EXPERT REPORT OF DR. SUSAN E. KOENIG

IN THE SUPREME COURT OF JUDICATURE OF JAMAICA

IN THE CIVIL DIVISION

CLAIM NO. SU2022CV02353

BETWEEN	VICTORIA GRANT	1ST CLAIMANT
AND	LINSFORD HAMILTON	2ND CLAIMANT
AND	CYRIL ANDERSON	3rd CLAIMANT
AND	MERLINA ROWE	4th CLAIMANT
AND	BEVERLY LEVERMORE	5th CLAIMANT
AND	ALTY CURRIE	6th CLAIMANT
AND	BOBLET CAMPBELL	7th CLAIMANT
AND	LAWFORD FLETCHER	8TH CLAIMANT
AND	EDLIN WALTON	9TH CLAIMANT
AND	NORANDA JAMAICA BAUXITE PARTNERS	1ST DEFENDANT
AND	NORANDA JAMAICA BAUXITE PARTNERS II	2ND DEFENDENT
AND	NEW DAY ALUMINUM (JAMAICA) LIMITED	3RD DEFENDANT
AND	ATTORNEY GENERAL OF JAMAICA	4TH DEFENDANT

I, SUSAN E. KOENIG was appointed as an expert witness to Claim No. SU2022CV02353 between Victoria Grant (1st Claimant), Linsford Hamilton (2nd Claimant), Cyril Anderson (3rd Claimant), Merlina Rowe (4th Claimant), Beverly Levermore (5th Claimant), Alty Currie (6th Claimant), Boblet Campbell (7th Claimant), Lawford Fletcher (8th Claimant) Edlin Walton (9th Claimant) and Noranda Jamaica Bauxite Partners (1st Defendant) , Noranda Jamaica Bauxite Partners II (2nd Defendant), New Day Aluminum (Jamaica) Limited (3rd Defendant) and the Attorney General of Jamaica (4th Defendant).

My expertise and relevant experience

1. For the purposes of this report my address is Windsor House, Sherwood Content P.O, Trelawny, Jamaica. I am an expert in wildlife ecology.

2. I received a Doctorate in Forestry and Environmental Studies from Yale University, New Haven, Connecticut, USA in 1999. The topic of my dissertation research was the breeding biology and conservation implications of Jamaica's endemic Black-billed Parrot (*Amazona agilis*) in Cockpit Country. In 1999 I moved from the USA to Jamaica, to my reported address. In 2002 I became a co-founding director of Windsor Research Centre (WRC), which operates out of Windsor House. Since 2002 I have been serving as WRC's Director of Research and I have been the Principal Investigator

on a range of research projects, including studies of birds, bats, and the endemic Jamaican Boa (*Chilabothrus subflavus*). Since 2018 I also have been the Managing Director of WRC.

3. During my field research, particularly on the Jamaican Boa, I observed on many occasions the ecological importance of rainwater-holding tank bromeliads, a group of plants belonging to the scientific family Bromeliaceae, known locally as "wild pine" and of which cultivated pineapples also are members. As but one example to highlight the functional relationships between bromeliads and wildlife, I exhibit an image of a Jamaican Boa resting amongst the leaves of a large tank bromeliad belonging to the scientific genus *Wittmackia*, marked as **SEK-1**.

4. On November 22nd, 2022 I was awarded by the Council of the Institute of Jamaica a Bronze Musgrave Medal in recognition of my contribution in the field of Science.

5. I attach a copy of my *Curriculum Vitae* (CV) marked **SEK-2**.

6. Windsor House, of which I have been the titled owner since February 28th, 2017, is located at the headwaters of the Martha Brae river deep inside north-central Cockpit Country. The National Water Commission (NWC) does not provide any service to Windsor District, Trelawny; consequently, I am responsible for collecting and storing water for all household needs. This is achieved via rain falling directly into an uncovered 20,000 gallon stone-and-concrete tank which was erected on a hillside in 1948 (i.e., the tank is an elevated cistern, which is plumbed to gravity-feed water to the house). River water also can be pumped into this storage tank directly from the Martha Brae with an appropriate mechanical water pump. Additionally, I collect rainwater intercepted by the metal roofing on the house, to store the rain in 55-gallon barrels. I do this latter storage as a backup for when the primary 20,000 gallon storage tank needs to be drained and cleaned of accumulated sediments. I undertake this routine maintenance approximately once every 12 – 18 months, after I detect biofilm -- a thin layer of slime which is a matrix of yeast, bacteria and / or fungi microorganisms -- beginning to form on a water filter installed on the main plumbing line. I examine the filter every three to four months. I am, therefore, directly familiar with water catchments similar to those used by the Claimants in this claim.

Background knowledge regarding the claim

7. My knowledge of the issues pertaining to the positions of the Claimants and the Defendants was obtained from studying documents submitted to the Court by the parties. These included affidavits and the exhibited documents relied on by the parties, including environmental permits issued to the 2nd Defendant by the Natural Resources Conservation Authority (NRCA) and administered by the National Environment and Planning Agency (NEPA).

8. I referred to an electronic copy of the Environmental Impact Assessment (EIA) that was prepared for Special Mining Lease (SML) 173 by Conrad Douglas & Associates Limited, dated August 3rd 2021. I submitted two written reviews of the EIA to NEPA. I submitted my first review of the draft EIA on December 28th 2020 and my second review of the so-named final EIA on November 26th 2021. I rejected both versions of the EIA, noting: "**I reject this version of the EIA for its inadequate, data-deficient, and incorrect descriptions of the karstscape and for its myriad unsupported conclusions that no-to-minimal impact will be experienced to key functional components when bauxitic soils are removed and limestone corridors are eliminated from the landscape. Repeating assertions, as CD&A did in response to technical questions from December 2020,**

does not make the assertions true." The bold font shown here is the format I presented in my reports.

9. My two reviews of the EIA for SML 173 were included in an Expert Report I prepared on the impacts of bauxite mining activities on forests, flora, and fauna and on the area which is known to be Cockpit Country. My report, hereafter referred to as Koenig 2022, was filed with the court for Claim SU 2021 CV00187 on May 24, 2022. In that report my reviews of the EIA for SML 173 are listed as **DOCUMENTS SEK-5 (a)** and **(b).**

10. During the preparation of this report I relied upon the information in the documents noted in Paragraphs 7 and 8, information from published literature, my expertise, and my direct experiences. The latter includes not only my experience maintaining rainwater catchments as presented in Paragraph 6, but also having stayed from one night to several months in homes within and around Cockpit Country, where stored rainwater was used for household needs. I also have considerable direct experience with the areas of SML 165, SML 172 and SML 173 due to my driving: (a) the segment of the northern boundary of SML 173 which adheres to the B11 road for approximately 10.5 kilometers, connecting Stewart Town to Browns Town; (b) the myriad mining haulage roads networking within SML 165; and (c) the road through the communities of Endeavour and Gibraltar and the district of Industry (St. Ann), which aligns to the conjoined boundaries of SML 165, SML 172, and SML 173. Having driven these roads countless times for more than two decades, I also have directly observed in these SMLs multiple hillside water catchments (i.e., large concrete slabs on hillsides) and private stone and concrete catchment tanks which farmers use to collect and store rainwater and homeowners use to store roof-harvested rainwater. Marked **SEK-3**, I have included an image of a hillside water catchment located in the district of Caledonia, St. Ann, within SML 165.

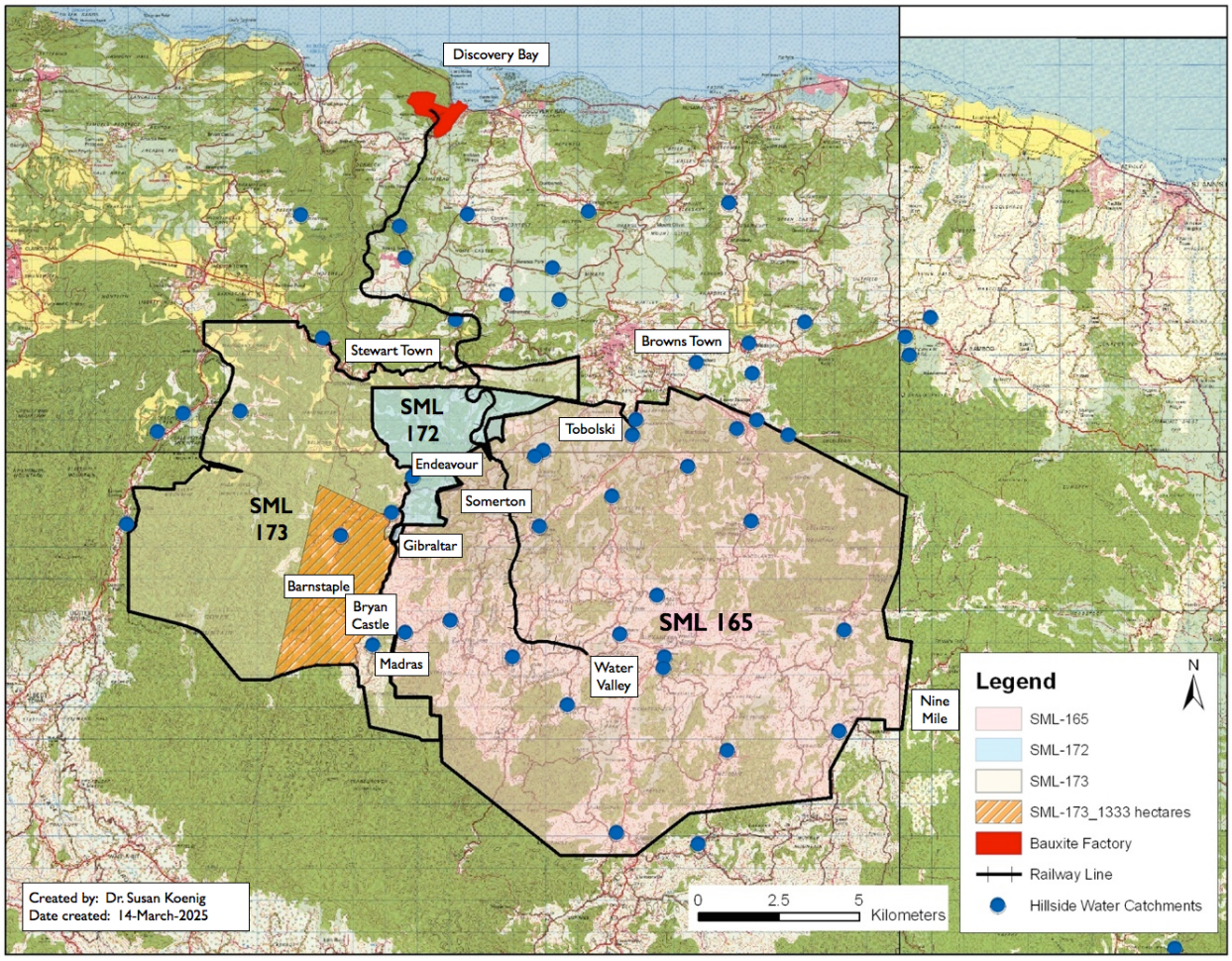
11. Also while driving through the areas of SML 165, SML 172 and SML 173 I have repeatedly observed large plumes of fugitive dust being generated by bauxite haulage trucks as well as by other heavy equipment such as front-end loaders and hydraulic breaker (aka percussive hammer) excavators, the latter of which are used to excavate haulage roads through limestone hillsides. I exhibit an image of the fugitive dust phenomenon marked as **SEK-4** and exhibit an image of a hydraulic breaker photographed in the district of Caledonia, St. Ann, marked as **SEK-5**.

12. The geographical area of interest to this report is shown in Figure 1 on page 4. In previous Access-to-Information (ATI) requests related to SMLs, Mines and Geology Division (MGD) (presently in the Ministry of Agriculture, Fisheries and Mining) advised it "does not request data to define the boundaries of mining leases in the format of shape files" and, thus, MGD has never provided to me electronic GIS files. Consequently, I had to create the GIS shapefiles to map the SMLs from the latitude and longitude details presented under the leases' heading "DELINEATION OF THE AREA". I am aware that an area of 841 hectares was removed from SML 173 and allocated to the Cockpit Country Protected Area (CCPA), which was gazetted on March 18th, 2022. I have not seen an updated version of SML 173 from MGD but I included the removal of the 841 hectares in Figure 1.

13. When registering SML 173 on August 28th 2018 the boundary approved by the Commissioner of Mines and the Minister of Transport & Mining included all of the hectares previously registered to SML 172 on May 16th 2017. For the purposes of this report I shall include delineation of SML 172 even though these hectares will be double-counted in discussions about SML 173 (Figure 1).

14. With the reallocation of 841 hectares to the CCPA, the area delineated by the boundary of SML 173 will encompass 7,494 hectares. Although these 841 hectares of SML 173 were deliberately excluded from the CCPA, as I presented in Koenig 2022, ***the majority area of SML 173 historically, hydrologically, and geomorphologically is the northeast region of Cockpit Country***. Contrary to the technically incorrect and highly misleading description of the landform presented in the EIA for SML 173, ***the area of SML 173 is quantitatively cockpit karst (Chenoweth 2022). Only when the correct morphology is presented can mining impacts be identified correctly***.

Figure 1. Map of geographical area of interest showing boundaries of Special Mining Leases (SMLs) 165, 172, and 173 and other mining infrastructure -- the railway line between the Water Valley and Tobolski loading stations and the drying factory at Discovery Bay -- referenced in this report. The locations of hillside water catchments are printed directly on the 1:50,000 topographic base map. I extracted their geographic location data to create a new GIS file to render their locations visible on this figure.



15. For the purposes of this report, I recognize that the operations which are necessary for the purposes of extracting and exporting bauxite and for being compliant with NRCA/NEPA permits, include: clearing of overburden (e.g., vegetation), removal of topsoil, creation of haul roads, extraction of ore bodies, haulage transport (road, rail, and ship as applies to the Defendants), surface reclamation, and surface rehabilitation. Collectively these define **mining activities** for which impacts can be identified.

16. The affidavit of Delroy Dell dated October 14th, 2022 leads me to reiterate an important technical point I presented in Koenig 2022 about the stages of bauxite mining in Jamaica. After an ore body is extracted from the ground, the mined-out pit can be **reclaimed** and **rehabilitated**. It is physically impossible to **restore** – return something to its original state – after an area has been subjected to surface mining because of changes to geochemistry and morphology. Usages of the terms **restore** or **restoration**, in my opinion, are highly misleading in the context of irreversible changes caused by surface mining.

17. For the purposes of this report **sensitive receptor** means: (a) any natural or human-constructed feature that may be adversely affected by a hazardous material and includes sensitive ecological areas, soils, public water sources, sources of water for potable water supplies, groundwater and surface waters; and (b) people or other organisms that may have an increased sensitivity or exposure to contaminants by virtue of their age and health (e.g. school children, the elderly), status (e.g. sensitive or rare and endangered species), or proximity to the contaminants.

18. I was guided as to the issues to consider in this report by instructions from Attorneys-at-Law Hylton Powell, 11A Oxford Road, Kingston 5. The instructions are exhibited as **SEK-6**. Those instructions presented that one of the significant issues in this case is what effect (if any) bauxite mining activities and the dust from bauxite mining activities have on the environment including the forests, flora, fauna and water catchments within SMLs 165, 172, and 173. I was asked to prepare a report addressing this issue.

19. Literature cited in this report are exhibited in **SEK-7.**

20. In this report I have highlighted in ***bold italics*** my major conclusions.

<u>Sensitive Natural Water Catchments: "Wild Pine" tank bromeliads, where a little dust is beneficial but too much can be lethal</u>

21. Forests growing in limestone-bedded environments face unique challenges. All plants require water for photosynthesis, survival, and growth. For forests, rainfall is typically the primary source of water. Unfortunately for plants, limestone is a highly porous rock so that when rain reaches its surface, the water promptly drains vertically and flows below ground. Thus, even though a tropical limestone forest may receive more than one meter (39 inches) of rainfall over the course of a year, the flora and fauna can easily experience drought-induced stresses even just weeks after a storm.

22. Bromeliads (family Bromeliceae) are one group of plants that have evolved to overcome water stresses such as those encountered with a limestone bedrock. Their long slender leaves are arranged in a rosette pattern, which creates holding spaces – little nooks and crannies -- called phytotelmata. In many species of bromeliads, rainwater can be retained in these phytotelmata and we call these forms "tank bromeliads" (Figure 2). So good are tank bromeliads at holding water that

in some tropical locations bromeliads impound 50,000 liters (13,209 gallons) of water per hectare (per 2.5 acres) (McCracken and Forstner 2014). When this water slowly evaporates, air temperature around the bromeliad is made cooler. This physical process – natural cooling and regulation of air temperature – is but one of the important ecosystem services provided by tank bromeliads. Other services of nutrient cycling, providing refugia for biodiversity and highly efficient absorption of atmospheric carbon dioxide (CO_2) are described below in paragraphs 21 -27. Ladino *et al.* 2019 provides an even more comprehensive review of bromeliad ecosystem services.

Figure 2. Dissected illustration of a tank bromeliad with various types of organisms living between its leaves and in its stored water, and examples of a Jamaican bromeliad community, all of which are endemic to the island. Clockwise from top: endangered Jamaican Blackbird (aka Wildpine Sergeant; *Nesopsar nigerrimus*), Jamaican Laughing Frog (*Osteopilus ocellatus*), tank bromeliad (*Aechmea paniculigera*), Jamaican Bromeliad Damselfly (*Diceratobasis macrogaster*) and Cockpit Eyespot Pawli-gecko (*Sphaerodactylus semasiops)*.



23. The water stored in tank bromeliads provides habitat for a highly diverse array of organisms (Frank and Lounibos 2009). This includes microorganisms which live their complete life cycles in water, such as some species of saprotrophic bacteria and fungi (decomposers which feed on dead organic material and recycle inorganic minerals back into the environment) and cyanobacteria (primary producers, as all plants are). But it also includes fauna that have an aquatic larval (immature) stage

and a free-flying or terrestrial adult stage. Examples of these are dragonflies and damselflies (predators which feed on other insects), treefrogs and their tadpoles (predators of insects), and the larvae and adults of a special species of endemic freshwater crab, *Metapaulias depressus* (feeds on fruits and preys on insects; see also paragraph 26 below). For these animals, the water in a tank bromeliad is literally life-transforming and without it they would go extinct. Secondary predators (i.e., predators which feed on other predators, such as reptiles like the Jamaican Boa) and birds also visit tank bromeliads for drinking water, for the nutritious soup, or to prey on the other animals occupying the phytotelmata. All of these fauna, in turn, contribute mineral nutrients (notably nitrogen and phosphorus) via their excretions (e.g., fecal pellets, urea, invertebrate exoskeletons), which are absorbed by the bromeliad's leaves (Leroy *et al.* 2016). Thus, a tank bromeliad in a tropical forest is not merely a simple plant to note on a checklist, but it represents a fully functional ecosystem nestled within a much larger forest ecosystem. The presence of a complex foodweb of trophic biodiversity (decomposers, primary producers, primary predators, secondary predators) demonstrates one of the highest levels of symbiotic mutualism between plants and animals. ***This is why, when bromeliads are removed from the natural environment, there will be extensive collateral damage***.

24. When forest-dependent frogs are found successfully breeding in tank bromeliads, their presence signals healthy natural environmental conditions. Equally, ***because they are highly sensitive receptors of environmental changes, frogs also function as biological sentinels of environmental degradation (i.e., frogs are heralded as the proverbial Canary in the Coal Mine, which dies of carbon monoxide poisoning before a human will succumb)***. Bromeliad-dependent treefrogs are particularly effective biological sentinels because:

    (a) Their aquatic tadpole stage is sensitive to changes in water quality (e.g. turbidity, temperature, pH, chemical pollution);

    (b) Their terrestrial adult stage is highly sensitive to air-borne pollutants due to the fact that their moist skin is a permeable respiratory organ i.e., frogs absorb atmospheric gases like oxygen but will also absorb harmful nitrogen oxides (NO_x) and sulfur oxides (SO_x) directly through their skin as well as via their noses into their lungs; and

    (c) Their central position in food webs (predators of insects; prey item for secondary predators) means their disappearance eliminates a functional level, not just a single species.

25. With regards to paragraph 24, the freshwater Jamaican Bromeliad Crab *Metapaulias depressus* has a highly specialized, globally unique trait. Endemic to Cockpit Country (i.e., it occurs nowhere else on earth, not even elsewhere in Jamaica), it is the only species of crab in the entire world that uses tank bromeliads as a nursery in which to rear its offspring. When necessary, the mother crab carries in empty snail shells she finds on the forest floor to ensure the water in the bromeliad has the correct pH and dissolved calcium for her brood: this endemic crab directly manages the freshwater chemistry of bromeliads (Diesel and Schuh 1993). The EIA for SML 173 confirmed the presence of tank bromeliad species in the genus *Hohenbergia* (now classified as *Wittmackia*) and the species *Aechmena paniculigera*. It also presented on pages 5-158 and 5-159 that "These plants serve as water reserves for small terrestrial crustaceans (such as crabs), frogs and invertebrates such as mosquitoes." What the EIA failed to assess was how the destruction, death or removal of tank bromeliads will impact Jamaica's unique ecological heritage – a tiny crab which is a master in

managing water chemistry and also a sensitive receptor whose disappearance will signal degradation of the environment.

26. In addition to providing habitat for fauna, many species of bromeliads have a second important functional characteristic: they are epiphytic, meaning they survive and grow on another living plant. By growing on canopy-forming tree branches, the epiphytes are better-positioned to intercept rainfall, so much so that they are frequently called 'wetlands in the sky' (McCracken and Forstner 2014) and they remain sources of water for fauna during dry seasons. A further point is that epiphytes are not parasites – they do not draw any nutrients from their structural host. Instead, epiphytes obtain all of their nutrients atmospherically (e.g., wind-borne dust, raindrops, volatile compounds emitted by trees) or in the case of tank bromeliads, also from decomposing organics (e.g., leaf litter, exoskeletons, fecal pellets) which collect in their reservoirs.

27. The number and sizes of epiphytic bromeliads living on any given support tree is significantly correlated to the size of the tree: the larger the branches, the greater the number and sizes of bromeliads which can be supported. This, in turn, means greater abundances of animal communities associated with the tanks of water (Galindo-Leali *et al.* 2003). As explained in Koenig 2022, ***because deep, moisture-holding bauxitic soils drive vegetation structure – the tallest and broadest trees (forest, fruit, and lumber) grow in bottomland soils while trees on cockpit hillsides and hilltops are stunted – , eliminating these soils will irreversibly reduce the growth potential of any tree which may be planted post-mining. Smaller trees means a lower abundance and smaller size class of arboreal tank bromeliads, which means the potential for highest-quality bromeliad refugia will be irreversibly compromised by bauxite mining.***

28. There is a third characteristic of bromeliads that is critical to understand. In the vast majority of plants, nutrients are absorbed via roots. In bromeliads, that function has been transferred to special structures that grow on the dermis of the leaves. Called foliar trichomes, these are unicellar, hair-like outgrowths that operate as a one-way valve: when moisture reaches the leaf surface, the trichomes permit water molecules and nutrients to be absorbed directly into the leaf tissue while at the same time preventing moisture loss, as would occur with a non-valved open pore (e.g., as occurs during the process of photosynthesis). It is via these foliar trichomes that bromeliads absorb their required mineral nutrients from atmospheric sources, such as wind-borne dust particles. ***If these foliar trichomes become clogged or damaged (e.g. as would occur with heavy layers of dust), the bromeliad's functional health would be compromised as it would be unable to efficiently absorb atmospheric nutrients*** (Zhang *et al.* 2019).

29. The structural characteristics and myriad ecosystem services (e.g., microclimate regulation via evaporation of the stored rainwater, highly efficient absorption of CO_2 via foliar trichomes, aquatic nursery pools, the 'watering hole' where terrestrial predators know a good meal or drink of water is waiting for them) provided by bromeliads create one negative condition for the plant. The ability to absorb nutrients into their tissues via a one-way valve and an ability to store water also means that bromeliads will bio-accumulate pollutants and toxins. While one research discipline finds this useful -- as highly efficient accumulators of heavy metals (e.g., cadmium, lead, chromium), bromeliads can be used as low-cost indicators of air quality in human modified landscapes (Giampoli *et al.* 2016, Benítez *et al*. 2019) -- ***the EIA for SML 173 correctly recognized that epiphytes are "sensitive species" (see pages 4-4, 5-62) in regards to mining impacts***.

30. The EIA set out certain mitigation strategies that the Defendants intend to pursue and which form the basis of their approach regarding the removal of tank bromeliads. Specifically, the EIA recommended that bromeliads and other epiphytic plants such as orchids and cacti be "removed and relocated to nearby areas that will be unaffected by mining operations or to a nursery managed and operated by NJBP II" (Table 7.1, page 7-6). ***The EIA notably failed to quantitatively define "nearby": is that 10 meters (32.8 feet), 100 meters (328 feet), 1000 meters (3,281 feet), or more to ensure bromeliads are unaffected by mining operations? To adopt the wording of the EIA, we must ask what is the "spatial extent or the zone of impact influence" for bromeliads, a group of plants which are highly sensitive receptors to air-borne particulate pollution. And how far away from mining operations is NJBP II's nursery?***

31. NEPA approved the EIA and issued permits pursuant to it, essentially sanctioning the mitigation strategies proposed by the EIA (ref 2018-06017-EP00197):

> 27. The Permittee shall develop and submit to the Managers of the Enforcement and the Ecosystems Management Branches of the National Environment and Planning Agency, 10 Caledonia Avenue, Kingston 5 or EnforcementManager@nepa.gov.jm and EcosystemsManager@nepa.gov.jm, a Relocation Plan for approval. The Plan shall include, but not be limited to:
>
> - Identification of a replanting site for direct relocation of plants to the wild (for suitable species) and/or the establishment of a nursery;
> - Relocation activities for endemic, rare and threatened plant species prior to the commencement of and during the vegetation clearance (or other related activities). This shall include epiphytic plants (including, but not limited to, orchids, bromeliads, and cacti);
> - Relocation of species from nursery on a phased basis to allow for the decommissioning of the nursery in year 5;
> - Monitoring of indirect impacts on endemic, rare, and threatened plant species surrounding the mining (or other related activities).
> - The monitoring of relocated species in the wild and/or nursery

32. To the best of my knowledge the Defendants have not exhibited the Relocation Plan which is required by the NEPA permit; therefore, I remain uninformed as to:

    (a) what parameters will be used by the Defendants to monitor indirect impacts on endemic, rare and threatened plants;

    (b) what is the spatial extent or zone of impact associated with mining activities for which the indirect impacts will be monitored i.e., what quantitatively defines the distance presented as "surrounding the mining (or other related activities)"; and

    (c) what parameters will be used to monitor relocated species and for how long will species be monitored after being relocated or returned to the wild from the nursery. These parameters and pre-determined quantitative measures-of-success are necessary for NEPA to gauge the Defendants' compliance with the permit and, ultimately, to evaluate whether these mitigations are, in fact, valid.

33. Grounded in my experience as an ecologist, it is clear that proper consideration must be given to assessing the viability of permit mitigation strategies and the effectiveness of these strategies in

reducing the impacts of the Defendants' mining activities on the environment and human health. Several major questions / issues arise for me. These include:

(a) For bromeliads, will the Defendants restrict removal and relocation to **epiphytic** forms (i.e, those individuals found growing on other plants)? As described in the EIA (on pages e.g. 5-178 and 5-182), **terrestrial** bromeliads were observed growing on the forest floor. In my direct experience of the forest within the boundary of SML 173, **lithophytic** bromeliads – plants which grow directly on rock – also can be found. This may appear to be semantics, but as per the language of the permit, if terrestrial and lithophytic bromeliads are destroyed during mining activities (particularly with deforestation during haul road excavation or during the stage of reclamation when the base of a forested cockpit hillside is excavated as "swell" to create rock rubble filler), the Defendants, arguably, will not breach the permit. In my experience throughout Cockpit Country, the biomass of terrestrial and lithophytic bromeliads in SML 173 could easily be equal to the biomass of epiphytic bromeliads.

(b) What would be the ultimate objective in moving epiphytic plants? If it is to protect these sensitive receptors from harmful levels of air-borne pollutants during mining activities, then I question if the Defendants and NEPA are aware that every epiphytic (and here I would include all bromeliads -- terrestrial, lithophytic and epiphytic) would need to be removed from every hillside surrounding an ore body and hillsides peripheral to all haul roads and rail lines. While coarse dust particles up-to 100 microns in diameter made air-borne by large trucks and heavy equipment can be seen covering forest along the edges of roads and mining pits in SML 165 (with an estimated dispersal distance of 30 meters (98 feet) from point-source to deposition of vegetation; see exhibit **SEK-4**), smaller-grain dust particulates measuring < 10 microns in diameter (i.e. PM_{10}) can travel even greater distances. For example, in July 2022 I deployed a Dylos DC1700 laser air quality sensor in the community of Gibraltar. The sensor was located approximately 450 meters (1,476 feet) south of a bauxite ore body (see exhibited PowerPoint presentation marked **SEK-8)**. ***During active mining operations in SML 165 and SML 172, concentrations of PM_{10} were detected by the Dylos to be in excess of national safe guidelines; these data discredit the Air Dispersion Model predictions in the EIA***, which presented that "The proposed mining and hauling activities within SML 173 would result in ambient concentrations of TSP and PM_{10} at a maximum of 50-60% of the ambient air standards, including background concentrations, at locations outside of the ore body mining sites**"** (EIA page 1-10). As further commentary on the zone-of-impact for epiphytes, in his affidavit filed 14th October 2022, Mr. Kent Skyers noted that "The general practice of the Defendant Companies is to avoid mining within 300ft of any residence or building." ***Recognizing that humans and epiphytes are sensitive receptors, If we apply Mr. Skyers' avoidance distance of 300 feet (91 meters) to identify epiphytic plants (including all forms of bromeliads) and all the sensitive aquatic fauna held in tank bromeliads which may be exposed to harmful concentrations of PM_{10}, then nearly all plants on every hillside associated with an ore body or haul road are vulnerable to dust pollution.*** (Figure 3, presented on page 12).

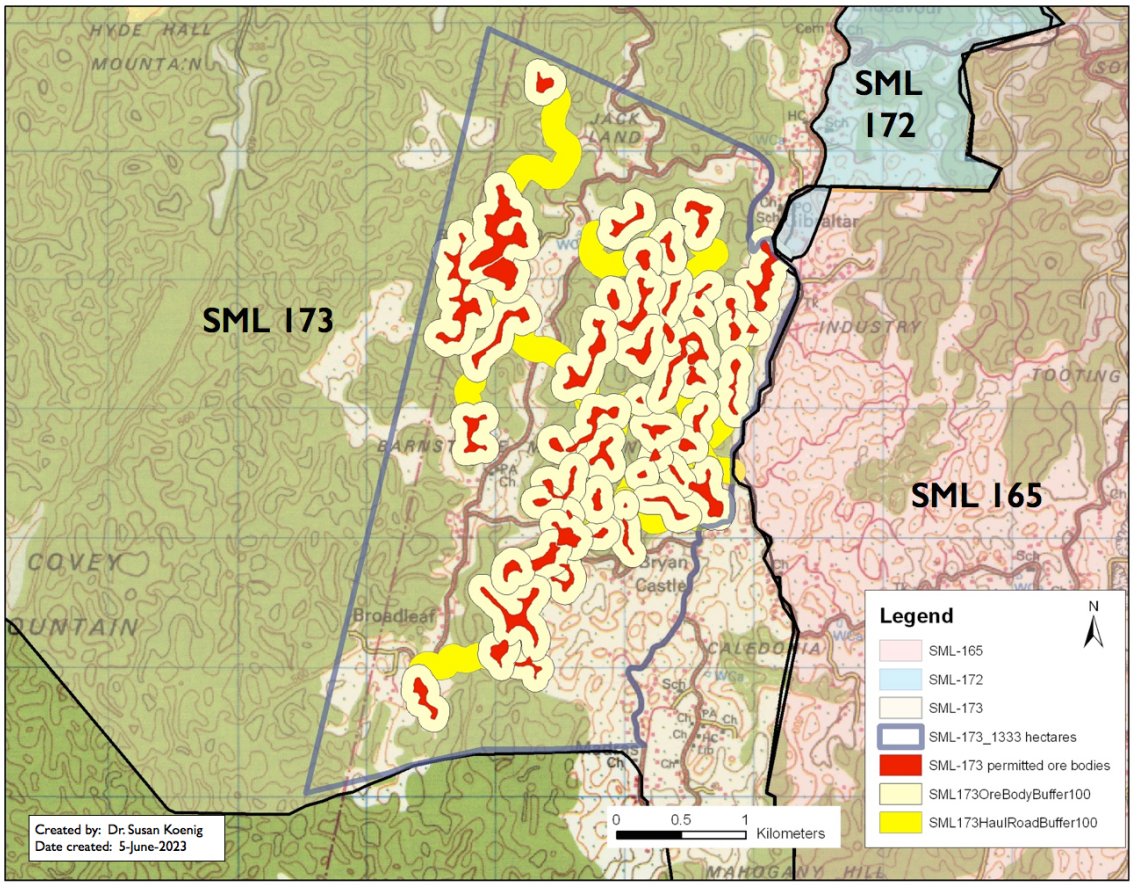
(c) With regards to deforestation, forest fragmentation, and what ecologically is known as an 'edge effect' (Box 1, presented on pages 13 and 14), as will result from the demolition of cockpit limestone saddle corridors during haul road excavation, I am concerned that the Defendants are unaware that epiphytic plants in Jamaica are impacted by edge effects penetrating into forest by a distance of 100 – 120 meters (Gonsiska 2007). The impacts -- reduced species diversity and reduced abundances of individuals -- are due in part to changes in microclimate (i.e., sunlight

penetration, temperature, relative humidity, and wind) associated with the elimination of vertical forest structure (e.g. understory seedlings, immature saplings, and large trees which may also support large epiphyte communities). ***If all of the forest-dependent bromeliads are moved to a nursery, which itself is to be decommissioned in 5 years, what in reality will be the fate of these plants?*** The microclimate from where they were originally collected will be irreversibly altered from mining activities (particularly haul road excavation, ore body removal, and reclamation actions), and they cannot be relocated to any areas that will be mined in the future. It also is important to note that, with regards to the functional contributions of tank bromeliads for fauna, arboreal tank bromeliads cannot be relocated to the forest floor – canopy-dwelling birds like the Endangered endemic Jamaican Blackbird (aka Wildpine Sergeant; *Nesopsar nigerrimus*) will not fly down to the forest floor.

(d) For relocated epiphytes, what time-dependent mortality rates will be applied to determine success or failure? If only 5% of epiphytes die within three months of relocation but 40% are dead after 16 months, should this still be considered successful? For long-lived species with low annual recruitment of a new generation (such as occurs with bromeliads [Winkler *et al* 2005]), when adult mortality increases annually by as little as 10% from natural sustainable baselines, population growth becomes negative and the population will eventually go extinct.

(e) Is the Defendant's nursery a valid mitigation for protecting the functional health of tank bromeliads? In an experimental study of bromeliads in Ecuador, O'Reilly-Berkeley (2022) found that bacterial diversity (species numbers, abundances, and functional roles) in greenhouse-reared tank bromeliads was significantly lower compared to wild bromeliads. This isn't necessarily a surprise and, indeed, is predicted for a constrained artificial environment. But it begs the questions: (1) to what extent will bromeliad leaf and foliar trichome development be impacted in the absence of their full suite of natural, nutrient-recycling microrganisms; (2) how does substandard leaf development impact water holding capacity; (3) if water holding capacity is compromised, how will this directly impact wild fauna which depend upon quality tank bromeliads? That is, ***by moving tank bromeliads to nurseries, what is the full collateral damage which will be caused to the plants and all of their dependent fauna?***

Figure 3. Location map of SML 173 ore bodies, which were permitted for extraction to the 2nd Defendant under Permit No. 2018-06017-EP00196. Research by Gonsiska (2007) and McCracken and Forstner (2014; see also Schmidt *et al.* 2017) indicate that ore body extraction, ore haulage, and pit reclamation will impact bromeliads out to a distance of at least 100 meters, even more than the 91 meter (300 feet) avoidance distance which the Defendants note they try to apply to any residence or building. To protect these sensitive plant receptors, practically all tank bromeliads need to be removed from hillside forests directly adjacent to ore bodies and haul roads. This will, however, cause collateral losses of habitat for sensitive fauna receptors like crabs and treefrogs. Ecologically, this is profoundly different from removing bromeliads from within only the direct footprint of an ore body or haul road.

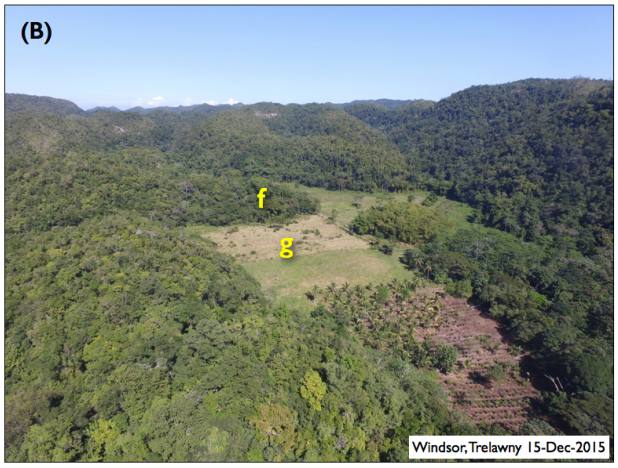


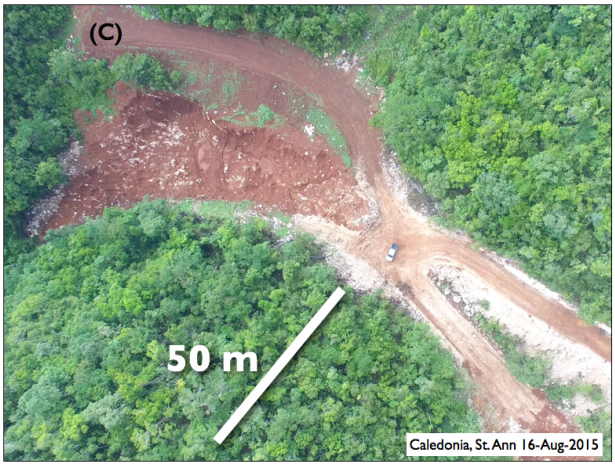
Box 1. Deforestation and Edge Effects.

Before Europeans colonized Jamaica, the *Degraded Cockpit Karst* of SML 165 and the *Cockpit Karst* of SMLs 172 and 173 was blanketed by a closed-canopy forest, where the crowns of trees have direct physical connect with each other (image A). Recognizing that 'red dirt' was accumulated in the bottomlands, over the past five centuries humans have selectively removed forest and converted bottomlands to agriculture (image B). While this creates gaps in the previously-contiguous forest, connectivity is maintained via saddle corridors which connect hillsides (see also Figure 7 in Koenig 2022).

Converting forest significantly alters the vertical structure of the landcover. Boundaries (i.e. edges) between landuse types in image B are easily seen between forest (f) and grass pasture (g), where vertical complexity of forest seedlings, young saplings, and mature trees is replaced by short grass. The loss of forest cover and structural complexity, in turn, impacts microclimate as more sunlight and wind reach the ground surface. As the EIA for SML 173 confirmed, grassland fields are hotter and drier compared to forest-covered hills. What the EIA failed to account was that microclimate changes may be detected penetrating forests up-to 125 meters (410 feet) from the edge (Schmidt et al. 2017). That is, insidious edge effects are not limited to what appears most visible to the human eye. Based on the findings of McCracken and Forstner (2014) sensitive bromeliad-dependent fauna will be impacted by edge effects penetrating the forest up-to 100 meters when haul roads are excavated in SML 173 (image C). When ore bodies and haul roads encircle hillsides (image D), the forest will cease to function as a refugium for sensitive receptors like bromeliads and treefrogs.

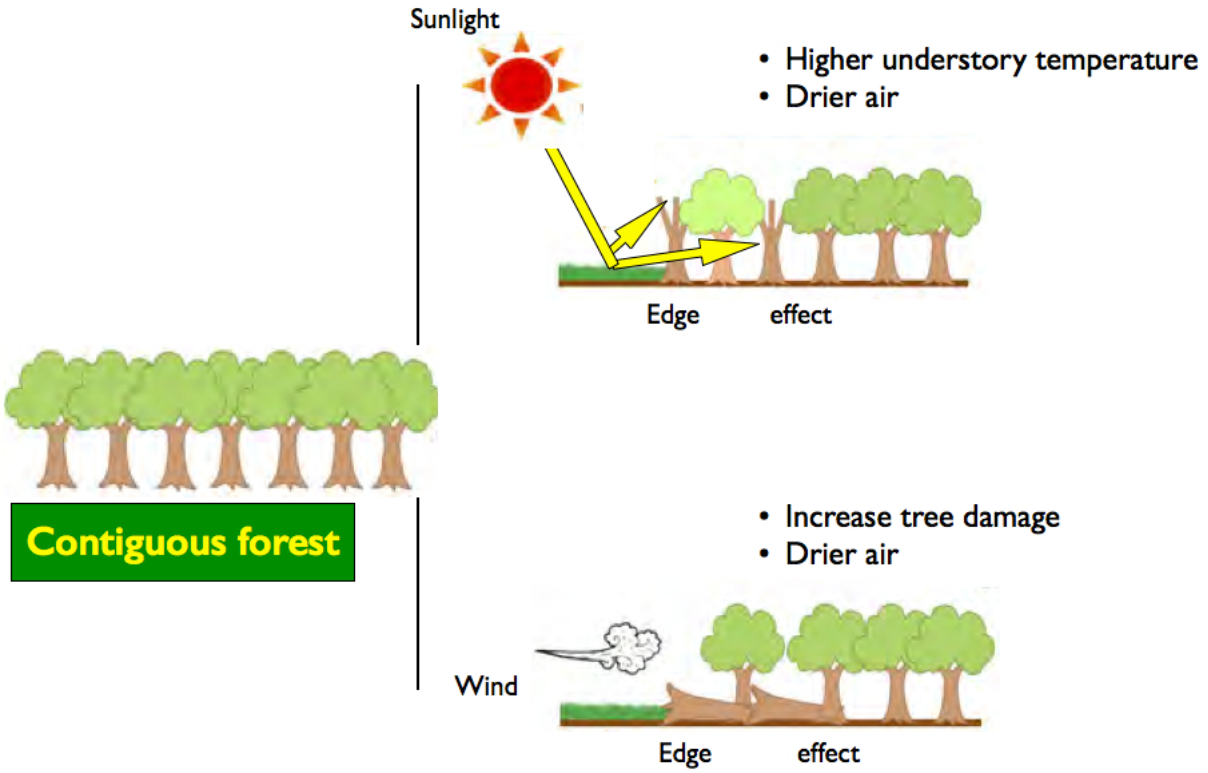








Box 1 (continued)



Field Research: A step towards assessing the validity of environmental permit mitigations

34. Given the knowledge gaps associated with the environmental permit I outlined in the subsections of Paragraph 34 and the absence of data presented by the Defendants that permit mitigations are, indeed valid, I secured a small grant and received a research permit from NEPA to collect quantitative data on tank bromeliads and their associated faunal communities within the boundaries of SML 165, SML 172, and SML 173 and in Windsor, Trelawny (Figure 4, shown on page 17). The goal was to determine what, if any, short-term impacts and long-term effects there are on bromeliads which are located within 100 meters of mining activities compared to unmined habitats. To identify faunal species using bromeliads, I used the molecular analytic technique of Environmental DNA (eDNA) sampling, whereby species are detected by the presence of biological particles they leave behind in the environment, such as shed skin, fur, urine, feces, etc. (Clare *et al.* 2022). The study design and sampling methodology were as follows:

    (a) Six land cover classes in three mining categories were identified: (A) UNMINED: (A.1.) Agriculture and (A.2.) Forest; (B) ACTIVE MINING: (B.1.) Forest on limestone hillside adjacent to mining pit, land cover in the bottomland prior to mining was agriculture and (B.2) Forest adjacent to active haul roads and railway haulage; and (C) POST-MINING REMEDIATED: (C.1.) One-year post-mining and (C.2.) 10-years post-mining. ***For category (C), sampling had to be***

restricted to forest on adjacent limestone hillsides as we could not find bromeliads in mined-out remediated pits.

(b) Thirty (30) large arboreal tank bromeliads (23 *Wittmackia* sp. and 7 *Aechmea paniculigera*) were identified i.e., five bromeliads were located per land cover class. Tree branches were accessed with rope-assisted climbing aids.

(c) eDNA aquatic sampling kits were purchased from Nature Metrics Ltd (Guildford, Surrey, UK; www.naturemetrics.com). From each bromeliad, approximately 80 ml of water was extracted (20 ml from the central reservoir and 20 ml x three peripheral leaves) using a sterile syringe. The water was injected through a filter optimized for invertebrate and vertebrate DNA. The filter was then immediately immersed with DNA preservation solution (near-saturated ammonium sulfate solution buffered with sodium citrate and with some EDTA for metal chelation). To ensure no post-collecting contamination and for bio-security, each preserved filter was placed in a discrete ai650 95kPa certified specimen safety bag and all bags were placed in a freezer within four hours of their collection in the field.

(d) Sample kits were couriered by DHL to Nature Metrics Ltd for multispecies DNA testing. All 30 sample filters passed Nature Metrics' quality control tests for DNA amplification and Illumina sequencing. To identify sequences, Nature Metrics utilised GenBank, an online library of publicly available DNA sequences of over 504,000 described species from around the world (www.ncbi.nlm.nih.gov/genbank/). Nature Metrics' reporting included Excel spreadsheets of the sequence results, resolution of operational taxonomic units (OTUs; this is the number of species, but resolution might only be to a higher taxonomic level, such as family, owing to limitations in the DNA reference library database) and graphs of community composition, species richness and evolutionary diversity. Nature Metrics' *Environmental DNA Report : Freshwater Insects* is exhibited as **SEK-9**.

(e) With awareness that eDNA may be transported by wind, I assessed the data first using the complete dataset of sequences and then looked at a subset of the organisms which have an aquatic stage in their lifecycle. It is these aquatic stages for which one would have greatest confidence that the animals were actually present in the water and which one would predict should experience the most immediate impacts of changes in water quality and chemistry.

(f) To statistically evaluate the patterns of community composition (e.g., species richness and evenness) and degrees of similarity by land cover and mining categories, the relative abundance of each OTU was calculated. Bray-Curtis resemblance matrices were then used to construct non-metric multidimensional scaling (MMDS) plots to visualize the degree of overlap amongst faunal communities. I used *R package vegan* for graphing and analyses and *R package pwr* for a power analysis to determine minimum number of samples needed for each land cover based on the effect sizes and degrees of freedom calculated in *vegan*.

(g) Water chemistry was measured for each bromeliad (central reservoir and three peripheral leaves) using hand-held sensor probes. *In situ*, an Apera Instruments PC60-Z Smart Multi-Parameter Tester was used to measure: pH, temperature, salinity, total dissolved solids, electrical conductivity, and resistivity (the latter being the reciprocal of conductivity). Also *in situ*, a Lutron PDO-519 meter was used to measure dissolved oxygen. To measure calcium, at least 8 ml of water was extracted using a pipette from each bromeliad (2 ml from central reservoir and 2 ml x three peripheral leaves). Each sample was stored in a separately labeled vial and subsequently tested with a LAQUATwin Calcium Ion Meter Ca-11, with a B-Y046 filter to prevent damage from sediments to the sensor. All three sensors were newly purchased for this project and verified with calibration and standards solutions provided by their respective manufacturers. In addition to the 30 arboreal bromeliads for which DNA samples were

collected; water chemistry also was evaluated for 30 terrestrial tank bromeliads amongst the 6 landcover classes for a broader sampling effort.

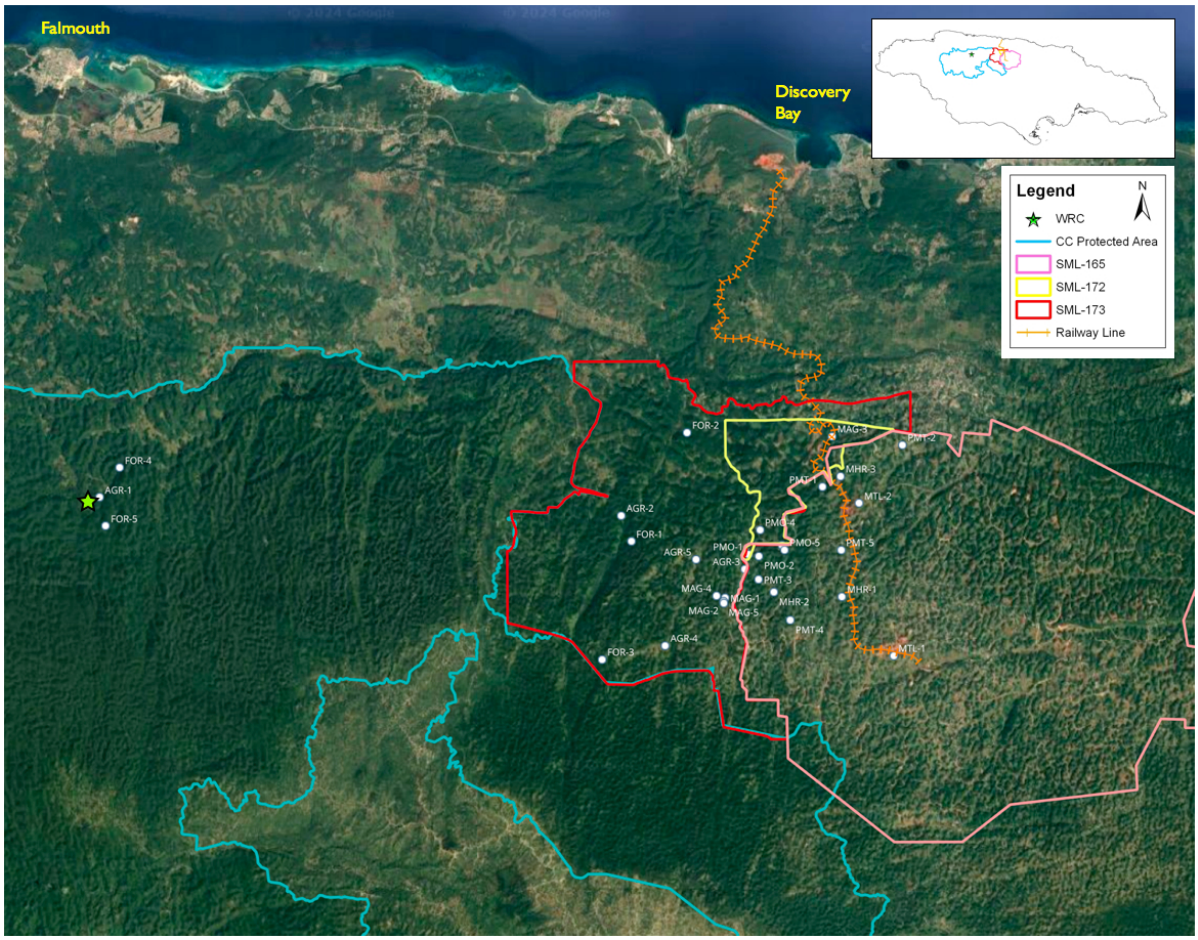
(h) eDNA and water chemistry field sampling took place from October 14th through November 12th 2023, during the fall rainy season. Water chemistry sampling also took place from May 2nd through May 9th 2024. Ostensibly this was the dry season and residents in western St. Ann communicated that it had not rained in more than a month, but a week of "Nor'Easter" rainfall filled bromeliads with fresh rainwater, which ensured the probes could be properly submersed.

(i) While collecting bromeliad water samples, portable optical laser air quality sensors were deployed to measure concentrations of air-borne particulates. The sensor, a Dylos DC1700-PM (Dylos Corporation, Riverside, California USA, http://www.dylosproducts.com/dcpmaqm.html) classifies particulates by two groupings: PM10 (particulates < 10 microns in diameter) and PM2.5 (particulates < 2.5 microns). PM10 includes dust but can also include organics such as pollen and mould spores, whereas PM2.5 particulates are typically generated during combustion, such as the burning of hydrocarbons or wood. Because physical samples are not collected in the Dylos, users cannot know the chemical composition of air-borne particulates, but for short-term monitoring where ambient air temperature and relative humidity conditions are comparable across sampling points, optical particulate counters offer a robust snapshot of immediate local conditions (Giordano *et al*. 2021). As it took a minimum of one hour to collect bromeliad eDNA samples and measure water chemistry parameters, minute-by-minute PM10 and PM2.5 air quality readings were recorded for at least 60 minutes, at ground level, at all sites. ***I note that in order to avoid interfering with mining operations and large trucks, sampling in proximity to active mining pits was restricted to Sundays, when no digging or haulage was being conducted.*** For a local baseline, a second Dylos DC1700-PM was deployed at the field house in Endeavour (St. Ann), which was positioned > 3.5 km from active mining and haul roads. This allowed comparison of hourly averages between 09hr00 (9 am) and 14hr00 (2 pm), when bromeliad sampling occurred.

(j) Air temperature and relative humidity were recorded using Kestrel Drop 3 data loggers. One device was deployed at the field house; a second device was carried into the field and hung on a small branch, protected from direct sunlight, to record while air quality was being measured by the Dylos sensor. Daily rainfall was measured at the field house using a graduated cylinder rain gauge, to record totals over 24-hour intervals.

(k) Exhibited as **SEK-10,** I include a video recorded on 29th October 2023, recorded at 18^0 19' 23" N 77^0 26' 09" W, where the haulage road created in the Industry district bisects Parish Council Road 155 (aka Gibraltar Road). This video not only shows a typical weather event during the fall rainy season but confirms that the excavation of the haul road has irreversibly changed the hydrodynamics at the site: prior to excavation, rainfall would have drained vertically into the limestone and disappeared below ground (see Day 1979). Heavy horizontal discharge of water from a hillside is abnormal in cockpit karst.

Figure 4. Bromeliad eDNA sampling points in: (a) unmined agriculture and forest sites; (b) hillside forest immediately adjacent to active mining pits, haul roads, and the railway line; and (c) hillside forest adjacent to remediated pits one- and ten-years post mining.

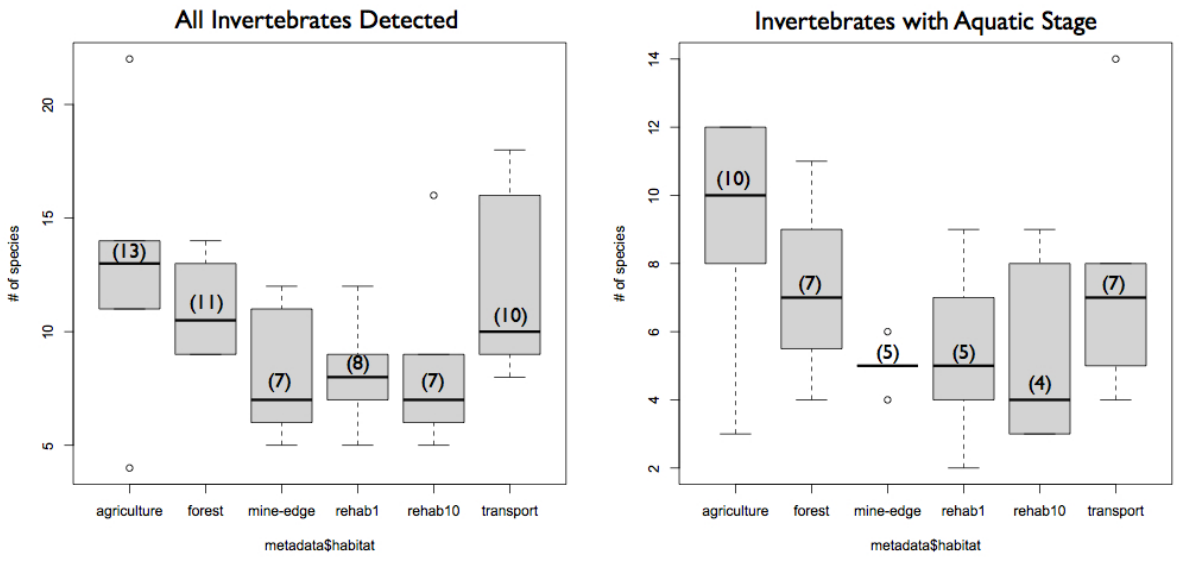


Research Results: eDNA Results: Freshwater Invertebrates

35. A total of 87 invertebrate OTUs were detected in the tank bromeliad water samples. A summary table is exhibited as **SEK-11**. Because very few Jamaican invertebrates have been genetically barcoded, only two (2.3%) of the OTUs were identified to species-level. However, these two identified species (*Zaprionus indianus*, a Drosophilidae African fig-fly and *Empyreuma pugione*, an Arctiidae moth) are both invasive alien species (IAS). This highlights how important it is to be able to assign status (native / endemic vs. IAS): the invasive moth was detected at one of the active mining sites and the invasive African fig-fly was detected at one of the sites remediated ~ 10 years ago. ***The presence of the African fig-fly in an old remediated pit would be off concern to agricultural interests.***

36. Although sample sizes of 5 (e.g. per land cover class) typically afford limited statistical power, we may already be detecting a real pattern that forest adjacent to pits rehabilitated 10 years ago support the fewest aquatic invertebrates in their bromeliads. These pits also were numerically low for all vertebrates detected (Figure 5).

Figure 5. Patterns of species richness: the median number of invertebrate species detected by eDNA sampling. Box presents the upper/lower quantiles, whiskers indicate minimum and maximum values, and outliers are presented as circles. No significant difference was detected in alpha richness ($p < 0.1$) but sample sizes of 20 per land cover class would be needed for statistical confidence.

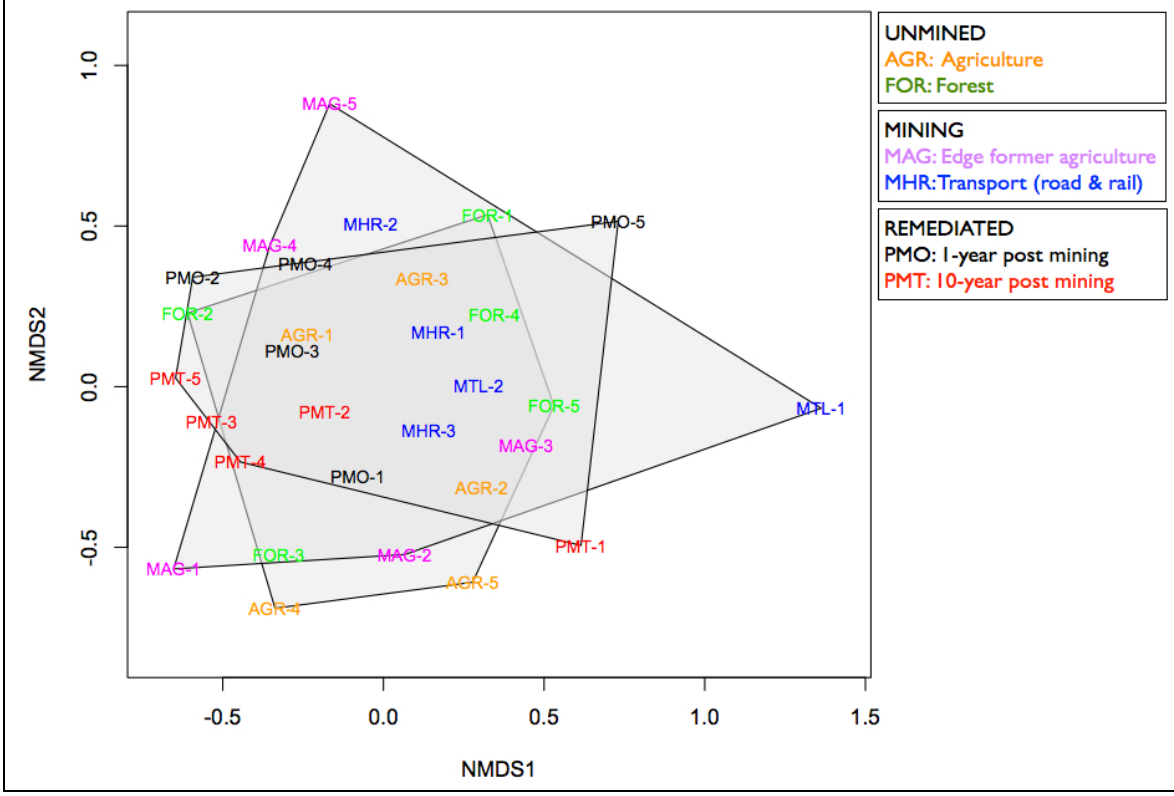


37. Knowledge of IAS status would be extremely helpful for a deeper understanding of species richness numbers. For example, two species of Psychodidae (Diptera) – a family commonly called "drainfly" or "sewerfly" – were restricted to samples collected near railway transport sites. To quote wikipedia, "larvae . . .live in aquatic to semi-terrestrial or sludge-based habitats, including bathroom sinks, where they feed on bacteria and can become problematic."

38. Overall, bromeliads positioned in isolated trees in agriculture sites showed the highest species richness. This may be due to the fact that large host trees (e.g., mango *Mangifera indica*) in agriculture fields typically support > 15 medium & large and > 100 small bromeliads, in contrast to all other sites where host trees supported < 5 medium & large and < 20 small bromeliads (i.e., agriculture sites presented greater occupancy opportunities, literally islands in a sea of pasture and ground crops). ***This highlights the importance of maintaining deep bauxitic soils* in situ *to support the growth of large trees.***

39. Deploying non-metric multidimensional scaling (NMDS) to the relative abundances of OTUs (species) enables comparison of the degree of similarity of invertebrate communities across the land cover classes (Figure 6). Graphing helps us to appreciate the high variability in samples collected from bromeliads adjacent to active mining activities (MAG in Figure 6), two of which had commenced just months before eDNA sampling. Graphing also highlighted the extreme outlier of MTL-1, an industrial loading area at Water Valley where bauxitic soils are temporarily stored before being loaded into rail cars and which was one of the sites with the Psychodidae drainflies.

Figure 6. NMDS visualization of the degree of community composition overlap amongst bromeliad samples as a function of land cover and mining status. In this example, the OTUs of all detected invertebrates were included to facilitate comparison to Nature Metrics' "Community Comparison" figure (see page 9 in exhibit **SEK-9**). More-similar samples appear closer together on the chart, such as seen with PMT-3, -4, and -5, revealing high homogeneity in these sites rehabilitated 10 years ago.



40. In further examination, Bray-Curtis matrices were generated in *R vegan* and subjected to Analysis of Variance (ANOVA)-like tests to further quantify the degree of community overlap across the samples. Not only did this confirm that bromeliad communities near haul roads are significantly different ($p \leq 0.05$) from undisturbed natural forested sites (Table 1) but that sites which were rehabilitated 10 years ago are approaching statistical significance for having bromeliad communities which are completely different (and numerically impoverished) compared to the other land cover classes (Figure 7). ***That is, despite low sample sizes (due to funding limitations), eDNA surveys appear to be identifying long-term effects of mining on bromeliad-dependent invertebrate communities.*** Given the observed effect sizes, a post-hoc power analysis showed that a sample size of 20 would achieve > 70% power at a 0.05 significance levels for all of the land cover categories.

Table 1.

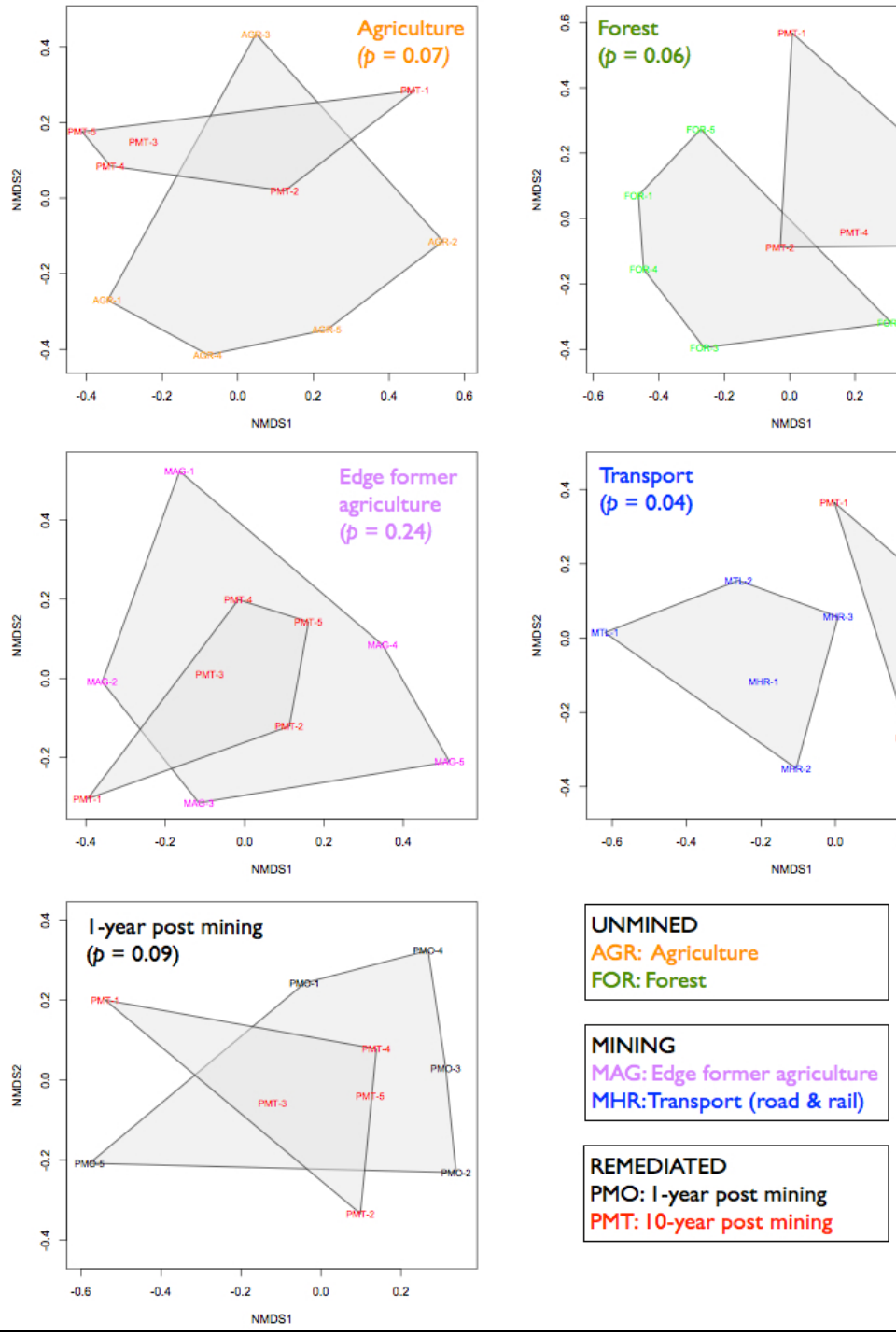
Significance levels for comparisons of invertebrates which have an aquatic stage in their life cycle.

	AGR	FOR	MAG	MHR	PMO	PMT
AGR	.	0.28	0.95	0.13	0.81	0.07
FOR		.	0.36	0.04	0.43	0.06
MAG			.	0.52	0.92	0.24
MHR				.	0.04	0.04
PMO					.	0.09
PMT						.

Significance levels for comparisons of invertebrate communities (all invertebrate OTUs).

	AGR	FOR	MAG	MHR	PMO	PMT
AGR	.	0.37	0.94	0.10	0.78	0.05
FOR		.	0.37	0.03	0.43	0.07
MAG			.	0.74	0.93	0.10
MHR				.	0.35	0.03
PMO					.	0.07
PMT						.

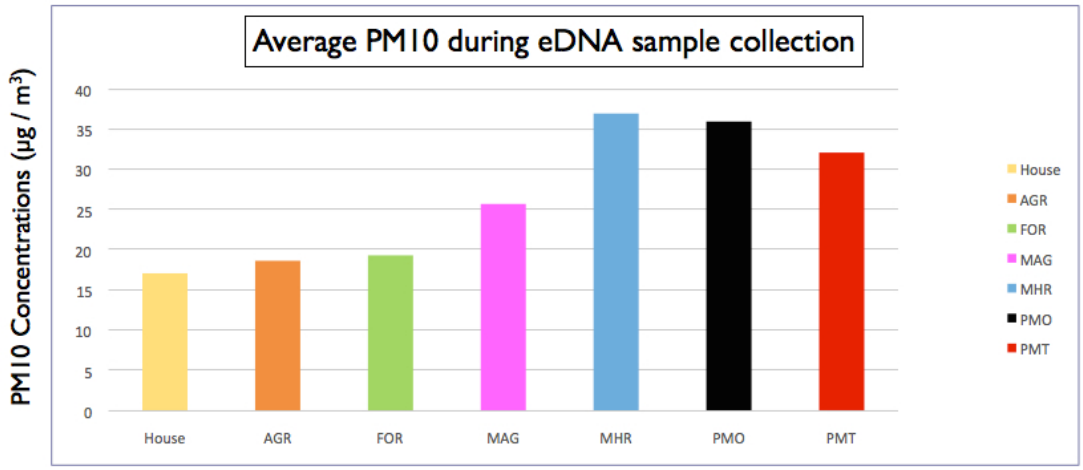
Figure 7. Pair-wise comparisons of invertebrate communities, where OTUs were identified as having an aquatic stage in their life cycle. Land cover categories were compared to PMT (post-mining, remediated 10 years ago) to explore for potential long-term effects of mining on sensitive fauna. Overlapping areas of the polygons indicate the co-occurrence of identical species. Larger polygons indicate greater heterogeneity in community composition.

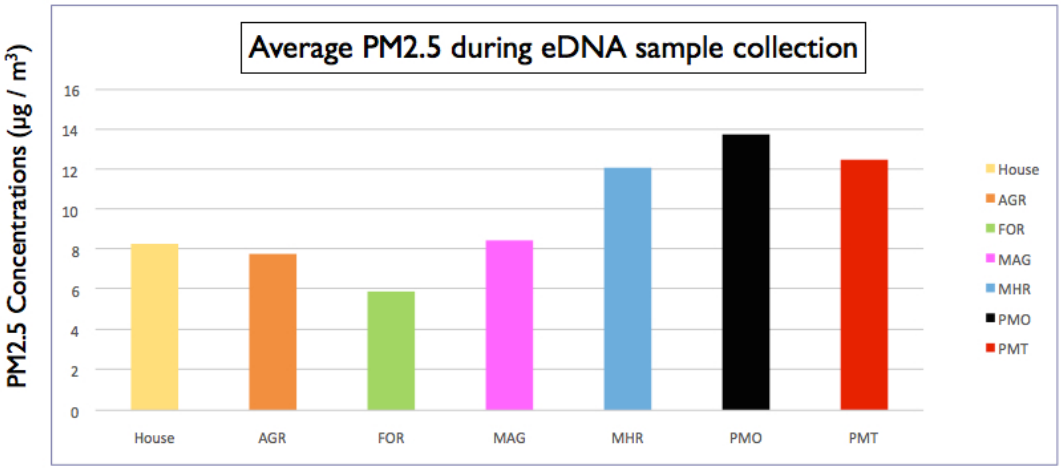


Research Results: Air Quality

41. During the 2023 fall rainy season when eDNA samples were collected, un-mined categories (agriculture, forest, and the field house) displayed the lowest average concentrations of PM10 and PM2.5 (i.e., these had the best air quality conditions) (Figure 8). PM10 concentrations at un-mined sites were significantly lower than active mining and haulage ($p < 0.03$) and significantly lower than post-mined rehabilitated sites ($p < 0.01$). There was no significant difference in PM10 concentrations between active mining and post-mined rehabilitated sites ($p = 0.92$), revealing there are long-term effects on air quality even after mining activities are concluded.

Figure 8. PM10 and PM2.5 concentrations recorded during the October-November 2023 rainy season, when bromeliad water samples were collected between 09hr00 and 14hr00. A Dylos DC1700-PM was placed at ground-level and recorded concentrations minute-by-minute to calculate an hourly average per site. ***Readers are reminded that sampling at sites adjacent to active mining pits (MAG) was restricted to Sundays, when no mining or haulage occurred, so concentrations are likely biased to under-reporting.***





42. As expected, the lowest PM2.5 concentrations were recorded at forest sites, and all un-mined sites had significantly lower PM2.5 concentrations compared to post-mined rehabilitated sites ($p<0.01$) (Figure 8). There was no significant difference in PM2.5 concentrations between active mining and

post-mined rehabilitated sites (p=0.39), again suggesting long-term changes in environmental conditions persist which affect local air quality.

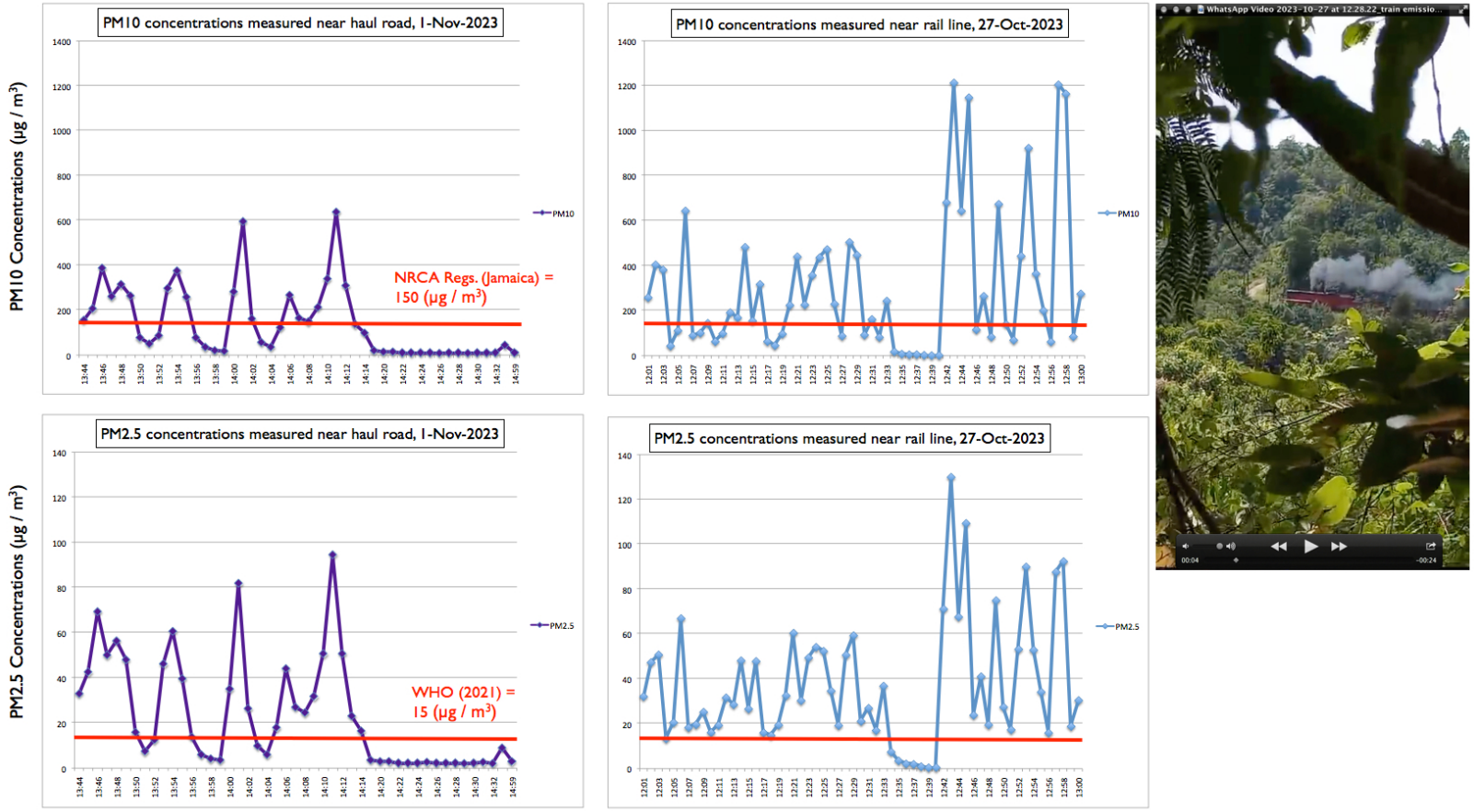
43. During the sessions when eDNA samples were collected from arboreal bromeliads, PM10 concentrations never exceeded Jamaica's national standard of 150 µg / m^3. However, when water chemistry data was being measured for terrestrial bromeliads, unsafe levels of PM10 and PM2.5 concentrations were recorded: (a) at sites located within 100 m of an unpaved haul road, where trucks were observed passing during data collection; and (2) at a haul road site which was also located within 200 m of the railway line (Table 2).

Table 2. Concentrations of PM10 and PM2.5 averaged for the period of time required to collect eDNA samples and measure water chemistry parameters. PM10 exceeding 150 µg / m^3 is considered unsafe by Jamaica's national standard and PM2.5 exceeding 15 µg / m^3 is considered unsafe by the World Health Organization.

ID	DATE	HOUR (time of day)	HABITAT	STATUS	Average PM10	Average PM2.5
MHR-1	25-Oct-23	11:00	transport	mining	38.7	10.9
MHR-2	26-Oct-23	11:00	transport	mining	55.7	17.5
MHR-3	27-Oct-23	10:00	transport	mining	27.3	10.4
MTL-1	21-Oct-23	11:00	transport	mining	18.0	5.6
MTL-2	26-Oct-23	12:00	transport	mining	45.3	16.1
T-MHR-1	27-Oct-23	12:00	transport	mining	237.8	33.5
T-MHR-2	27-Oct-23	12:00	transport	mining	517.8	54.4
T-MHR-3	1-Nov-23	13:00	transport	mining	211.4	44.0
T-MHR-4	1-Nov-23	14:00	transport	mining	13.4	2.9
T-MTL-1	26-Oct-23	13:00	transport	mining	45.3	16.1
				AVERAGE	121.1	20.2

44. As described in Koenig 2022, presenting averages of air quality data may mask extreme pulse events of air pollution when activities are not undertaken continuously during a recording period. The data from haul roads and rail exemplifies this mathematical construct, where maximum concentrations of PM10 and PM2.5 were more than double the average for the recording session (Figure 9 shown on page 24).

Figure 9. Minute-by-minute examples where air quality conditions exceeded safe levels for national and World Health Organization (WHO) guidelines during the fall rainy season of 2023. A maximum PM10 concentration of 1212.1 µg / m^3 and maximum PM2.5 concentration of 129.9 µg / m^3 were recorded approximately 450 meters from a passing train. Larger soot particulates, classified as Total Suspended Particulates (TSP), which measure less than 100 microns in diameter, were clearly visible in the train's exhaust emissions.



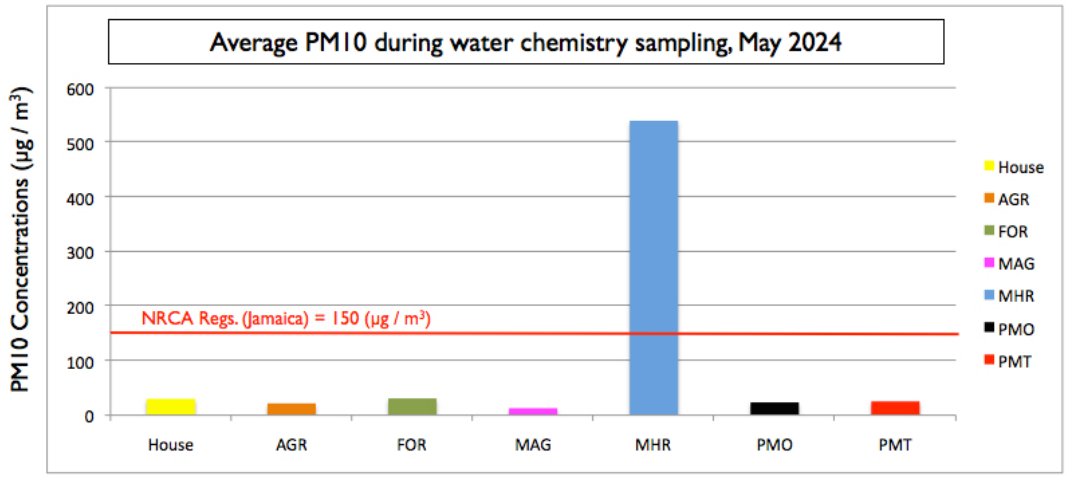
45. Although the first week in May is considered part of the spring dry season, a weather system delivered a minimum of 90.4 mm (3.6 inches) of rain in the four days prior to collecting air quality data along the haulage road between SML 173 and the railway loading area in Somerton district (Table 3):

Table 3. Daily rainfall totals in spring 2024, during the 7 days when bromeliad water chemistry was re-measured at sites in western St. Ann.

DATE	RAIN (mm)	RAIN (inches)	COMMENT
29-Apr-24	*	*	Heavy mid-afternoon downpour in St. Ann, which lasted for at least 2 hours; rain gauge deployed at 6 pm
30-Apr-24	72.1	2.84	
1-May-24	6.4	0.25	
2-May-24	11.9	0.47	
3-May-24	0.5	0.02	PM10 and PM2.5 measured along haul road
4-May-24	12.2	0.48	
5-May-24	13.2	0.52	
6-May-24	49.53	1.95	

46. During May 2024 data collection, not only were PM10 and PM2.5 concentrations at sites along haul roads and the rail line significantly higher ($p < 0.05$) compared to all other land cover types, but hourly averages exceeded national and WHO guidelines because of haul truck activity (Figure 10 on page 26). Despite rain in the days preceding air quality measurements, PM10 concentrations along the haul road reached a maximum of 6532.3 µg / m^3 (Figure 11 on page 27) and extensive dust was present on bromeliad leaves (Figure 12 on page 28). ***Based on my observations of how quickly the surface of road dust dries out, I would like to see air quality data for the Defendants' efforts using water tankers to suppress fugitive dust on roads. In the absence of additional data, I adopt the Precautionary Principle and assume all private vehicles and their occupants, as well as pedestrians, are being exposed to unsafe concentrations of PM10 and PM2.5 along all active haul roads.***

Figure 10. PM10 and PM2.5 concentrations recorded during the May 2024 "dry"season, when bromeliad water chemistry was measured between 09hr00 and 14hr00. ***Readers are reminded that data collection at sites adjacent to active mining pits (MAG) was restricted to Sundays, when no mining or haulage occurred.***



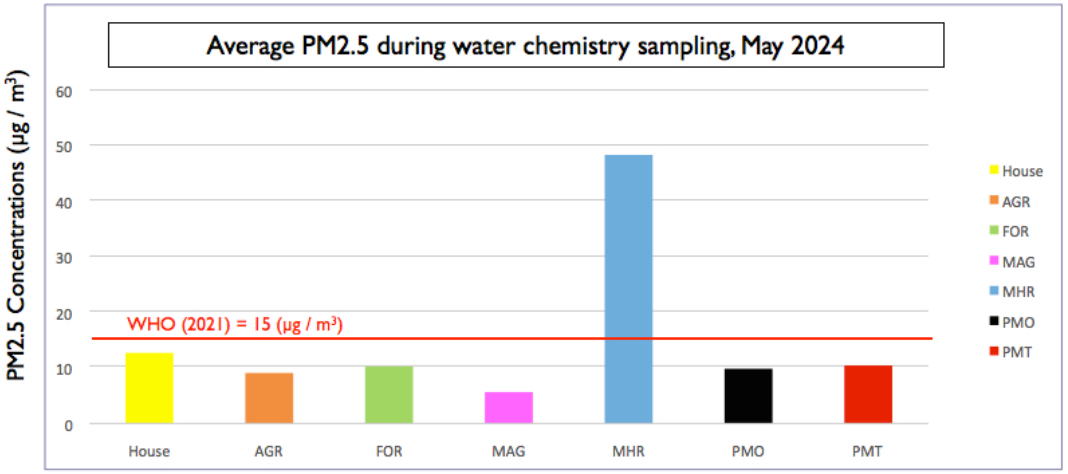
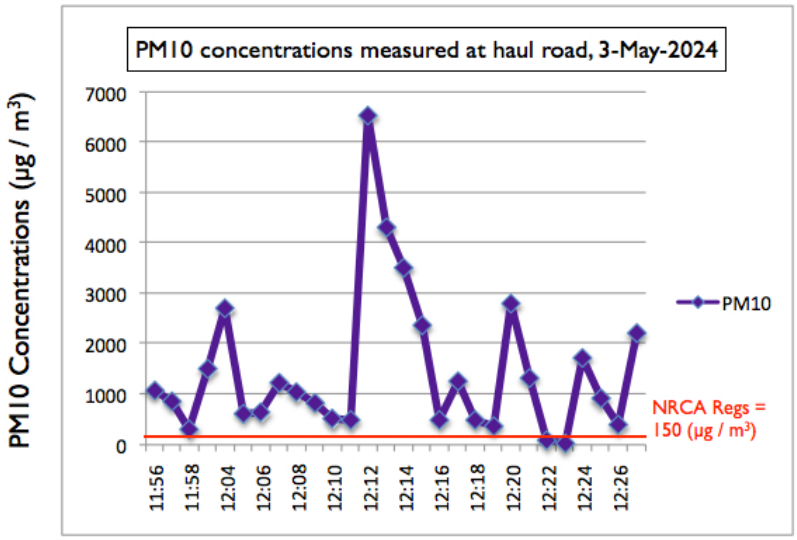


Figure 11. Minute-by-minute examples where air quality conditions exceeded safe levels for national and World Health Organization (WHO) guidelines during the first week of May 2024 along the haul road between SML 173 and the Somerton rail loading area.



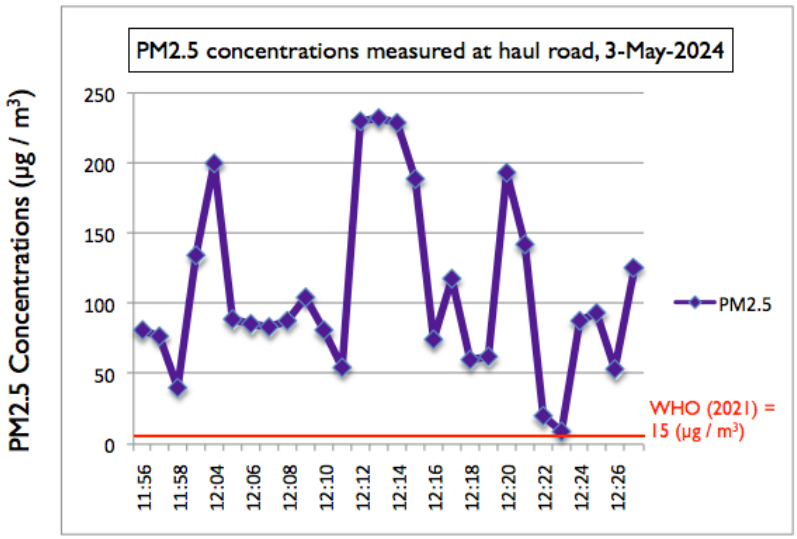


Figure 12. Examples of bromeliads for which water chemistry was measured in 2023 and 2024. Accumulations of dust on leaves were only observed in active mining sites (especially near haul roads), even on days following rainfall where one would have expected the rain to clean the leaves.

Forest (FOR)



Agriculture (AGR)



Haul road (MHR)



Haul road (close-up)



Post-mining 10 years (PMT)



Post-mining 10 years (PMT)



Research Results: Water Chemistry

47. From arboreal eDNA and terrestrial bromeliad water samples collected during the 2023 rainy season (October-November), post-hoc Tukey tests confirmed that the six land cover classes could be grouped by mining status:

    (a) Unmined: (AGR) Agriculture (mixed ground crops and fruit trees); (FOR.) Forest (p = 0.32);
    (b) Active mining: (MAG) Forest on limestone hill adjacent to active mining pit, land cover in the bottomland prior to mining was agriculture; (MHR) Active unpaved haul roads and train line haulage (p = 0.99);
    (c) Post-mining remediated: (PM0) One-year post-mining; (PMT) 10-years post mining (p = 0.96).

48. While there were no significant differences in average water temperature (p = 0.34) and dissolved oxygen (p = 0.62) in bromeliads in 2023 (Figure 13a), there were significant differences in pH, salinity, total dissolved solids, electrical conductivity, resistivity, and calcium (Figure 13b on page 30). For these parameters, un-mined and post-mining remediated sites did not differ from each other, but they each differed significantly ($p < 0.001$ for each parameter) from active mining sites. Electrical conductivity and resistivity are particularly important for the movement of ions across biological cell membranes.

Figure 13a. Water chemistry analyses for 2023 data (rainy season) recorded no significant differences in average water temperature and dissolved oxygen in tank bromeliads across the study area.

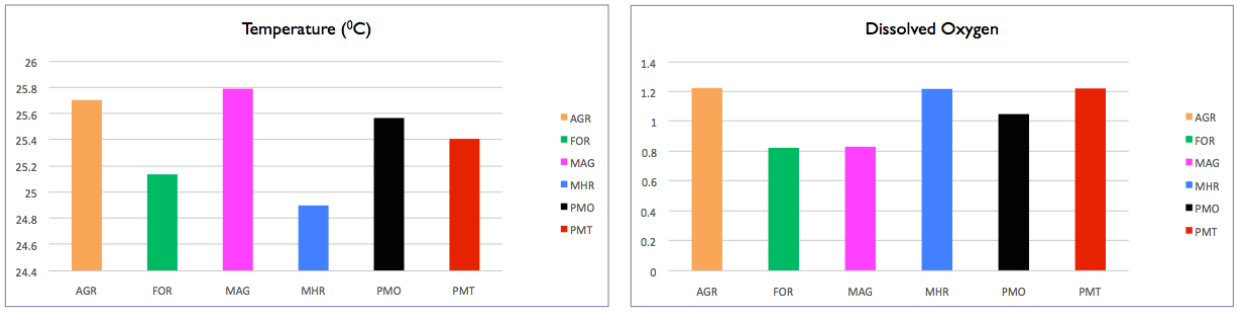
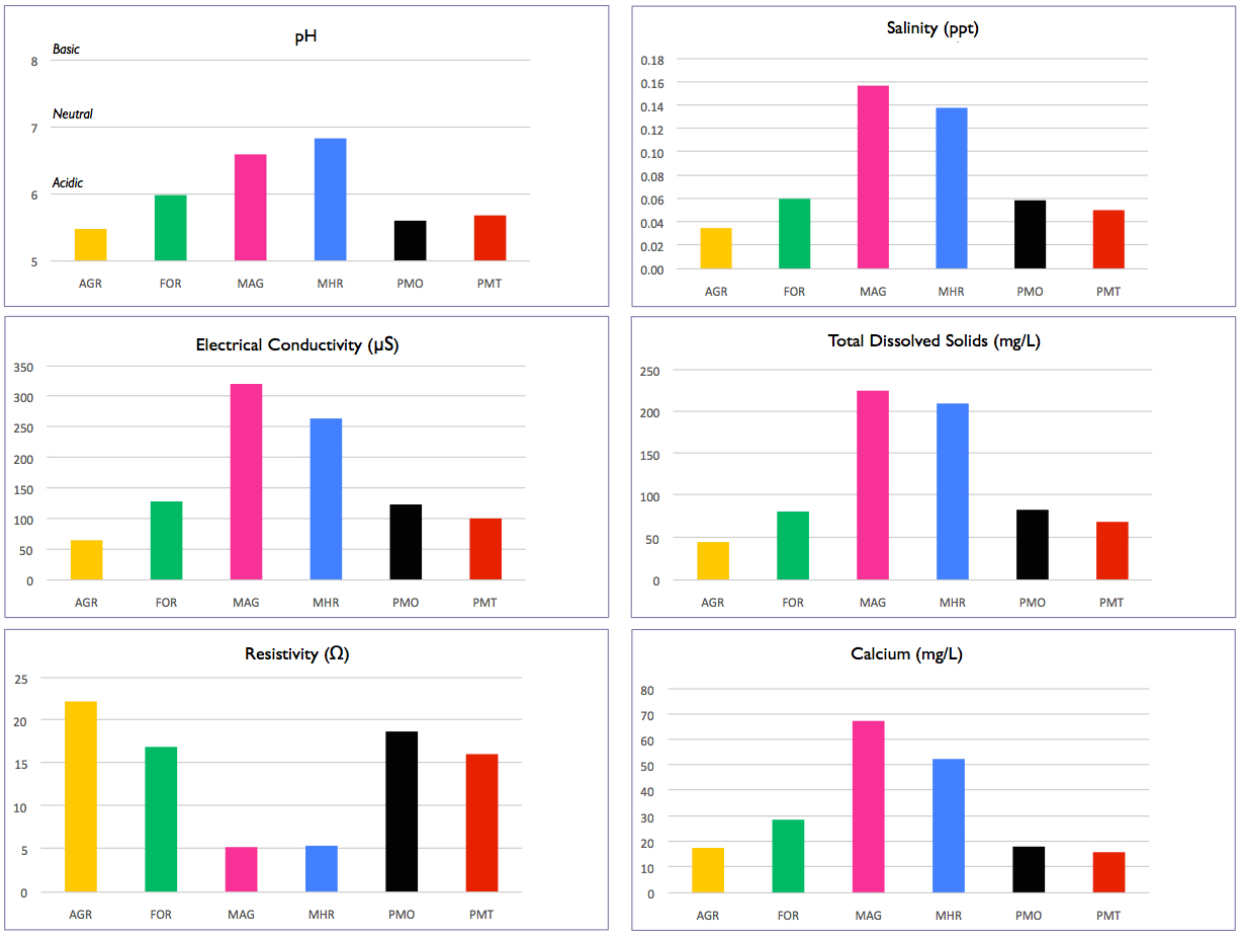
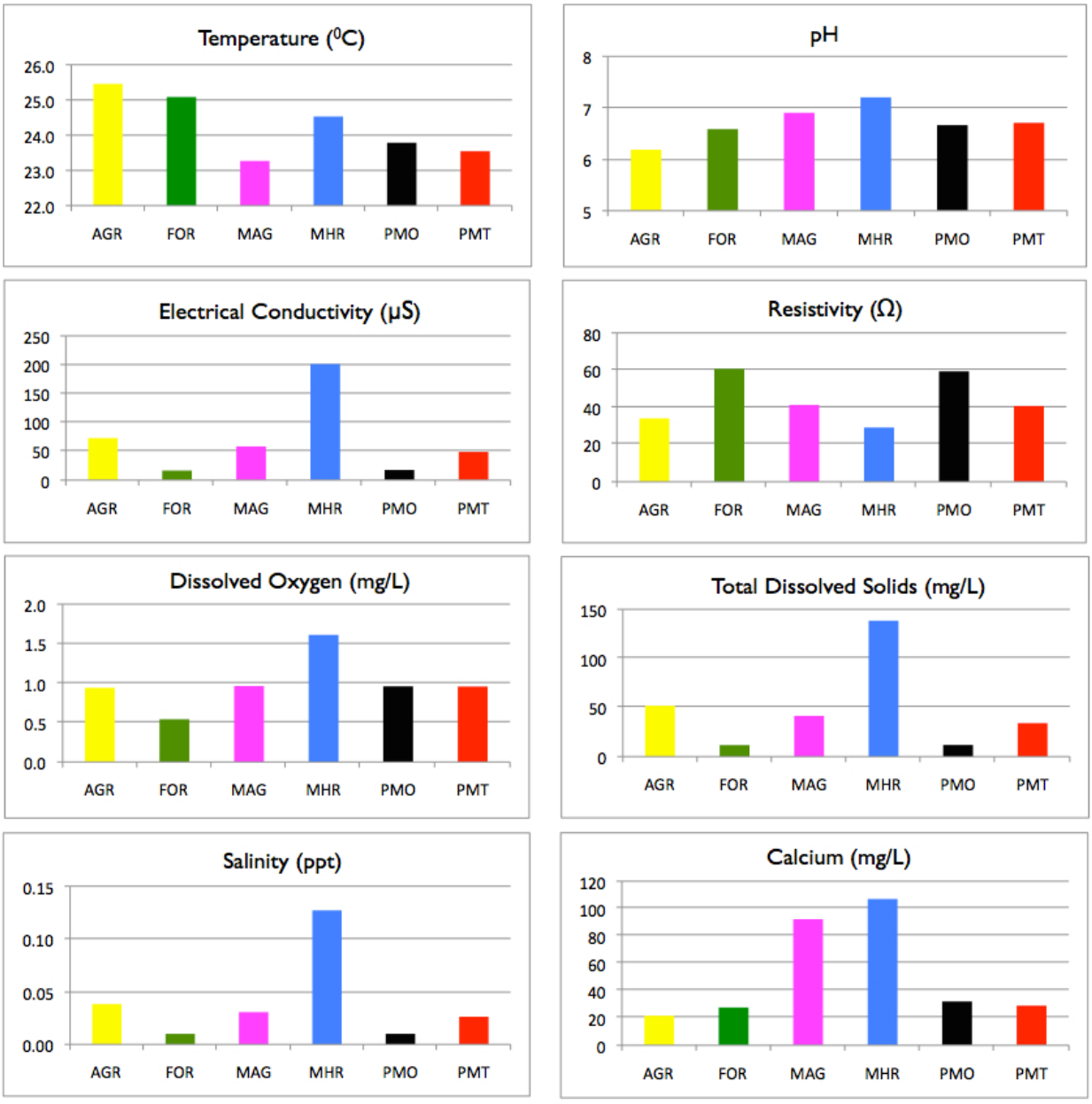


Figure 13b. Water chemistry analyses for 2023 data did, however, document significant differences in all other parameters, with active mining sites differing significantly from un-mined and rehabilitated locations, but un-mined and rehabilitated did not differ significantly from each other.



49. For the 2024 dry season water samples collected exclusively from terrestrial bromeliads, post-hoc Tukey tests indicated that the six land cover classes should not be grouped by mining status. Graphing reveals that grouping pits being actively mined with rail and road transport would mask the detectable impacts of haulage-generated dust on water chemistry (Figure 14 on page 31).

Figure 14. Limited sampling of terrestrial bromeliads during the 2024 dry season precluded statistical analyses, but graphing reveals similar patterns to the 2023 wet season samples where water chemistry appears heavily impacted along mining haul roads and rail lines (MHR).



50. Given the poorer air quality conditions of post-mining remediated sites compared to un-mined sites, further research is needed to understand the water quality conditions. ***What is clear, however, is that bromeliads situated within at least 150 meters of active mining operations, especially along transport haulage networks, experience significant changes in water chemistry. This distance is more than the 91 meter (300 feet) avoidance distance which the Defendants note they try to apply to any residence or building.***

Sensitive Household Water Catchments: Parallels with tank bromeliads and public health consequences of mining dust

51. Transferring knowledge of healthy tank bromeliad aquatic ecosystems to human-made water catchments and public health (i.e., understanding how sensitive bromeliad receptors serve as indicators of environmental conditions) means that several sentences about household rainwater catchments presented by two Claimants stand out. In her affidavit filed July 29th 2022, the 4th Claimant Merlina Rowe wrote in paragraph 10:

> 10. The dust contaminated my rainwater catchment that I rely on for drinking water. I would sometimes see a red film on the water in the storage tank, which would then settle and form into mud at the bottom. I had to buy bottled water because there is no running water in Gibraltar.

And in his affidavit filed July 29th 2022, the 2nd Claimant Linsford Hamilton wrote in paragraph 18:

> 18. The dust from Noranda's mining operations damaged my roof and contaminated my water tank. In 2020, when I repaired my tank, I was shocked to see about 2.5 inches of red dirt clotted at the bottom.

52. The usage of the term "film" immediately calls to mind the presence of water-borne fungi, which in wild tank bromeliads constitute a natural, healthy ecosystem. Nearly all microbes, including fungi, grow as crowded cell communities, firmly attached to surfaces, presenting in a matrix known as biofilm.

53. ***Fungi, themselves, generally are not harmful. Instead it is the waste products they produce, known as secondary metabolites, which can be toxic to animals and humans when they are produced in high concentrations or under prolonged periods of exposure.*** Depending upon the species of fungi, the waste products they produce can cause allergies, respiratory illnesses, mucosal eye infections, skin infections and even life-threatening meningitis (Babič *et al.* 2017). While non-sensitive persons may still experience irritating superficial or localized fungal infections, sensitive persons (e.g. those with immune deficiencies such as experienced during chemotherapy or with HIV/AIDs or those with underlying health conditions such as diabetes mellitus) are at risk of severe invasive infections. Based on my experience, I would say to any layperson who harvests rainwater -- not only those who are sensitive receptors but also those who feel healthy -- "if you've got itchy skin, red & itchy eyes, swollen & itchy fingers which you can't stop rubbing until the skin is raw, it's time to drain your rainwater catchment, remove the sediments and give it a thorough scrubbing to eliminate the biofilm because chlorine bleach doesn't kill or remove the fungi."

54. In water catchments, the number of fungi is positively correlated to turbidity, which is related to the amount of suspended particulate matter (Ren *et al.* 2023). Particulates such as airborne dust and any nutrients adhering to the dust's surface provide a place and nutrition for the growth of fungi. ***Hence, the more dust blowing into a water catchment from mining operations, the predicted greater number and concentration of fungi and their secondary metabolites***.

55. Thanks in part to major advances in molecular DNA testing techniques, the scope and magnitude of pathogenic (i.e., disease causing) waterborne fungi is increasingly recognised by experts in the discipline of emerging infectious diseases (Mhlongo *et al.* 2019). Back in the 1960s and 1970s fungi in treated drinking water was thought to only be of concern in relation to taste and odor problems. By the 1980s causal relationships were being identified between fungal contaminated aerosolised water and hypersensitivity pneumonitis (inflammation in the lungs) (Hageskal *et al.* 2009). Since then, the list of pathogenic waterborne fungi has expanded (Babič *et al.* 2017).

56. Although the World Health Organization labels waterborne fungi broadly as "nuisance organisms" and recognizes a class of parasitic fungi called Microsporidea as "emerging human pathogens," and more than 15 European countries and the UK have measured fungi in groundwater, surface water, tap water and non-mineral bottled water in the past 30 years, Sweden thus far is the only country where policy makers have kept up with the science and diagnostic capabilities and have integrated testing for fungi in drinking water monitoring programmes (Mhlongo *et al.* 2019).

57. The World Health Organization notes in its 2021 guidelines for recreational water quality the need for further work on fungi and other biological groups with regards to establishing exposure thresholds so as to develop analytical recommendations. To quote: "In the absence of guideline values, efforts should focus on preventative measures."

58. During 2023 and 2024 when eDNA water samples were collected from tank bromeliads, soil samples also were collected to evaluate the effects of bauxite mining on soil microbe communities in pits rehabilitated 1-year post-mining and 10-years post-mining within the boundaries of SML 165 and SML 172; these were compared to un-mined areas of agriculture and forest cover. The aim was to expand upon a project funded by JAMALCO / ALCOA in 2007-08, which documented long term mining impacts on soil microbial communities, soil function, and soil fertility in rehabilitated pits (see paragraph 59 of Koenig 2022). While the JAMALCO / ALCOA project presented results for bacterial communities, Nature Metrics (UK) was able to analyze bacteria and fungi composition in soil samples using the amplification and sequencing techniques described in section 34 (d) of this document. As with the JAMALCO / ALCOA project, significant mining impacts were detected for both bacterial and fungal soil communities, re-affirming that reconstructed soils do not recover their microbial communities over time. I exhibit as **SEK-12** a map of (a) the soil sampling sites; (b) NMDS plot of bacterial communities; and (c) NMDS plot of fungal communities. These plots augment graphs in reports prepared by Nature Metrics, exhibited as **SEK-13** and **SEK-14**.

59. In a published review of fungal contaminants in drinking water, Babič *et al.* (2017) highlighted opportunistic and pathogenic fungal species from 10 genera documented to produce vivo biofilms in water systems and which can produce allergenic or irritating compounds and mycotoxins. As presented in Table 4, species in six of these genera were detected in soil

samples analyzed by Nature Metrics; consequently, these would have the potential to become air-borne during mining operations and potentially settle into water catchments.

Table 4. List of some fungi genera known to affect public health via the production of biofilms (Babič *et al.* 2017) and their detection status in soil samples collected during October-November 2023 and April 2024.

Genus	Number of OTUs (species) detected in soil samples
Aspergillus	9
Candida	0
Exophiala	3
Fusarium	6
Malassezia	2
Ochroconis	0
Penicillium	13
Phialophora	0
Phoma	1
Rhinocladiella	0

60. Unfortunately for the Claimants and, indeed, all members of the Jamaican public, national ambient water quality standards for freshwater do not require testing of any waterborne microorganisms (e.g. viruses, yeast, bacteria, fungi). These inadequate standards would apply to public rainwater catchments, such as those present in SML 165, SML 172, and the 1,333 hectares presently permitted by NEPA in SML 173, which are owned and maintained by the St. Ann Municipal Corporation. Marked **SEK-15**, I exhibit the Draft Jamaica National Ambient Water Quality Standard-Freshwater, 2009, which is administered by NEPA and which I downloaded from the internet on May 22nd 2023: https://www.nepa.gov.jm/sites/default/files/2019-12/water_quality_standard_freshwater.pdf

61. Also on May 22nd 2023, the National Water Commission's (NWC) website showed that, although their objective is to ensure that water is safe for drinking, the only microorganisms for which NWC tests are coliform bacteria (total and total fecal): https://www.nwcjamaica.com/water_treatment.php Marked **SEK-16**, I downloaded a pdf of NWC's webpage.

62. In the EIA for SML 173, **Table 11-1: Framework for Environmental Monitoring Plan** presented a water monitoring scheme on page 11-4. In alignment with NWC, coliform bacteria are the only microorganisms recommended for testing:

Water	Baseline	BOD, Total & Faecal Coliform, DO, Nitrates, Phosphates, Turbidity, pH, Oil & Grease	One set of measurements
	Impact (during Operations)	Visual Survey of watercourses in area of active mining works and other areas with stockpiled materials on exposed ground surface BOD, Total & Faecal Coliform, DO, Nitrates, Phosphates, Turbidity, pH, Oil & Grease	Once bi- monthly during operations.

63. Not only am I concerned that the EIA does not recommend monitoring of nuisance (potentially pathogenic) waterborne fungi in rainwater catchments impacted by dust, but I also find it incomprehensible that the consultants believe a baseline for water quality can be established with "One set of measurements". This demonstrates a poor understanding of how rainfall patterns and maintenance routines impact water quality in rooftop and hillside water catchments. Is this baseline during the rainy season? During the dry season? If one wants to present statistically robust conclusions about the impacts of mining dust on water quality, then a baseline has to include the range of pre-mining variation for at least a year.

64. In the EIA for SML 173, **Table 7.1. Impacts to Physical Resources** outlined the impacts on water quality to humans during mining operations and rehabilitation. On page 7-8, the following details were presented:

Potential Impact	Mitigation
Item WQ2 –There is a potential impact for water quality reduction to water collected from roofs and catchment that may have accumulated dust generated during the trucking of bauxite.	NJBP II conducts assessments of complaints and provides compensation for fugitive dust fall and supply water to impacted households. The primary source of dust along the haul roads is from the road surface during dry periods. This is mitigated by increasing the frequency of wetting of the road surfaces from one to up to four times daily, as necessary, in addition, to the use of a dust suppressant.

65. ***With reference to Exhibit SEK-4, I submit that the 2nd Defendant fails to prevent the generation of fugitive dust during operations*** (ref Permit Number 2016-06017-EP00152, Dust Control/Air Emissions paragraph 19). Additionally, I submit as Exhibit **SEK-17** that the 2nd Defendant does not cover materials during transport to prevent the generation of fugitive dust (ref paragraph 18 in the permit) nor does the 2nd Defendant "ensure that dust, mud and other loose materials are removed from the carriage and wheels of haulage trucks before leaving the site" (paragraph 22 in the permit): residual dust is clearly visible on tyres, rim, and the diesel fuel tank.

66. With regards to assessing complaints lodged by community residents, I find myself asking the following questions:

(a) Has the 2nd Defendant ever tested water samples from residential homes or any hillside water catchments?

(b) If yes to (a), were the tests undertaken to all parameters specified in national freshwater standards or were they restricted to the parameters noted in the EIA in Table 11-1 (BOD, Total & Faecal Coliform, DO, Nitrates, Phosphates, Turbidity, pH, Oil & Grease)?

(c) Are reports of water quality testing results filed with NEPA?

(d) If any community member has complained of itchy skin or red & itchy eyes from bathing or doing laundry and other household cleaning chores, has the 2nd Defendant ever tested for fungi in rainwater catchments?

67. It is clear from the Claimants' affidavits that their first-hand experience of mining dust accumulating in their rainwater catchments has caused them to look for alternate supplies of drinking water. Mr. Edlin Walton's affidavit filed July 29th 2022, however, raises a note of added concern for me. In paragraph 6 he noted, "At times the water was too dirty to wash our clothes." This suggests that the household uses the catchment water for household chores if it "looks clean." Mr. Walton, of course, will not be able to see microscopic organisms, such as fungi and their secondary metabolite waste products, in his water.

68. Based on Mr. Walton's observations, I must summarize key points from my previous paragraphs 53 and 54, ***airborne dust and any nutrients adhering to the dust's surface provide a place and nutrition for the growth of fungi; in water catchments the number of fungi will be positively correlated to turbidity (the amount of suspended particulate matter); and high concentrations or prolonged exposures to pathogenic waterborne fungi are a direct risk to public health, as outlined in Babič et al. 2017.***

69. In the absence of appropriate diagnostic laboratory testing for pathogenic waterborne microorganisms, especially fungi, in my expert opinion the Precautionary Principle must be applied: I must assume all water catchments (natural tank bromeliads and human-made structures) impacted by fugitive mining dust are compromised and that human-made structures present a public health risk if water is not tested on a monthly basis.

70. In my expert opinion, Jamaica's national ambient water quality standard for freshwater is not up-to-date with the discipline of emerging infectious diseases. Compliance to the current standard cannot guarantee safe water in mining-impacted communities which depend on rainwater catchments for their household needs.

Summary

71. As natural water catchments, tank bromeliads are functionally irreplaceable plants in tropical limestone forests, where rainfall otherwise drains quickly below ground.

72. These sources of water, reliable during wet and dry seasons, provide habitat for organisms which have an aquatic stage in their life cycle: without bromeliads, these organisms would cease to exist and their loss would cause a cascade of degradation in the foodweb (i.e. collateral damage will be experienced amongst the fauna which are higher up in the trophic pecking order, the species which feed on bromeliad aquatic organisms).

73. The ability to store water, along with adaptations to extract nutrients and minerals directly into their leaves from the air (instead of via roots, to which nearly all other plants are restricted) makes bromeliads highly sensitive receptors to airborne pollutants.

74. Fauna which require tank bromeliads for their survival also are highly sensitive receptors to airborne pollutants owing to the fact that they are physically restricted to the pools of water (e.g., swimming larvae and tadpoles cannot escape from the pool or, in the case of the Cockpit Country-endemic Jamaican Bromeliad Crab, the mother must stay in the bromeliad to provide food for her offspring and protect them from predators).

75. Bromeliad-dependent treefrogs are sensitive receptors not only because of their tadpoles' vulnerabilities, but also because the moist permeable skin of adults functions as a respiratory organ: frogs absorb everything through their skin, life-sustaining oxygen but also toxic nitrogen and sulfur oxides.

76. As sensitive receptors, frogs are heralded as the proverbial Canary in the Coal Mine (aka Biological Sentinels); their disappearance signals environmental degradation, not least because they, themselves function as predators, as prey for other fauna, and as sources of nutrient inputs for the plant itself.

77. Bauxite mining activities (particularly haul road excavation, haulage of bauxitic soils, transfer of bauxitic soils from truck to rail, and pit reclamation and rehabilitation activities) generate fugitive PM10 dust particulates and PM2.5 products of combustion, unsafe concentrations of which can be detected at least 450 meters from their point-source.

78. Water-holding tank bromeliads located within at least 150 meters of mining activities, particularly haul roads and rail line, experience PM10 and PM2.5 concentrations in excess of national and international standards.

79. The water chemistry of tank bromeliads that are located within at least 150 meters of mining activities (esp. haul roads) and, consequently, subjected to high levels of fugitive dust, is significantly impacted across multiple parameters, including calcium, electrical conductivity, and resistivity, the latter two of which are important for the movement of ions across biological cell membranes.

80. eDNA sampling of faunal communities associated with tank bromeliads indicates that invertebrate species diversity decreases over time and that, at least 10 years after a pit is rehabilitated, invertebrate community assemblages in tank bromeliads appear to be significantly different (or nearly statistically significant at the standard $p < 0.05$) from unmined agriculture and forest-covered habitats. These apparent long-term effects of mining require further research to fully understand the environmental dynamics underpinning the observed patterns.

81. eDNA sampling of tank bromeliad invertebrate communities also reveals that large host trees located in un-mined areas of agricultural activities support the largest sizes and number of tank bromeliads, which in turn support the most diverse assemblages of invertebrate species. The removal of deep bauxitic soils will irreversibly diminish the ability of these lands to support these large trees and their associated bromeliad ecosystems.

82. With awareness that tank bromeliads are sensitive receptors that need to be protected from excessive fugitive dust generated during mining activities, relocation of bromeliads is deemed to be an acceptable mitigation by NEPA, as demonstrated by the conditions of the environmental permit issued to the 2nd Defendant.

83. While a proposed mitigation of relocating bromeliad plants to protect them from fugitive dust intuitively sounds reasonable, it fails to account for: (a) the wide zone-of-impact (at least 150 meters) from which all bromeliads must be removed; (b) the ecological consequences for what will be the loss of entire faunal communities which are obligate to the bromeliads; and (c) the fact that rehabilitation of the microhabitat from which the bromeliads were originally removed can never be recreated to un-mined conditions (e.g. trees will never reach their full stature potential because mining eliminates deep, moisture-holding soils; smaller trees cannot support numerically as many tank bromeliads). With detection of impoverished invertebrate communities in bromeliads at least 10 years after pit rehabilitation, the validity of current bromeliad mitigations is not supported.

84. My concern about the impacts of mining and fugitive dust on tank bromeliad communities developed directly from observations filed by the Claimants, who themselves rely on man-made water catchments for their household needs (bathing, cleaning, cooking, drinking, etc.). With their detailed descriptions of increased turbidity in their catchments, one could say the Claimants have been Biological Sentinels for tank bromeliads and their associated wild fauna. This means, of course, that the Claimants and their water catchments also are sensitive receptors for airborne pollutants, including airborne fugitive dust.

85. Airborne dust and any nutrients adhering to the dust's surface provide a place and nutrition for the growth of fungi. In water catchments the number of fungi is positively correlated to turbidity (the amount of suspended particulate matter) and high concentrations or prolonged exposures to the waste metabolites excreted by fungi are a direct risk to public health.

86. The fact that the Claimants and their water catchments are sensitive receptors is presented in the EIA and by the fact that the Defendants understand that mining activities should be avoided within 300 feet (91 meters) of any residence or building.

87. Jamaica's national ambient water quality standard for freshwater does not require testing any waterborne microorganisms (e.g. viruses, yeast, bacteria, fungi) and is not up-to-date with the discipline of emerging infectious diseases. Compliance to the current standard cannot guarantee safe water in mining-impacted communities which depend on rainwater catchments.

88. Because of the spatial configuration of ore body deposits and the haul roads which need to be excavated to access the ore, a minimum buffer zone around ore bodies of 300 feet (91 meter) means that no mining should be allowed within SML 173 (including the 1,333 hectares) if ALL

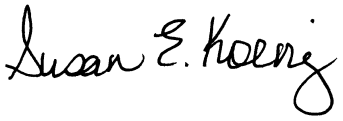
sensitive receptors – human and natural (along with their ecosystem services) -- are to be protected and kept functionally healthy.

Assertions of the Expert Witness

1. In preparing this report, I examined documents provided by Hylton Powell and which I downloaded directly from the internet or created from GOJ-sourced materials. Based on information gleaned from the documents, reference to scientific literature and my knowledge and experience with the areas of SML 165, SML 172, SML 173 and other areas of Cockpit Country, I arrived at my conclusion as to the validity of the Claimants' claim. I believe that this approach complied with instructions given in Part 32 "Experts and Assessors," of Jamaica's Civil Procedure Rules and in particular Section 32.3 "Expert witness's overriding Duty to the Court", and section 32.4 "Way in which expert witness's duty to the court is to be carried out".

2. I was also aware of my right to apply to the court for directions (section 32.5), my need to address my report to the court and not any other person (section 32.12) and the details of the required contents of my report (section 23.13).

3. I believe I have included all matters within the realm of my knowledge that are relevant to the issues and that I have made clear where I feel that uncertainties in my opinions or in the opinions of others exists.



SUSAN E. KOENIG DATE: 24 March 2025