Ramu Nickel Mine:

A preliminary review of risks facing the Ramu Catchment

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A Review of Risks Facing the Ramu Catchment

This briefing outlines some of the risks of riverine impacts from the *mine-site* of the Ramu Nickel project. It summarises key riverine risks that have been discussed in the Environmental Plan as defined by NSR Environmental Consultancy Pty Ltd. (NSR), while highlighting some further risks or impacts that have not been properly addressed, and evaluating aspects of the environmental assessment and management plan proposed. This study is preliminary in its nature, and does not attempt to provide a comprehensive analysis of all aspects of the environmental plan, or to discuss in detail environmental or social impacts that will be the likely result of these issues. It focuses primarily upon the risks from sedimentation, waste rock and waste water from the Ramu Nickel mine. It does not review the impacts of mill and tailings disposal. The authors would like to highlight the limited nature of the evaluation, as a number of other issues that warrant greater scrutiny are not discussed in this paper. It has not looked in detail at the long-term impacts of the mine, which are also potentially serious in nature. The authors of this report strongly recommend that further independent studies into the issues raised in this report, and into the environmental management system proposed generally, be undertaken.

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Executive Summary

Key Concerns regarding Riverine Impacts:

1. The 'laterite' soils in which the Ramu deposit occurs are highly vulnerable to erosion once disturbed, impacting downstream environments and communities, while the loss of soil structure and increased metal content of surface soils will make future regeneration difficult. Due to lack of reliable data and revegetation trials, there is no basis on which confident prediction of the stabilization of disturbed soils can be made.

2. In general settling ponds do not have a good record for managing sediments in conditions of high rainfall, steep topography and seismic activity. Of heightened concern in the case of the Ramu mine is the failure to properly model the settling ponds (the primary management strategy for ensuring excessive sediments do not enter the river system) based on conditions during peak rainfall periods indicates that the ponds will not function as predicted, and a much greater proportion of sediments and metals will be carried into the river system. The acknowledged flaws in the modeling system means that no accurate prediction of these impacts is contained in the risk assessment and any impacts will in all likelihood be greater than predicted.

3. The NSR report for the Ramu Environmental Plan stated that further consideration of the impacts of trace metals should be undertaken, but it is unclear whether this has been done. The existence of heavy metals in fish tested in the creeks in close proximity to the mine site area indicates that trace metals present are mobile and will be absorbed into the environment, and that bioaccumulation of metals in plants and animals (including humans) is a significant risk. There has also been minimal investigation of the leaching of metals into the groundwater in the region and how this may affect ecosystem functions or the food web. The lack of detailed study into the impacts of these trace metals, and the absence of any management strategy to remove the metals from mine waste rock or water entering the environment poses serious potential risks to both ecosystem and human health of the Ramu catchment.

The Environmental Plan as stands cannot be relied on to present an accurate or realistic picture of the impacts of the mine upon the Ramu River system due to a lack of reliable data and the gaps in analysis of the local conditions. In particular, we would expect:

1. Greater than predicted (TSS) Total Suspended Solids in the river system and unpredicted and extensive impacts upon the river's ecosystem including decreased fish breeding and fish catch rates.

2. Greater than predicted sedimentation both along the creeks and in the Ramu River itself. This sedimentation will lead to alterations in the river system, including shallowing and braiding, with likely effects of increased flooding in areas along the Ramu River that have not previously experienced flooding, and dieback of vegetation along the river.

3. Greater than predicted loads of dissolved metals in the hydrology of both the Ramu River system, and in groundwater in the region of the mine. Mine sediments deposited along the river system will also contain high concentrations of trace metals and these will impact both natural ecosystems and cultivation taking place on the floodplains of the river. This poses associated eco-toxicological risks to the food web, including plant, animal and human health.

e **The Ramu Environmental Plan**

In their report on the risks to the catchment area of Ramu River and its tributaries, NSR highlighted the four major problems that will face the riverine environmental over the twenty years of mining operation and beyond. These four main factors include sedimentation, TSS (total suspended solids –the extent or rock, soil or silt that is carried by the water), heavy metal deposition and miscellaneous chemical runoff from sewerage systems and road surfaces.

- **Total Suspended Solids** (TSS) – this is how much mud, silt etc., is floating in the water, making it cloudy or even muddy. For example, clear water has a very low amount of TSS.

- **Sedimentation –** this is how much mud, silt, sand, gravel etc., has sunk to the riverbed and settled.

- **Trace Metal Deposition** – this is when metals usually found underground are brought to the surface and washed into waterways, and then absorbed by sediment, plants or animals. In high concentrations, some of these metals can be toxic, stunting growth, reducing fertility or even killing plants and animals. Generally speaking, the impact of different levels of these metals on the environment, plant and animal life is not well understood.

- **Miscellaneous Chemical Runoff** – this includes a wide range of chemicals and wastewater that can wash into waterways as waste products from building sites, vehicles and roadwork. Such chemicals could include sewerage, detergents and oils.

NSR's focus in this study was mostly on the 3 creeks that drain from the mine site to Ramu River, as well as Nape Swamp and Banap Oxbow, as opposed to the Ramu River mainstream itself. The effects predicted upon these creeks are acknowledged by the environmental plan as severe. However, the company's plan suggests that all four factors are predicted to have little to no effect on the Ramu River due to major dilution once it left the creeks and entered the Ramu River.

A review of the reports suggests that there is insufficient modeling of potential impacts, or baseline science to make these conclusions regarding the Ramu River. Various risks have been underestimated, downplayed or not considered, such that accurate predictions of impacts cannot be made.

This review, as a preliminary investigation, highlights potential risks to the Ramu River system, includes an examination and assessment of risks that NSR identified in their studies, and the extent to which some of these risks may have been underestimated and downplayed.

TSS and Sedimentation

Due to natural conditions, nickel laterite deposits are often located in tropical regions characterised by high rainfall, steep topography and endemic vegetation species, and thus highly vulnerable to erosion.[1] The Ramu Nickel project follows this trend.
Laterite soils in their natural state tend to be quite hard and cemented, but once disturbed they are highly prone to erosion.[2] The Ramu Environmental Plan acknowledged this characteristic in the Ramu area[3]. Research by industry experts highlights that due to the large surface area impact and the factors outlined above, erosion and sediment

[1] Parffit and Tae, 'Erosion Control and Reclamation For Nickel Projects', Sudbury 2003 at http://www.ott.wrcc.osmre.gov/library/proceed/sudbury2003/sudbury03
[2] Parffit and Tae, p1
[3] Appendix 4, 2.4.1 Page 13: "The mine site is located on a heavily weathered geological unit known as the Marum Basic Belt…once disturbed and reworked these soils erode very easily and are prone to tunneling" , "Mine preparation, bulk earthworks, topsoil and overburden storage areas, mine access and haul road construction…increase existing rates of both soil erosion and sediment production." And "Exposed areas of cut and fill material and disturbed soils will be particularly prone to erosion by…rainfall events"

movements during mining can have significant environmental impacts on the environment and downstream populations.[4]

Levels of TSS and Sedimentation

The NSR report acknowledges that the Ramu River will receive inputs of mine-derived sediment via the Ban, Banap and Angari creeks[5]. While the overall predicted impacts during the construction phase (0-5 years) of operations were classified as "*severe*"[6] on the Banap, Ban and Angari Creeks, the impacts on the Ramu River were largely judged minor due to massive dilution. The only areas of the Ramu River that were expected[7] to be affected were in the immediate vicinity of the joining of the creeks to the river, and just downstream[8]. It is of great concern however that there does not appear to be appropriate modelling or scientific evidence on which the assumption of dilution and minimal impacts has been calculated. (See section below entitled 'settling ponds for further discussion.)

Management Plan for Sedimentation and TSS

One of the most important environmental aspects of nickel laterite projects is the provision of a suitable Erosion and Sedimentation Control Plan (ESCP) to minimize impacts on the surrounding environment and downstream communities. Experiences in New Caledonia, where nickel operations have been underway for a number of decades in similarly tropical conditions to PNG, have found heavy rains cause even very old sites to slump and erode. The mud slides and eroded soils contaminated rivers and eventually ended up in the coastal waters. This sediment has degraded fringing reefs and the lagoon[9]. Efforts to revegetate nickel mine sites are often difficult as the soil contains toxic levels of minerals.[10] Difficulties with revegetation and negative impacts upon existing vegetation are also likely to extend to sites where sedimentation and siltation from the mine waste rock occurs.

Ramu Erosion and Sedimentation Control

The Ramu project takes rudimentary measures to reduce TSS and sedimentation in creeks and rivers that receive mine-derived sediment, primarily through the construction of settling ponds. It is unclear to what extent the practice of progressive mining and backfilling has been integrated into its design, or of progressive rehabilitation of the areas already mined, so as to prevent ongoing erosion of mined out areas. Recent descriptions of the project would indicate that the company does not intend to backfill the mined out areas, but simply contour the site from the soil structure below the deposits. The environmental plan does not discuss the probability of success of the revegetation or rehabilitation of the areas, which will be an important measure of long term erosion control. Revegetation trials on disturbed soils with similar profiles to the final landform are necessary to predict the likelihood of success of erosion management of mined out areas, and should take place before mining occurs, but the authors could not find evidence that such trials are underway.

Settling Ponds

A settling pond is a large man-made dam that a creek flows into, slowing the water flow down and allowing gravel, sand and silt to settle to the bottom before it is carried further downstream. However without comprehensive modelling taking into account peak rainfall periods, the settling pond is likely be ineffective, spilling over. Additionally, while settling

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[4] Parffitt and Tae, p1
[5] Appendix 4, 2.5.1 pg 18: *"the sediment runoff is expected to be both high in volume and sediment concentration"*
[6] Severe impacts include major loss of aquatic habitats, and therefore loss of animal and plant population, diversity and density.
[7] Most of the predictions for the Ramu River were educated guesses.
[8] Appendix 4, 4.2.8 pg 83, "Some in-river deposition of mine-derived sediment is expected in the Ramu River mainstream at and immediately downstream of its confluences (joining) with the Ban, Banap and Angari Creeks." and "…expected to be transient and highly localized along the west bank immediately downstream of the confluences."
[9] ESCAP Virtual Conference, Integrating Consideration as into Economic Policy Making Processes, 'Mining Activities in New Caledonia- (Draft, 2003), http://www.unescap.org/drpad/vc/conference/ex_nc_147_man.htm
[10] ESCAP Virtual Conference, Integrating Consideration as into Economic Policy Making Processes, 'Mining Activities in New Caledonia- (Draft, 2003), http://www.unescap.org/drpad/vc/conference/ex_nc_147_man.htm

ponds can be efficient in the removal of heavier particles, such as gravel and sand they are less efficient in the removal of fine particles such as silts and clays (fines)[11].

The failures of settling ponds in nickel mines in similar conditions elsewhere in the tropics is an indication of the likely problems that will be experienced with their use in the Ramu project. Indigenous communities in the Philippines have opposed the development of further nickel mining industries after toxins from existing nickel-mining operations noticeably affected water sources. Siltation ponds designed to hold waste runoff from mining activity overflow during heavy rains, causing the rivers to become silted up.[12]

The environmental plan proposes that three settling ponds will be built to cope with sediment load at various times over the 20 year mine life. NSR predict that these ponds will be very efficient at removing sediment from the creeks, preventing it from entering the river. However the environmental plan admits that the effectiveness of the ponds as predicted in the environmental plan is not realistic [13], and thus a number of potential risks have not been assessed or quantified.

- Through mine preparation, earthworks, mine access and haul road construction, a large amount of sediment will be produced *before* the settling ponds are working, and the company acknowledges that major increases in TSS are predicted[14]. Without settling ponds and erosion control mechanisms in place before such works begin, it is likely that the TSS and sediment will not only severely affect the creeks, but most likely have a greater impact on Ramu River than the conservative estimates predict. It is standard practice that environmental management measures are in place to manage impacts before they occur, not once operations have already started.

- A review of historical monthly and extreme rainfall data is required to develop design flow criteria. The computer model used to predict sediment capture by settling ponds relies on a rainfall pattern that is not based on a comprehensive review of this localized data.[15] On this basis alone, the effectiveness of the proposed model is flawed, and the effectiveness of the operation of the settling ponds as predicted cannot be relied upon.

- The modeling is not based on extreme rainfall events that occur in the area, and thus have not been designed to control sediments during these periods. The company analysis acknowledged that conditions for consecutive daily storm events might prevent the effective release of stormwater runoff in the settling pond. The computer model mentioned above relies on the assumption that the water levels are dropped in the dams on a daily basis, while at the same time they have acknowledged that this will not be possible when consecutive days of extreme rainfall occur. It can thus be concluded that during these extreme rainfall conditions-common during the wet season- the settling ponds will not provide the level of sediment capture predicted in the plan. [16].

While the settling ponds will, to some degree, reduce the levels of TSS and sedimentation, there is not sufficient or accurate analysis of local conditions on which to base the predictions that have been made in the environmental plan. Given the flaws in the modeling outlined above, the effectiveness of the settling ponds designed as a means of controlling sedimentation would appear to have been overestimated.

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[11] Appendix 4, 2.4.1, page 13: *"A significant portion of these fine sediments (<125µm) is expected to enter the natural drainage and augment background suspended sediment loads"*
[12] Indigenous Peoples in the Philippines Fight Nickel Mine Expansion , in 'Drillbits and Tailings', Vol 7 No 7 at www.moles.org
[13] Appendix 4 2.7.1 , see p18-25
[14] Appendix 4. 2.7.1, page 26: *"Major incremental increases in TSS are predicted to occur in mine site catchments prior to the operation of the settling pods."*
[15] Appendix 4, 2.6, Page 18.*"the model was calibrated using results of field erosion trials"*
[16] Appendix 4, 2.6, page 18: *"…the model was run assuming the storm event runoff could be discharged during the same day of the storm",* but *"during periods of consecutive storm days…it may not be possible to draw down (settling pond) to the design level"*

Other Measures

When considered in light of standard practice, the ***E**rosion **S**ediment **C**ontrol **P**rogram (ESCP)* of The Ramu Nickel Project is rudimentary. Generally an ESCP includes various components that are designed to work together to prevent erosion and collect sediment so as to clarify runoff from mining areas prior to discharge to the environment. There are a number of further sediment reduction techniques possible that can enhance the efficiency of settling ponds:

- Sediment Diversion/Collection channels
- Sediment Fences
- Sediment Weirs
- Brushwood Barriers
- Mechanical water treatment and recycling.

These simple structures and practices are typical components of any ESCP, however they have been largely neglected in the original mine design as a way to manage sediments or improve the quality of mining site discharge.

Additional Risks relating to Settling Ponds

A question largely ignored in the study was that of possible sudden failure of engineered containment structures such as settling and holding ponds, resulting in release of high concentration/high volume contaminants. With the high levels of rainfall in the region, and the geological formations in the region vulnerable to landslides, the partial or full collapse of the settling ponds itself is a significant danger. The lack of detailed geophysical investigations or seismic investigations, and the failure to account properly for maximum rainfall periods greatly increases this risk.

The sediment that stays within the settling ponds has the potential to accumulate high loads of toxic trace metals, leading to other questions requiring consideration in regards to settling pond management:

- What post-mining practice will deal with this potentially metal-laden sediment in the settling pond? (Possibilities include the removal of ponds, recontouring of surfaces, and revegetation.)

- If left to revegetate, is there the potential of leachates (metals or other toxins dissolved in groundwater and moving through soil, usually towards streams and rivers) leaving the sediment over long periods of times and entering groundwater or finding its way into rivers or streams?

Groundwater flow and chemical investigations into the mine site orebody, would enable predictions of downstream changes in dissolved element chemistry, where currently impact prediction is hindered by lack of reliable data.

Pipeline Breach

The Environmental Plan briefly mentions the possibility of a pipeline breach, although it fails to explore the extent of the risk of this occurring.[17] Given the experience in other mines sites, it can be assumed that a number of pipeline breaches are likely to occur over the life of the mine. Pipeline breaches have been relatively common at the Ok Tedi mine, with one reported by the company in 2003 [18], and the most recent occurrence in February 2004, which according to reports from the region spilt thousands of tonnes of copper

[17] Ramu Nickel Environmental Plan, 3.3.1 Sediment – Page 29: Pipeline "Should pipeline rupture occur, the worst case scenario involves a rupture in the Ramu Valley between the mine and #1 pump station…. 1,985 tonnes of solids (in slurry).

[18] "Inmet Mining Annual Report 2003 " http://www.inmetmining.com/pdf/Inm2003AR.pdf, Table 7 reports <600 m3 of copper concentrate were released into the environment from a breached pipeline."

concentrate into the Ok Mart River system[19]. Failure to design the pipeline taking into account the seismic activity in the region greatly increases the risk of rupture, as does the extraordinarily long length of the pipeline. Were a rupture to take place in the sections near the river (identified as pump station 1) the impact of the concentrated metal slurry into the river system would be extremely damaging, with levels of metals present likely to result in both acute and chronic toxic effects, including significant deaths of aquatic organisms and ongoing chronic toxicological impacts from contamination.

<u>The Effects of Sedimentation and TSS</u>

Sedimentation

Sedimentation is an important impact because it can negatively affect the physical structure of waterways. NSR states that during the construction phase of the mine life (0-5 years), before the use of settling ponds, sand sized sediment from the mine site will cause changes in river structure, such as shallowing, local braiding and widening of the Ramu River channel bed in some places[20]. Implications of these changes are more prolonged periods of flooding, and an increase in the size of land areas prone to flooding along the Ramu River. According to the environmental plan, "the main impact is expected to be…the dieback of riparian vegetation within areas of heavy sediment deposition…characterised by an area devoid of vegetation." This is likely to impact upon both natural habitats and garden in floodplain and low-lying areas, and particularly in slow flowing sections of the stream, which will be vulnerable to sedimentation. These risks could be more accurately estimated if further analysis of both the amount of sedimentation and also the likely deposition points along the river were calculated.

The nature and makeup of the materials that will be deposited will be higher in heavy metal content, including nickel, cadmium, and magnesium than sediments ordinarily deposited by the river system. This has serious eco-toxicological implications that will be discussed in a later section of this report.

Siltation

If the settling ponds work as predicted, the sediment entering the Ramu will be primarily limited to finer silts and clays (fines). The environmental plan states that the settling ponds are not designed to remove fine particles.

The input of high levels of fines will be locally noticeable, and may also impact on both riverside ecosystems such as floodplains, upon which riverine sediments are traditionally deposited. This will impact gardens, sago and banana plantations as well as the natural ecosystems that exist along these floodplains, as many of these plants may not grow in the altered soil conditions. The tolerance of these ecosystems to increased silt in the soil structure has not been evaluated.

Riverbed samples of Ramu River have shown that fines are only minor contributors to the sediment structure. Siltation also fills the gaps between stones and gravel of the bottom habitat. This reduces water flow into the gravel and habitat diversity. With less habitats available, the animals and plants inhabit these area will also be negatively affected[21]. Without detailed analysis it is difficult to predict what impact this will have on the overall river ecosystem and food chain, and the variety of aquatic and other species that rely on these plants and animals for their own survival. NSR did not carry out the necessary examination of the aquatic flora and macroinvertebrate (bugs, snails, beetles, worms etc.) populations of Ramu River in the course of their environmental analysis to allow any confident prediction of these impacts. The guesswork on which the assessment of riverine impacts is based is of great concern, as stated in 4.2.8 pg. 84-85 of their environmental plan "*…plant biomass in the Ramu River is* ***expected*** *to be negligible.",* and "*…resident macroinvertebrate communities of the channel habitat* ***may*** *already exhibit low diversity and abundance".* This lack of definitive examination is likely to cause underestimations of

[19] Reported to MPI by local community members and confirmed by local level government members from the Western Province.
[20] Appendix 4, 2.7.2 Page 26
[21] Appendix 13, 4.1, pg 95

potential impacts of siltation on the aquatic habitat and therefore on the higher plants and animals, including human sources of food such as fish that rely on it.

High levels of TSS are ordinarily linked to high flow rates, which, in its natural occurrence has reduced fishing catches. The constant influx of sediment into the river even when it is flowing slowly will likely cause a steady disruption of fish catch and more studies need to be done on fish breeding cycles, and on tolerance to sediments and suspended solids to assess both the short and long term impacts.

2.Trace Metal Deposition

The problems of metals leaching into groundwater or otherwise depositing along or entering the river systems and its surrounding ecology have been an issue at nickel laterite deposits in countries including the Philippines[22] and New Caledonia. Traditional Kanaky leaders, who are the customary owners of lands proposed for nickel laterite mining in New Caledonia, concerned over the impacts of metals upon the environment and human health, and have demanded that independent studies be conducted into the toxicological effects of metals that will be entering their environment from the Goro project prior to their acceptance of the project.[23]

NSR identified the potential for trace metals being taken into Ramu River from soil disturbance as a result of mining activities such as stormwater runoff and treated sewerage discharges. It did not fully consider the risks, including failures in the effectiveness of the settling ponds or of groundwater contamination in the region. THe NSR assessment did not look in detail or fully examine the possible effects of these trace metals, but the original consultant's report in the appendix of the plan highlighted the need for further examination of these issues[24]. The report states

"...Cadmium, Chromium, Cobalt and Nickel occur in concentrations likely to be disturbed during construction and operations such that potential impacts associated with the offsite transport of these materials require further consideration."

The presence of highly elevated levels of trace metals already in the creeks surrounding the mine sites was acknowledged, with increased metal loads and concentrations predicted. Various negative impacts upon the ecosystem were expected, including elevations of metals in plants and animals[25]. The examination stops short of examining what the impacts upon humans whose livelihoods depend on these environments might be. This is of great concern given the reliance of the majority of people in the region on their surrounding environment for subsistence livelihoods and cash cropping.

Of the many kinds of trace metals that may be harmful, some were found to be most likely to cause problems downstream.

- Cadmium
- Chromium (in certain conditions, such as floodplains, can be toxic to plants).
- Cobalt
- Manganese (particularly toxic in certain conditions, and present in high concentrations in the ore extracted from the mine).
- Nickel

[22] Indigenous Peoples in the Philippines Fight Nickel Mine Expansion , in 'Drillbits and Tailings', Vol 7 No 7 at www.moles.org/
[23] *A Done Deal? Inco/Goro Nickel, the Environmental Impact Assessment Process, And Public Finance in Kanaky/New Caledonia,* A Brief Examination of INERIS and Park Service Analyses of the Inco/Goro Nickel Mine Environmental Impact Assessment *with comments by independent scientists*
Compiled by Stephanie Gorson Fried, Ph.D. Senior Scientist, Environmental Defense, November 6, 2002, Stephf@environmentaldefense.org
[24] Appendix 4, 3.3.2 page 32: "…Cadmium, Chromium, Cobalt and Nickel occur in concentrations likely to be disturbed during construction and operations such that potential impacts associated with the offsite transport of these materials require further consideration."

[25] Appendix 4, 4.3.3 – Nape Swamp – "…metals dissolved…are expected to be readily available to rooted macrophytes and benthic microflora."

While it is not known exactly what effects high concentrations of various trace metals can have on plants and animals in this environment, it is accepted that all of the above, in high enough concentrations, may cause "chronic sub-lethal responses[26]" in plants and animals, including fish, and also in humans. This means that plants or animals affected by these metals may not die, but will have retarded growth rates, reduced fertility or exhibit other effects. These effects occur more strongly in larger predatory fish, as well as amphibians, reptiles and birds (not to mention humans), through a process called *bioconcentration*. Bioconcentration is the increasing build up trace metals within the tissues of a particular organism.

The report is increasingly vague when discussing the impacts along the Ramu River generally, however it does predict likely increases in trace metals along the floodplains of the Ramu. These included the increased cobalt concentration in plants along the floodplains[27], and an increased presence of chromium, which under certain conditions of the floodplain soil could be converted to a more toxic form.[28] The beneficiation plant at the mine site will comprise of a specific process for chromite removal/slurry preparation, which will separate around 1.4 million tonnes of the ore for disposal at the mine site[29] yet there has been virtually no discussion in the environmental plan for the project of how the chromium, or the other materials separated at this plant will be managed. This material is likely to be high in various trace metals. This is consistent with experiences as nickel mine in the Philippines where concentration levels of hexavalent chromium Cr (VI) at 0.17mg/L and 0.21mg/L from the sampling stations exceed the required standards.[30] Additionally recent company disclosures have described the deposits as high in manganese[31] but this is limited discussion of the toxicological impacts of this metal upon the environment.

Scientific researches have shown hexavalent chromium compounds have been implicated as being responsible for such effects as ulcerated nasal mucosa, kidney damage, erosion and discoloration of teeth, skin ulceration and other skin disorders. Occupational exposure to chromium has been associated with lung cancer.[32] Scientific studies have showed that exposure to soluble and insoluble nickel compounds (for example, as a normal constituent of food or as a contaminant in drinking water) is carcinogenic, however the USEPA's 1996 draft of cancer guidelines has so far failed to specify what could constitute a safe limit on the basis that the carcinogenic potential of oral exposure to soluble nickel ''cannot be determined because there are inadequate data to perform an assessment.'[33]' NSR has acknowledged that "metal concentrations in soils and mine-derived sediment can impact on plant growth if concentrations are high and present in bioavailable form," but fails to examine the more complex issue of their impacts on the overall food web and upon humans reliant upon these environments for their livelihood and food source. Similar concerns are likely to exist for nickel, cobalt and possibly also manganese and other trace metals, but the report appears to have failed to examine the likely output of these metals into the mine site waste rock and water, and the potential effects of this upon the ecosystem. [34]

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[26] Appendix 4, 3.5.1 page 57.

[27] Appendix 4, 4.5.3 "there is a likelihood that floodplain plants may show enriched Co concentration in tissues.

[28] Appendix 4, 4.5.3 Chromium – "under certain conditions in floodplain soils…Cr(III) may be oxidised to the more phytotoxic Cr(VI)

[29] Highlands Pacific Ramu Nickel / Cobalt Project Project Overview, "The beneficiation plant will treat run of mine ore to produce a fully deagglomerated, correctly sized and consistent slurry density feed for overland pipeline transportation to the refinery. The plant will comprise a deagglomeration/ screening plant and a chromite removal/slurry preparation plant. It will be designed to treat 4.6 Mt per annum of dry ore at a 44% moisture content to provide 3.2 Mt per annum (dry) of feed to the refinery having metal contents of typically 1.09% nickel and 0.11% cobalt. (see highlands pacific website)

[30] Rio Tuba Nickel Mining Corporation's Hydrometallurgical Processing Plant: A Threat to the Indigenous Peoples, Local Communities and the Environment of Bataraza, Palawan," position paper, Environmental Legal Assistance Center, Environmental Law Alliance Worldwide, April 3, 2002, http://www.elac.org.ph/riotuba.html

[31] Highlands Pacific Ramu Nickel / Cobalt Project Project Overview, see highlands pacific website

[32] Felipe A. Albayda, Jr., Health Environmentalist, Health and Environmental Commentaries for HPP, in Rio Tuba Nickel Mining Corporation's Hydrometallurgical Processing Plant: A Threat to the Indigenous Peoples, Local Communities and the Environment of Bataraza, Palawan," position paper, Environmental Legal Assistance Center, Environmental Law Alliance Worldwide, April 3, 2002, http://www.elac.org.ph/riotuba.html

[33] LT Haber, GL Diamond, Q Zhao, L Erdreich, ML Dourson, Regulatory Toxicology and Pharmacology, 2000, Vol 31, Issue 2, Part 1, pp 231-241.

[34] Appendix 4, 4.5.3– NSR uses examples of nickel-tolerant vegetation found on plateaus to justify minimal impact on vegetation in low-lying floodplain regions. However, direct comparisons of plateau and floodplain vegetation in regards to nickel tolerance is inappropriate due to such variable conditions species present between these environments.

The environmental plan has also highlighted that the risks of bioconcentration of these trace metals in flora and fauna in the area exists[35], however it failed to take further steps to quantify this risk, or to assess the nature of the trace metals to examine the extent to which they are likely to become soluble in the conditions present in the area. Nickel and other metals in lateritic soils are mobilised in wet conditions[36], and in the Ramu region, elevated concentration of these trace metals were already found in fish samples in the Banap Creek and Oxbow at the time of the environmental studies,[37] indicating that these metals are present in forms that do become bioavailable (ie able to be absorbed into the ecosystem, including in plants, animals and humans) and that further disturbance of soil structures high in these metals is likely to end up in the food web.

The risk of increased trace metals becoming bioavailabile in the environment exists wherever the sedimentation of the mine waste rocks occurs, and in waters where sediments and silts are suspended. The environmental plan acknowledged that the flood plains of the Ramu River could be affected by increasing trace metal contents[38] but once again fails to explore the likely extent of these impacts.

While a high pH (up to 8.79) in streams and rivers may be sufficient to minimise significant proportions of trace metals from changing to a toxic form, regions where waters or soils are more acidic will be particularly prone to metal contamination. Any practice or material that could increase the acidity of water (lowering the pH), e.g. rotting vegetation, mining runoff, may trigger a toxic change. Many mines use techniques to remove metals from wastewater (eg. The nickel laterite mine, Murrin Murrin in Western Australia, and cyanide reclamation in the Tasmanian Henty gold mine located near rainforest). The absence of any mechanisms to remove metals from the wastewater is of concern, particularly given the existing evidence that these metals are already present in fish sampled around the mine area.

<u>Miscellaneous Chemicals</u>

The primary inputs of various chemicals such as oil and grease come from mining vehicles and roadwork leading to and from the mine site. Detergents and sewerage can be washed into stormwater runoff as well as come from sewerage treatment works. NSR largely ignores the effect of such chemicals on the aquatic biology and resource use of Ramu River and it's tributaries in the assumption that the guidelines set by World Bank and followed as standard procedure are sufficient to reduce potential risk from such chemicals to a minimum.

However, in the case of these standards not being sufficient in particular circumstances such as unpredicted heavy rainfall events, these chemicals may have an adverse impact that may reach the Ramu mainstream itself.

The most noticeable impact could be the increase of nutrients (such as nitrates and phosphates) in the water. The upper reaches of rainforest waterways (such as the Upper Ramu River and its tributaries) are known to have relatively low levels of nutrients in the water, with most nutrients entering the water from decaying plant matter. With the addition of material such as sewerage into the catchment, these nutrient levels may rise dramatically.

An increase of nutrient levels can cause the sudden growth of blue-green algae. This simple organism rapidly reproduces in water with high nutrient levels, until it dominates all of the other vital elements (such as oxygen), causing major problems (and often diebacks)

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[35] Appendix 4, 3.5 page 57 – "Increased bioconcentration of trace metals in flora and fauna associated with the Banap Oxbow is possible"…"

[37] Appendix 4, 3.5 page 57 – "Elevated Cobalt and Nickel concentrations were reported from tissue samples of fish taken from Banap Creek or Banap Oxbow."
[38]Appendix 4, 4.3.6 – Ramu River Floodplain – "Although acute toxicity to aquatic organisms may not be expected, a subacute or chronic toxicity hazard may eventuate in such swamp water environments during the dry season"

for other animals and plants present in the water. This process is called *eutrophication*, and has occurred in many well-known waterways in Australia and North America with disastrous results. To make it worse, many of these blue green algae are toxic when consumed in drinking or cooking water, compounding the problem.

In a similar way to blue green algae, bacteria can rapidly overpopulate water with higher than normal levels of nutrients. These bacteria are commonly called *faecal coliforms,* and are always present in waterways to some degree. However when present in water with high levels of nutrients, these bacteria, which are normally harmless, can be harmful when consumed in drinking or cooking water due to sheer numbers.

Conclusion

NSR have produced an environmental impact study that has highlighted a number of factors that may affect the aquatic environment of Ramu river and its tributaries. However in numerous instances we have found that the practiced proposed fall short of standards currently proposed by the industry[39], and that the data relied upon is not sufficient to provide a reliable assessment of the risks or base the conclusions reached in the plan. We have also found that the broad "trivial to no effect" assumptions made in regards to impacts directly on Ramu River itself are insufficiently based on accurate modeling of the local conditions and mining impacts on mainstream flow warrant closer scrutiny.

Additionally, the EIS examines the effects *during* the 20-year life of the mine, and largely ignores the longer-term impacts of the mines. Assumption of a dramatic reduction to complete stop of impact after the mine lifespan is misleading and possibly incorrect, particularly if measure are not taken to progressively rehabilitation the mine site and stabilize the soil structure of mined out areas or to prevent long term leaching of heavy metals into the hydrological system.

[39]Parffit and Tae, 'Erosion Control and Reclamation For Nickel Projects', Sudbury 2003 at http://www.ott.wrcc.osmre.gov/library/proceed/sudbury2003/sudbury03