.00%).

Past explosives use for fishing was evident at the small atoll to the south of Fritu.

Water temperatures for the six locations ranged between 29.1°C and 29.7 °C indicating good conditions for coral growth.

Salinity ranged between 33.1 and 33.4 %0 also indicating good conditions for the growth of coral.

The presences and dominance of hard coral genera for each station is presented in Table 42.

In total 36 genera of hard coral was identified during the survey. At 3 meters depth 28 genera of hard coral were recorded, whilst at 10 meters depth 31 genera were present. The most dominant genera of hard coral across all locations were the Montipora type, followed by Porites type. Both genera were present at all six locations at both depths.

Table 42 Presence of Hard Corals (Genus level) in Sampling Locations

No	Genus	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
1	Favites	•	•	•						•	•		•
2	Fungia	•	•	•	•	•	•						
3	Galaxea	•	•	•	•		•						•
4	Goniopora	•	•			•	•						•
5	Gontrastrea	•	•				•	•			•		
6	Hydnopora	•	•				•			•			
7	Merulina	•	•		•		•						
8	Mycedium	•	•				•		•	•	•		
9	Montipora	X	X	X	X	•	X	•	•	•	X	X	X
10	Pectina	•	•		•						•		
11	Physogyra	•	•				•						
12	Platygyra	•	•	•			•	•		•	•		•
13	Pocillopora	•	•				•	•		•	•	•	•
14	Porites	X	•	X	•	X	X	X	X	•	X	•	•
15	Sandralolitha	•	•		•						•		
16	Serralopora	•	•	•	•	•	•			•	•	•	•
17	Stylopora	•	X	•			X		•		•		
18	Acropora			•		•			X				
19	Coeloseris			•						•			
20	Favia			•	•	•				•	•		
21	Mellipora			•									
22	Pachyseris			•					•	•			
23	Ctenactis				•								
24	Echinopora				•					•	•		
25	Herpolita				•								
26	COT (Achantaster)					•							
27	Diploastrea					•		X		X	•		•
28	Plesiastrea					•							
29	Leptoria							•					
30	Goneastrea								•				
31	Astreopora									•			

No	Genus	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
32	Oucophyllia									•			
33	Cyphastrea										•		X
34	Leptoseris										•		
35	Lobophyllia										•		
36	Rectinia										•		
37	Symphyllia										•		

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001

Reef Fishes

Indicator Species. Indicator species represent those species which have a simbiotic relationship with different coral genera, and thus provide an indication of the state of health of the reef by their presence, or absence. The indicator species groups found from the research locations consisted of 3 genera of the Chaetodontidae family. The Chaetodon genus consists of as many as 15 species, as well as 1 species of the Forcifiger genus 1 species and 3 species of the Heniocus genus. The results of observation of each station shows that the largest number of species and individuals are found at the river estuary of Sagea Lagoon (Station II) both at the depth of 3 meters (11 species with 184 ind./ transects) and at the depth of 10 meters (13 species with 178 ind./ transects). While the lowest number of individuals was found at the atoll in front of Fritu (Station I). In general, however, the conditions of the indicator fish groups in all stations including the control are not significantly different (as shown in Table 43).

The types of indicator fish dominating all stations of research are Chaetodon kleinii, C. vagabundus, C. trifasiatus, C. rafflesi and Heniocus acuminatus. Diversity of Indicator fish species is considered low (diversity index ranges from (0.41 – 0.99).

Table 43 Distribution and Abundance of Indicator Species from Two Depth in Sampling Locations

No	Spesies	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
Chaetodontidae													
1	Chaetodon kleinii	8	18		21		11	8	1	10	18		4
2	C. vagabundus	16	5	51	29	21		19		7	36	37	4
3	C. meyeri			2	3	1	3	11		2			
4	C. ocillicaudus	1						13			2	14	
5	C. ulietensis							16					
6	C. baronessa	2		31	2	2	1	7			4	6	12
7	C. trifasialis		6	9	5	6	12	2			3	4	
8	C. trifasiatus	12	5	48	51	2	8	16	1	15	24	18	
9	C. rafflesi	2		11	17		2	9	4	2	21	14	4
10	C. punctatofasiatus		2	5	4		4				17	4	2
11	C. octofasiatus			5	13		12			16	33		29
12	C. citrinulus	1			3		5				1		
13	C. auriga			9		1	1	1		2			

No	Spesies	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
14	C. mellanotus								11		2		
15	C. semeion			2									
16	Forcipiger longirostris				3								
17	Heniocus acuminatus		3	11	26	8	15	11		2	5	1	2
18	H. singularis		2		1	3		3			9		
19	H. Varius									11			
	Total individual	42	41	184	178	44	74	116	17	67	175	98	57
	Total Species	7	7	11	13	8	11	12	4	9	13	8	7
	Diversity Index	0.66	0.71	0.84	0.88	0.68	0.92	0.99	0.41	0.83	0.94	0.74	0.64

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001

Target and Major Species. The census for target fish (i.e. speices for human consumption) and the major groups (i.e. species important in the food chain) at the six locations recorded 163 species. The Labridae (27 species) and Pomacentridae (26 species) genus were the most diverse genera. A full list of species is presented in Table 44. The greatest abundance was found at atoll in front of Fritu (Station I) at the depth of 10 meters and Lelilef (station V) at the depth of 3 meters. While the least abundance was found at Tanjung Ulie/Wosea Cape(Station IV) at the depth of 10 meters and at the Tanjung Pagelessesen (control station) at the depth of 3 meters. The diversity indexes range between 1.10 – 1.52 indicating moderate diversity at locations and depths.

Table 44 Distribution and Abundance of Target and Major Species from Two Depth in Sampling Locations

No	Species	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
Acanthuridae													
1	Acanthurus sp	15	65	18		60				45		9	
2	A. pyroferus		41	15		70	28		19	17	57		
3	A. lineatus			125						28		38	
4	A. xanthopterus		33										
5	A. mata									9	20		
6	A. thompsoni		101								5		
7	A. leucocheilus		27								9		24
8	A. gahhm		27										
9	Naso sp										75		
10	N. vlamingi				25				22		55		
11	N. hexacanthus							18			125		
12	N. lituratus			6	11			5	16		124		1
13	N. lopezi										12		
14	Ctenochaetus striatus	38	47	36	62	18	62	33	6	85	38	30	25
15	C. tominiensis				21								
16	Zebrasoma scopes	31	36	46	19	36	26	114	37	38	22	81	
17	Z. veliferum			12			9						

No	Species	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
18	Zanclus cornutus		51	30	61	14	27	12	7	18	52	14	18
Siganidae													
19	Siganus sp				16								
20	S.doliatus			69	22						4		4
21	S. vulpinus			24	21	6	13	2			44		
22	S. puellus			22	11		21	38		5	11		
23	S. coralinus		6	14	31	23	18	4	2		51		
24	S. guttatus			20		12	30			14	39		
25	S. canaliculatus			39							39		
Mullidae													
26	Parupeneus sp					4							
27	P. bifasiatus	3	2	68	6	26	21	22	9	6	42		
28	P. multifasiatus	6		53	27	2	8	23	7	11	2		1
29	P. barberinus	9		2		4	39	33	1	11	1		1
Lutjanidae													
30	Lutjanus sp			9							9		
31	L. kasmira			12				20			20		
32	L. fulvus			16	78		16	3					
33	L. decussates	4		86	124	75	54	7	2	10	13		
34	L. gibbus				3						22		
35	L. carponatus			34	43			25		16	80	1	11
36	L. monostigma			14	25						35		
37	L. fulvillama				18						12		
38	Macolor macularis		14										
39	M. niger		1								14		
Lethrinidae													
40	Lethrinus sp			13				25			22		
41	L. lentjam			20				3	8				
42	Monotaxis granducolis		12	9	7		2				8		4
43	Gnadontex aurolineatus		4	43	11		2	6			6		2
Scaridae													
44	Scarus sp			8		18				36		2	
45	S. dimidiatus			65	7	35	5	11		135	5		
46	S. sordidus			15	9	9	14	3		14	19		
47	S. bleekri		9	12	16	14	17	3		6	21	22	3
48	S. ghoban	7		20	35		29	17	4	6	21	20	
49	S. altipinis				5			12					
50	S. shameleon	4		2	15	4	8	23		26		11	18
51	S. pyrrhunus			21		15				2			9
52	S. flavipectoralis			16			10	12			6		
53	S. schlegeli		13	30									
54	S. bowersi				27	23	23	7	25	6	35	6	
55	S. arabicus	6			6		7	9			15	6	
56	S. ermeacanthus					27				22			
57	S. japonensis			7		2		10					
58	S. tricolor	12	14							10	20		2

No	Species	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
59	S. franatus					10	11			10	1	1	
60	S. rubroviolaceus				6		10				33		
61	S. bicolor			7					43		26	3	
62	Calatomus sp			17	5	30		8	2	11	4		23
Kyposidae													
63	Kyposus cinerascens		2	56									
Caesionidae													
64	Caesio sp		450		310			100					
65	C. cuning					16			275		550		125
66	C. suevica				150						100		
67	C. caerulaurea										300		
68	C. striata									30			
69	C. lunaris				100								
70	Pterocaesio sp		250								75		200
71	P. tile		200		25		75		40	145			
72	P. pisang		450		400						450		
73	P. trilineata										400		
Labridae													
74	Cheilinus sp	2	3	4	3		1		6		6		2
75	C. undulates										1		
76	C. trilobatus	2		6	6		2	13					
77	C. fasiatus			11	2		5			5	2		4
78	C. chlorourus	1		1	7					7	15		1
79	Chaerodon sp	1		2	3	22		4		6	4		6
80	C. anchorago			5		3		1					
81	Helicheres sp	8	10	2	16			15				13	
82	H. hortulannus	19	4	13									
83	H. argus	2	4		23			6	7	7	14	2	
84	Thalassoma sp	7	2	7	5	37	6	6	51			4	
85	T. hardwikii	220		200		105		65		105		160	
86	T. lunare	18	3			15		10	1	25	1	18	
87	T. jenseni	6	5	28		23	4	13		3		23	
88	Anampses sp	2	4		14		4			2	2		2
89	A. caeruleopunctatus			9	4	5	1	5	4	2			
90	Bodianus sp	1	4	3	7	2					3	1	
91	B.mezotorax		4	5	6	3	5	3	1		13	9	2
92	Stethojulis sp	5		4	2	8		31		37		29	8
93	Pseudocoris sp		9		5					18		8	
94	Macropharyngodon ornatus			12							4	3	
95	Gomphosus sp	1		2	1		1				1	1	
96	G. varius			1	3	5	2	1		5	1		
97	G Caenoleus			2									
98	Coris sp	7		6	2	2	6	4	7	1	1	1	2
99	Coris gaimand									5			
100	Hemigymnus				5				1				

No	Species	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
	melapterus												
Nemipteridae													
101	Scolopsis sp						3						14
102	S. bilineata			4				2		1		2	
103	S.margaritifer			6	5		1	20	3		6		
104	S. lineata							4					
Pomacanthidae													
105	Pygoliptes diacanthus		12		3	3	11				6		1
106	Centropyge tibicen		3	6	3	9	3	2			8		5
107	Pomacanthus navarchus	500	3		1				1		73		
108	Chaetodontoplus mesoleucus		11	6	8					13			19
109	Centropyge sp					2							
Pomacentridae													
110	Abudefduf sp	32	20								20		16
111	A. bengalensis									250			
112	A. vaigiensis	18				350		250		250			
113	A. sexfasiatus					100							
114	Chromis sp	45	19	500		25	200			425	100	125	50
115	C.margaritifer	75	225	75	150	150		50		100	25	50	200
116	Pomachromis richardsoni				160	75							
117	Stegastes sp									75			
118	Neopomacentrus sp	30			420	150	75						170
119	Neoglypidodon sp			300	30								36
120	Neoglypidodon meles		25										
121	Neoglypidodon nigrosis		200							138	125		
122	Dascyllus sp				40	60							
123	D. reticulates		30	70						85		25	
124	D. melanunus								40				30
125	D. trimaculatus					25		21	18			25	45
126	D. melanurus											60	
127	Chrysiptera sp		500	300	275	100	175	100	22	50		375	75
128	Plectroglyphidodon lacrymatus	100	150	175		75		45		335		45	
129	P. johnstanianus										50		
130	P. dickii		16							290	50	475	16
131	P. sindonis			20									
132	Amblyglyphidodon curacao	70	150	50		100		270		650	150		275
133	A. auresus							75					
134	Pomacentrus sp		425	150	25	300	50		35	200	60		700
135	Stegastes sp	275		30		50							
Carangidae													

No	Species	Sampling Locations											
		I		II		III		IV		V		Control	
		3M	10M	3M	10M	3M	10M	3M	10M	3M	10M	3M	10M
136	Carans sp		2								3		18
137	Carangoides sp				5				20				
Serranidae													
138	Cephaloposis sp			2		4				1			
139	C. argus		4	5		1	2	3		1			
140	C.miniata	11	79		10		2	1			33		
141	C. urodeta	2	50	5			6	1					
142	C. hemitiletos		26										
143	C. sexmaculatus	21	20									11	
144	Anyperodon leucogrammicus			1									
145	Epinephelus sp		1		4		2				1		6
146	E.merra		13	1	1	4	1	19			6		
147	E. fasiatus		1	3	3			3	1	2	1		
148	E. sexfasiatus			1									
149	Plectropomus sp				3						1		
150	P. leopardus		8										
151	P.oligacanthus		25								28		
152	P. maculates		8								18		
153	P. punctatus										5		
154	Pseudanthias sp	130	250	300		250				20		300	
155	P. huchti	175	200	400		550							75
156	Pseudanthias spp	650								320			
Holocentridae													
157	Myripristis sp			6	23			4			9		
158	Sargonteus sp			6	22				2				
Balistidae													
159	Balistapus undulatus	12		12	18		7	6	9	3	22	12	7
160	Balistodei conspicillum		1										1
161	Sufflamen bursa	3									14		2
162	Odanus niger	5											
Apogonidae													
163	Apogon sp				20								
Total individual		2591	4384	3888	3101	3166	1160	1661	754	4222	4031	2021	2259
Total Species		45	64	86	76	58	52	62	36	63	88	39	45
Diversity Index		1.101	1.359	1.482	1.418	1.389	1.355	1.403	1.126	1.361	1.515	1.104	1.109

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001

Results of Study in 2009

To update and comprehend data of coral reef and fishes, a survey was undertaken from 22 February to 22 March 2009. The survey was undertaken at Tanjung Populi (TP), Lelilef Waibulen Village (LW), Plant Site (PS), Tanjung Uli – Project Site (TUP), Tanjung Uli – Camp (TUC), Gemaf Village (GV), Sagea Lagoon Channel – Seaward (SLC1), and West Waleh (WW).

Coral Reefs

There are 79 generas found in deep zone and 77 genera in shallow zone. Some hard coral colonies with diameter more than 1 m was generally found in survey locations i.e. Acropora, Anacropora, Diploastrea, Porites and Lobophyllia. Soft coral was also generally found in Weda Bay.

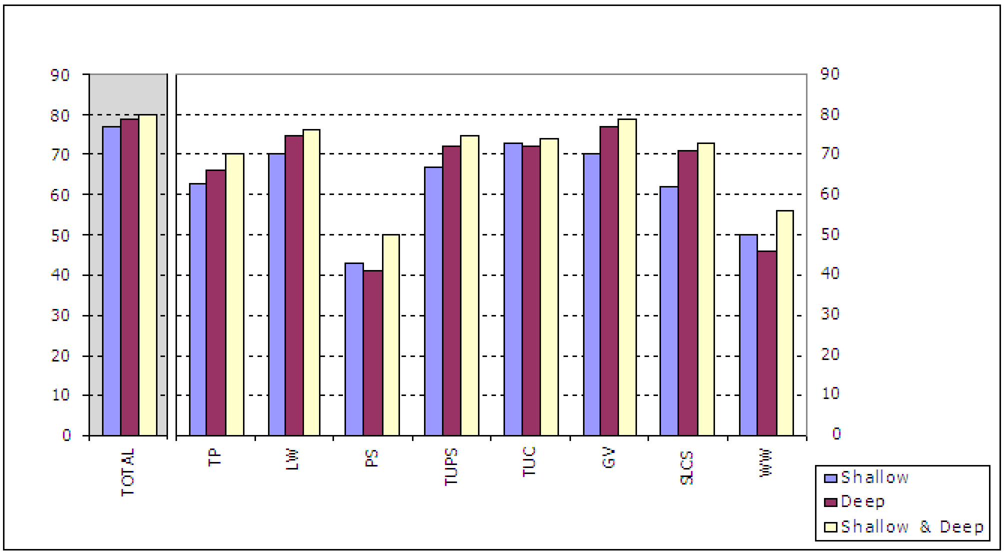


Figure 40 Number of Hard Corals Genera in Weda Bay

Observed coral in 8 survey locations are presented in the Table 45.

Table 45 Important Observed Coral in Weda Bay

No	Location	Code	Important Observed Coral Reef
1.	Tanjung Popoli	TP	Porites, Hydroids, Soft Coral (Sinularia)
2	Lelilef Waibulen Village	LW	Diploastrea, Acropora, Millepora, Hydroids, Soft Coral (Sarcophyton, Sinularia)
3.	Project Site	PS	Porites, Soft coral (Sarcophyton, Sinularia, Lobophytum)
4.	Tanjung Uli (Site Plant)	TUP	Porites, Soft coral (Sinularia, Sarcophyton, Nepthea)
5.	Tanjung Uli (Camp)	TUC	Diploastrea, Acropora, Soft coral (Sinularia, Sarcophyton
6.	Gemaf Village	GV	Acropora, Porites
7.	Sagea Lagoon Channel (Seaward)	SLC1	Porites, Soft coral (Sinularia, Sarcophyton)
8.	West Waleh	WW	Acropora, Porites, Soft coral (Sinularia, Sarcophyton)

Complete data of coral reef is presented in **Appendix B**.

Reef Fishes

There are 302 species of 39 families that was recorded at 4 through 5 m depth, at eight sampling locations. Twenty six of them are indicator species, 98 are target species and 178 are main species. Location with the most diverse was found at the outlet of Laguna Sagea (143 species). Location with the lowest diversity was Tanjung Populi (81 species).

Indicator Species. Butterfly fishes have a good association with condition of coral. Twenty six species are from 3 generas and 1 family (Chaetodontidae). Genera of Chaetodon covers 21 species, genera of Heniochus includes 4 species, and genera of Coradion includes 1 species. The most common butterfly species that encountered in Weda Bay are *Chaetodon baronessa* (19.13%), *Chaetodon vagabundus* (17,49 %), *Chaetodon trifasciatus* (14,75%), and *Heniochus varius* (13,1%)

Target Species. The most abundant species was *Caesio cunning* (Caesiodidae) (23.5% of total target species), followed by *Caesio caerulaurea* (Caesiodidae) and *Naso lituratus* (Acanthuridae) with 10% and 8.2%, respectively. From the most to the least, the target species was *Pygoplites diacanthus* (Pomacanthidae) followed by *Scarus quoyi* (Scaridae), *Scolopsis margaritifer* (Nemipteridae) and *Lutjanus decussatus* (Lutjanidae).

Major Species. There are 176 major fishes of 25 families. Two families i.e. Pomacentridae and Labridae are respectively the most diverse with 61 and 48 species. The major fishes are mainly *Chromis ternatensis* (Pomacentridae) with 22,4%, followed by *Chromis amboinensis* with 8,2%.

Appendix B of the ANDAL document presents complete data of coral fishes.

Seagrass and Seaweed (Results of 2001 Study)

A survey of seagrass and seaweed was conducted within the vicinity of the Weda Bay Nickel Contract of Work, using a combination transect and quadrant method. Data was collected form five sampling locations, which include coastal areas of Lelilef (Station I), Tanjung Lipe (Station II), Tanjung Ulie (Station III), river mouth of Sagea Lagoon (Station IV) and Sagea Village (Station V). The survey result shows that there are only one species of seagrass, *Thallasia sp*. and 2 species of seaweed, namely, *Sargasum* sp and *Gracilaria* sp at all sampling locations. The distribution of seagrass and seaweed in each research station can be seen in the following Table 46:

Table 46 Dominance Index of Seagrass and Seaweed at Sampling Locations

No	Species	Dominance Index				
		I	II	III	IV	V
1	*Thallasia sp*	0.74	0.88	0.78	0.89	0.67
2	*Sarghasum sp*	0.76	0.89	0.90	0.89	0.94
3	*Gracilaria sp*	-	0.90	0.95	0.89	0.98

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001

The *Thallasia sp*. type was dominant at all sampling locations. In accordance with the opinion of Odum (1971), if the Dominance Index is high it indicates lower dominance concentration, and in contrast if the Dominance Index is low, the dominance will be high.

The density analysis results of each station can be seen in Table 47.

Table 47 Density of Seagrass and Seaweed at Each Station

No	Species	Individual Density (ind/cm^2)				
		Station I	Station II	Station III	Station IV	Station V
1	*Thallasia sp*	0.81	0.70	1.37	0.92	1.14
2	*Sarghasum sp*	0.79	0.76	0.91	0.89	0.46
3	*Gracilaria sp*	-	0.73	0.69	0.91	0.35

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001

The above table shows that the highest density was recorded by *Thallasia* sp for all stations and the highest recording was at Tanjung Ulie. *Sarghasum* sp is the second most dense at all locations except Tanjung Ulie. The highest density indicates that the Thallasia sp type is well adapted to all locations. While the lowest density shows that this type is less tolerant to its habitat. The coverage percentage average of each station can be seen in Table 48.

Table 48 Percent Cover of Seagrass and Seaweed

Station	Percent Cover			Average
	Transect			
	1	2	3	
I	86.67	70.00	73.33	76.67
II	86.67	73.33	40.00	66.67
III	90.00	96.67	83.33	90.00
IV	100.00	73.33	50.00	74.44
V	90.00	96.67	93.33	93.33

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001

The highest average coverage was at Sagea Village, which also recorded the second highest density of *Thallasia* sp.

Results of Study in 2009

Intertidal community survey was carried out from 22 February to 22 March 2009 in the areas i.e. PS (Project Site), SRE (Sake River Estuary), GRE (Gemaf River Estuary), LW (Lelilef Waibulen) and SLC (Sagea Lagoon Channel).

Seaweed Community

Eight seaweed species are found in the survey i.e. *Halodule pinifolia* (Miki) den Hartog; *Halodule uninervis* (Frosskal) Ascherson; *Cymodocea rotundata* Ehrenb. & Hempr. Ex Ascherson; Cymodocea serrulata (R. Brown) Ascherson & Marson; *Syringodium isoetifolium* (Ascherson) Dandy; *Enhalus acoroides* (Linnaeus f.) Royle; *Thalassia hemprichii* (Ehrenberg) m Ascherson; *Halophila ovalis* (R. Brown) Hooker; and *Halophila spinulosa* Ascherson. Coverage of seaweed varied from 2% to 90%. There is a correlation between species distribution and seaweed coverage. Completed data is presented in **Appendix B** of the ANDAL document.

Macro algae community

Surveys identified 43 species (of 4 families) of microalgae. Chlorophyta family (green macro algae) was the most diverse and contributed 17 species. Phaeophyta (brown macro algae), Rhodophyta (red macro algae) and Cyanophyta (green blue macro algae) respectively contributed 11, 14 and 1 species. In general, there is no variability of diversity among survey areas. However, Sake River estuary indicated more species than other sampling locations. Complete data is presented in **Appendix B** of the ANDAL document.

Intertidal Biota (Results of 2001 Study)

Intertidal biota consists of any life form found in the foreshore, or zone which is exposed to air at low tide and submerged had high tide. In areas close to human settlements, the intertidal zones tend to be harvested for species of value. A survey of the intertidal biota was conducted in the vicinity of the Weda Bay Contract of Work. The survey observed intertidal biota at the following locations: Sagea Village (Station I), mouth of Sagea Lagoon estuary (Station II), Tanjung Lipe (Station III), Tjetju River (Station IV) and Lelilef (Station V). The types of biota found at the 5 stations in the waters of Weda Bay consisting of 4 classes, namely: (1) Gastropoda class, (2) Bivalve/ Pelecypoda (from phylum Molusca), (3) Asteroidea class and (4) Holothuroidea class (from Echidodermata phylum). Analysis of the data included Density, Abundance, Dissemination pattern, Diversity and Dominance Index at each station.

Density and Abundance. In general high densities correspond to species which are well adapted to the surrounding environment. Analytical results of the density and abundance present in each station is in Table 49. Sagea Village the biota recording the highest density was *Nasarius optimus*, whilst the lowest density is the starfish of *Archaster typicus*. At the river estuary of Sagea Lagoon the highest density was recorded by *Babylonia spirata* the lowest was *Diadema setosum*. At Tanjung Lipe, *Cypraea moneta* had the highest density, while the lowest is *Diadema setosum*. Tjetju River, *Bursa bamboo* had the highest density and the lowest is *Nassarius optimus*. Lelilef recorded the starfish of the *Archaster typicus* type having the highest density value, while *Anadara granosa* had the lowest density value.

Table 49 Intertidal Species Density and Abundance at Each Stations

No	Species	Density (Individual/m²)	Abundance (Individual/m²)
Station I			
1.	*Anadara granosa*	0.45	1.44
2.	*Archaster typicus*	0.60	1.20
3.	*Nassurius optimus*	0.46	1.27
4.	Thiara scabra	0.23	1.16
Station II			
1.	*Babylonia spirata*	1.03	1.63
2.	*Cypraea moneta*	1.10	1.94
3.	Diadema setosum	0.40	1.20
4.	*Echinothrix diadema*	0.33	1.25
Station III			
1.	*Anadara granosa*	0.73	1.22
2.	*Archaster typicus*	1.10	1.83
3.	*Babylonia spirata*	0.66	1.33
4.	*Cypraea moneta*	1.53	2.19
5.	*Diadema setosum*	0.60	1.28
6.	*Echinothrix diadema*	0.46	1.27
7.	*Nassarius optimus*	1.06	1.77
Station IV			
1.	*Anadara granosa*	0.33	1.66
2.	*Arcahaster typicus*	0.23	1.75
3.	*Bursa bamboo*	0.36	1.57
4.	Echinothrix diadema	0.26	1.00
5.	*Murex*, sp	0.33	2.00
6.	*Nassarius optimus*	0.06	1.00
Station V			
1.	*Anadara granosa*	0.50	1.36
2.	*Archaster typicus*	1.03	1.50
3.	*Babylonia spirata*	0.46	1.75
4.	*Bursa bamboo*	0.36	1.00
5.	*Cypraea moneta*	0.53	1.45
6.	*Holothuria edulis*	0.06	1.00
7.	*Nassarius optimus*	0.46	1.16

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001

Distribution Pattern. Random distribution patterns occur because the environment is uniform and there is no tendency to gather. While uniform distribution patterns occur because the environment is not similar and there is the tendency to gather. An organism can disseminate by group due to differences in the local habitat, the availability of diet in the form of nutrient substance and physical-chemical factors as well as the response towards the daily and seasonal weather (Noughton and Wolf, 1990). Table 50 shows that the distribution pattern of the biota types at the 5 sampling locations. Sagea Village, the river estuary of Sagea Lagoon, Tanjung Lipe and Lelilef all recorded 2 forms of distribution pattern, namely the clustered and uniform patterns. Meanwhile in at Tjetju River there were 3 forms of distribution pattern, namely, random, clustered and uniform.

Table 50 Intertidal Biota Distribution Pattern at Each Sampling Station

No	Species	Pattern
Station I		
1.	*Anadara granosa*	M
2.	*Archaster typicus*	S
3.	*Nassurius optimus*	M
4.	Thiara scabra	M
Station II		
1.	*Archaster typicus*	M
2.	*Babylonia spirata*	S
3.	*Cypraea moneta*	M
4.	Diadema setosum	M
5.	*Echinothrix diadema*	M
Station III		
1.	*Anadara granosa*	S
2.	*Archaster typicus*	M
3.	*Babylonia spirata*	S
4.	*Cypraea moneta*	S
5.	*Diadema setosum*	S
6.	*Echinothrix diadema*	M
7.	*Nassarius optimus*	M
Station IV		
1.	*Anadara granosa*	A
2.	*Archaster typicus*	A
3.	*Bursa bamboo*	A
4.	Echinothrix diadema	S
5.	*Murex*, sp	S
6.	*Nassarius optimus*	M
Station V		
1.	*Anadara granosa*	M
2.	*Archaster typicus*	S
3.	*Babylonia spirata*	S
4.	*Bursa bamboo*	S
5.	*Cypraea moneta*	M
6.	*Holothuria edulis*	S
7.	*Nassarius optimus*	S

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001
Notes : M = Clustered, A = Random, S = Uniform

Species Diversity and Dominance Index.

The Diversity and Dominance Index in each station is presented in Table 51. The results show that the diversities of biota types in all 5 stations is categorized as low. Sanders in Nybakken (1992) said that the highest diversity is due to stable long term environmental conditions, which enables species to evolve and specialize in order to survive in the micro-habitat or to utilize certain foods. In contrast low diversity in a community indicates disruption to both the physical and biological components of the ecosystem. The dominant form of biota varied between location, with *Cypraea moneta* being dominant at the mouth of Sagea Lagoon Estuary and Tanjung Lipe. The starfish, *Archaster typicus*, was dominant at Sagea Village and Lelillef, whilst two species, *Anadara granosa* and *Murex*, shared dominance at Tjetju River.

Table 51 Diversity and Dominance Index of Intertidal at Each Station

No.	Species	H`	C`	D`
Station I				
1.	*Anadara granosa*	0.346	0.0625	0.9375
2.	*Archaster typicus*	0.367	0.1190	0.8810
3.	*Nassarius optimus*	0.353	0.0720	0.9280
4.	Thiara scabra	0.269	0.0180	0.9982
	Total	1.335	0.2715	3.7440
Station II				
1.	*Archaster typicus*	0.326	0.4479	0.5521
2.	*Babylonia spirata*	0.352	0.8137	0.1863
3.	*Cypraea moneta*	0.360	0.9220	0.0780
4.	Diadema setosum	0.242	0.1219	0.8781
5.	*Echinothrix diadema*	0.214	0.0846	0.9154
	Total	1.494	2.3901	2.6099
Station III				
1.	*Anadara granosa*	0.251	0.0139	0.9861
2.	*Archaster typicus*	0.306	0.0314	0.9688
3.	*Babylonia spirata*	0.238	0.0115	0.9885
4.	*Cypraea moneta*	0.334	0.0665	0.9335
5.	*Diadema setosum*	0.224	0.0093	0.9907
6.	*Echinothrix diadema*	0.194	0.0056	0.9944
7.	*Nassarius optimus*	0.306	0.0314	0.9686
	Total	1.853	0.1696	6.8304
Station IV				
1.	*Anadara granosa*	0.316	0.036	0.964
2.	*Archaster typicus*	0.268	0.018	0.982
3.	*Bursa bamboo*	0.326	0.044	0.956
4.	Echinothrix diadema	0.286	0.023	0.977
5.	*Murex*, sp	0.316	0.036	0.964
6.	*Nassarius optimus*	0.248	0.013	0.987
	Total	1.76	0.17	5.83
Station V				
1.	*Anadara granosa*	0.278	0.0208	0.9792
2.	*Archaster typicus*	0.360	0.088	0.912
3.	*Babylonia spirata*	0.2687	0.0181	0.9819
4.	*Bursa bamboo*	0.235	0.0111	0.9889
5.	*Cypraea moneta*	0.286	0.0236	0.9764
6.	*Holothuria edulis*	0.0992	0.0008	0.9992
7.	*Nassarius optimus*	0.2687	0.0181	0.9819
	Total	1.795	0.1805	6.8195

Source: Marine Ecology and Fisheries for the Weda Bay Project, 2001
H': Shannon diversity Index
C': Similarity Index
D': Dominance

Additional Data of 2009 Survey

Survey of intertidal fauna community was carried out from 22 February to 22 March 2009 at the areas i.e. PS (Project Site), SRE (Sake River Estuary), GRE (Gemaf River Estuary), LW (Lelilef Waibulen) and SLC (Sagea Lagoon Channel). Results of identification indicated 7 fauna class and epifauna living in intertidal areas. These classes are Gastropod and bivalvia from mollusc group; Asteroidea, Crinoidea, Echinoidea, Holothuroidea and Ophiuroidea Echinodermata group. Totally, there were 39 identified species (from 23 families). Sake River Estuary is the richest area of intertidal fauna with 25 species and 110 individuals. It is followed by Project Site with 22 species and

98 individuals. Location with the lowest Intertidal fauna was lelilef Waibulen with 13 species (82 individuals). Complete survey data of the survey is presented in **Appendix B**.

16.1.1.2 Demersal and Pelagic Fish

A December 2007 study by the Research Centre for Oceanography (RCO LIPI) was employed as the source for this section. RCO LIPI was commissioned by WBN to compile baseline data on fish landing and heavy metals concentration on flesh and liver of fish that existed and consumed by local residents in surrounding of Weda Bay.

The marine and fisheries survey was performed in 7-11 December 2007 at Weda Bay. Data collection was followed by two months of laboratory activities (fish tissue analysis of heavy metal parameters, i.e., Pb, Cd, Cr, Cu, Zn, Ni, Fe, Mn, Co and Hg were conducted in RCO's chemistry laboratory in Jakarta and As analysis by ALS laboratory in Bogor). The assessment of fish resources was conducted through in-depth interview with local fishermen and direct observation in fish landing and fish market surrounding in Weda Bay area. Fish data inventory included family and species of fishes, weight and length, type of gear, type of boat and seasonal caught that usually done by local fishermen).

Fish samples were collected by hand line or long line fishing. The study found 15 fish species that live in Weda Bay, Halmahera. All the fish samples were identified based on family and species of fish. The identification species is also based on the group of fish, such as pelagic and demersal fishes. Standard international protocols for field sampling and sample preparation were used to minimize the contamination of sample from rusty boats and fuel.

Table 52 Fish catch during survey by RCO- LIPI in 2007

	Family/ Species	Local name	English name	Gear	Fish Categorized	Depth (m)
I	**LUTJANIDAE**					
1	*Etelis carbunculus*	Gumuru/kakap laut dalam	Ruby Snapper	Hand line	Demersal	90 - 100
2	*Etelis carbunculus*	Gumuru/kakap laut dalam	Ruby Snapper	Hand line		80
3	*Etelis radiosus*	Gumuru/kakap laut dalam	Ruby Snapper	Hand line	Demersal	100
4	*Lutjanus argentimaculatus*	Gumuru/kakap merah	Mangrove, Jack	Hand line	Demersal	150
5	*Lutjanus erythropterus*	Dalise/kakap merah	Crimson Sea perch	Hand line	Demersal	80
6	*Lutjanus erythropterus*	Dalise/kakap merah	Crimson Sea perch	Hand line	Demersal	85
7	*Lutjanus erythropterus*	Dalise/kakap merah	Crimson Sea perch	Hand line	Demersal	80
II	**SERRANIDAE**					
8	*Epinephelus fuscoguttatus*	Geropa	Flowery Cod	Hand line	Demersal	85 - 90
III	**CARANGIDAE**					
9	*Caranx secfasciatus*	Bubara	Big eye Trevaly	Hand line	Demersal	100
10	*Decapterus macarellus*	Layang	Mackerel Scad	Hand line/ Small purse seine	Small Pelagic	Surface
11	*Decapterus macarellus*	Layang	Mackerel Scad		Small Pelagic	Surface
12	*Decapterus macarellus*	Layang	Mackerel Scad		Small Pelagic	Surface
13	*Elegatis bipinnulata*	Salem	Rainbow Runner	Hand line	Demersal	100
IV	**SCOMBRIDAE**					
14	*Euthynnus affinis*	Tongkol	Mackerel Tuna	Hand line	Big Pelagic	70 - 80
15	*Gymnosarda unicolor*	Tuna	Dogtooth Tuna	Hand line	Big Pelagic	70 - 80
16	*Katsuwonus pelamis*	Cakalang	Skipjack Tuna	Hand line	Big Pelagic	-
17	*Rastrelliger brachysoma*	Kembung	Short bondied mackerel	Hand line/ Small purse seine	Small Pelagic	Surface
V	**SQUALIDAE**					
18	*Squalus* sp.	Hiu/Gurango	Shark, Dog fishes (spur dogs)	Hand line	Demersal	200
VI	**HEMIRAMPHIDAE**					
19	*Hemiramphus robustus*	Ikan roa/ Julung-julung	Robust Garfish	Small purse seine	Small Pelagic	-
VII	**EXOCOETIDAE**					
20	*Chelopogon cyanopterus*	Ikan terbang	Flying fish	Small purse seine/Hand line	Small Pelagic	-
VIII	**BELONIDAE**					
21	*Tylosurus crocodilus*	Cendro	Crocodilian Longtom	Hand line	Small Pelagic	-

Appendix D

Information Sources

No.	Document Title	Source	Year
1	Contract of Work Feasibility Study Volume I	WBN	2008
2	Weda Bay Project - General Design Specification For Plant Basic Data	Technip	2008
3	Weda Bay Project-Gazeous Emission Inventory	Technip	2008
4	Hydrological Baseline Study Weda Bay Nickel Project Halmahera Island	Golders	2008
5	Weda Bay Environmental and Financial Committee (presentation)	Eramet	2008
6	Weda Bay Process description (presentation)	Eramet	2008
7	APS DE L'EXPLOITATION DU GISEMENT SANTA MONICA - WEDA BAY Synthèse des données hydrologiques et hydrogéologiques	Mecater	2008
8	Weda Bay Project-Port Location	Egis	2008
9	Weda Bay Project-Port Design and Operation	Egis	2008
10	Weda Bay Project-Navigation Aids	Egis	2008
11	Weda Bay Project-Design Report Pilot Operation	Egis	2008
12	Weda Bay Project-Geotechnical	Egis	2008
13	Weda Bay Project-Design Report-River Water Intake Area	Egis	2008
14	Filter Cake Residue Dump Facility Weda Bay Nickel Project Halmahera Indonesia	Golders	2008
15	Design of Tailing Dump to Store Filter Cake Residues Weda Bay Compant	Mecater	2008
16	Weda Bay Project-Sea Water Intake	Egis	2008
17	GN ZORAH LIMESTONE Complementary Results End of Drilling Campaign (Memo)	WBN-Eramet	2008
18	PRE-FEASABILITY REPORT: MINING (Memo)	WBN-Eramet	2008
19	LIMESTONE QUARRY PFS STUDY: Extraction (Memo)	WBN-Eramet	2008
20	Liquid Effluent Discharge Limits (Memo)	WBN Eramet	2008
21	Weda Bay Project-Liquid Effluent Inventory	Technip	2008
22	Weda Bay Project-Solid Waste Inventory	Technip	2008
23	Bathymetry Study-Final Report	Research Centre for Oceanography-LIPI	2007
24	Deep Sea Tailing Survey	Research Centre for Oceanography-LIPI	2007

No.	Document Title	Source	Year
25	Risk assessment of the probability of low flow in the Kobe River	Alluvium	2008
26	Weda Bay EIA-Meteorological and Hydrological Data Collection (Technical Memo)	Dames&Moore	2001
27	Land rehabilitation study at the pit area: Soil properties characterization	Hatfield	2008
28	Surface Water and Sediment Quality Report	ERM	2006
29	Surface Water and Sediment Quality Report	ERM	2007
30	Surface Water and Sediment Quality Report	ERM	2008
31	Fish Landing Assessment and Fish Tissue Analysis	Research Centre for Oceanography-LIPI	2007
32	Marine Ecology (Technical Memo)	Dames&Moore	2001
33	Biodiversity and Biogeography of Gunung Zohra Karst in PT. Weda Bay Nickel	ERM-Dept. of Forest Resources Conservation Ecotourism IPB	2008
34	Forestry survey in lower montane areas of PT Weda Bay Nickel's COW	Hatfield-LIPI	2008
35	Socio-Economic and Cultural Studies (Technical Memo)	Dames&Moore	2001
36	Socio Economic, Socio Cultural and Community Health Baseline Study	ERM	2006
37	Socio Economic, Socio Cultural and Community Health Study	ERM	2007
38	Socio Economic, Socio Cultural and Community Health Study	ERM	2008
39	EMP of Lelilef Airstrip (in Bahasa)	PT. Reka Daya Sentosa	2000
40	Annual Report 2010 (January draft)	WBN-Eramet	2010
41	Minutes of Meeting with Central Halmahera Regent and Secretary April 22, 2009	WBN	2009
42	Minutes of Meeting between regional; government, local house representatives & communities of Central Halmahera with PT. Weda Bay Nickel 16 June 2008	WBN	2008
43	WBNewsletter English version (15-19th, 21st, 23-32th, 36-44th edition)	WBN	2009
44	WBNewsletter English version (47-48th edition)	WBN	2010
45	Security Guard Manning Service Agreement	WBN	2009
46	SOP handling visitor	Secom	
47	Deployment and Organization chart	Secom	

No.	Document Title	Source	Year
48	Module1-The Security Service Section A-The Role and responsibilities of the security officer (student note)	WBN	2008
49	Module1-The Security Service Section B-Customer Service (student note)	WBN	2008
50	Module 2-Safety Section A-Fire (student note)	WBN	2008
51	Module 2-Safety Section B-Health and Safety (student note)	WBN	2008
52	Module 2-Safety Section C-Emergencies (student note)	WBN	2008
53	Module 3-The Law (student note)	WBN	2008
54	Module 4-Security Functions Section A-Access control (student note)	WBN	2008
55	Module 4-Security Functions Section B-Searching (student note)	WBN	2008
56	Module 4-Security Functions Section C-Patrolling (student note)	WBN	2008
57	Module 4-Security Functions Section D-Security and Emergency Systems (student note)	WBN	2008
58	Module 5-Communicating Section A-Communication (student note)	WBN	2008
59	Module 5-Communicating Section B-Reporting (student note)	WBN	2008
60	Eramet Group Code of Ethics	Eramet	2010
61	Weda Bay Nickel Company Regulation 2009-2011	WBN	2009
62	List of EHS trainings	WBN	2009
63	The election of WBN's Employees Representatives in Tanjung Ulie	WBN	2009
64	WBN company culture	WBN	
65	Minutes of Inspection of roads contruction plan to Santa Monica area by Head of Forestry Office of Central Halmahera (in Bahasa)	WBN	2001
66	Minutes of Inspection of tree cuttings for ground penetrating radar survey by Forestry officer Central Halmahera (in Bahasa)	WBN	1998
67	Biodiversity at Weda Bay Nickel 2009		
68	Copy of Performance Standard Checklist		
69	IFC Performance Standards Compliance Matrix-Labor and Working Condition (Ref.No.21-01)		
70	IFC Performance Standards Compliance Matrix-Community Health, Safety and Security (Ref.No.22-01)		

No.	Document Title	Source	Year
71	Final Report on Exploration and Related Activities for the Period October 1996-February 2007 Volume 1: Text	WBN	2007
72	Approval Letter of Test Pit Exploration from Forestry Department of Republic Indonesia	Forestry Department of Republic of Indonesia	2007
73	Assigment letter to conduct vegetation inventory at WBN project area in Tanjung Uli	Central Halmahera Forestry Dept.	2007
74	Work Program & Budget Exploration period year 2006	WBN	2006
75	Land Acquisition update	WBN (Erry)	2010
76	List of Document required for WBN pre-construction ESIA	WBN	
77	Notes from Social History Presentation	WBN	
78	Public consultation report A preparation of EIA Nickel and Cobalt Ore Mining and Processing in Central Halmahera and East Halmahera Regency North Maluku Province	ERM	2008
79	Social Interaction-Brief Summary (presentation)	WBN	2009
80	The Eramet Group's Sustainable Development Policy	Eramet	2009