A Multidisciplinary Review of the Bauxite-Alumina Industry in Jamaica
RED DIRT

A Multidisciplinary Review of the Bauxite-Alumina Industry in Jamaica

Jamaica Environment Trust
DEDICATED TO THE
LIFE AND WORK OF

Contents

List of Figures / vii
List of Tables / ix
Acknowledgments / xi
List of Acronyms / xiii

Executive Summary / 1
JAMAICA ENVIRONMENT TRUST (JET)

Introduction / 37
DIANA McCaulay

Bauxite Companies in Jamaica / 41

1 Mining the Land: The Past and Future of the Bauxite-Alumina Industry in Jamaica / 43
TINA RENIER AND JORDAN HOWELL

2 The Regulatory Framework Governing the Bauxite-Alumina Industry’s Impact on Jamaica’s Environment and Public Health / 58
ANTHONY GREENAWAY

3 A Healthy and Productive Environment? The Public Health Impacts of the Bauxite-Alumina Industry in Jamaica / 91
PATRECE CHARLES

4 “New terrain, far from fambly an fren”: The Social Impact of the Bauxite-Alumina Industry in Jamaica / 110
HORACE LEVY AND PETA-ANNE BAKER
CONTENTS

5 Degradation of Ecological Heritage: The Impact of Bauxite Mining on Karst Ecosystems in Jamaica / 133
  SUSAN KOENIG

6 The Social Costs of Bauxite-Alumina Production in Jamaica / 198
  ERNIE NIEMI

The Authors / 221
The Reviewers / 223
Glossary / 224
List of Figures

Figure 1: Map of Jamaica Showing the Locations of Bauxites and the Processing Plants and Ports / 59
Figure 2: Map of the Area around the UC Rusal Bayer Process Plant, Ewarton / 76
Figure 3: An Example of SO₂ Data / 83
Figure 4: An Example of NO₂ Data / 83
Figure 5: Map of Noranda’s SML 165 Area / 84
Figure 6: Cartoon from the Front Page of *Workers Time* / 116
Figure 7: Map of Western St Ann Showing Some Population Centres and Mining Leases / 118
Figure 8: Map of St Elizabeth and Manchester / 125
Figure 9: Aluminum Bearing Soils / 136
Figure 10: Principal Bauxite Deposits / 138
Figure 11: Example of Mapping of the Rehabilitation Process / 141
Figure 12: Example of How GIS Software Is Used to Map Ore Body Characteristics / 143
Figure 13: Google Earth Image (2005) of Mining near Rio Hope Pen, St Ann under SML 162 / 146
Figure 14: The Stages of Reclaiming the Void Created by Extractive Mining / 147
Figure 15: Vertical Scars on Hillsides from Mining and Reclamation / 149
Figure 16: SMLs Since 1991 and SEPLs Active in 2019 / 151
Figure 17: Post Reclamation Land Use (Drakopoulos 2018) for Mined-out Ore Bodies / 152
Figure 18: Proven Underground Hydrology of the Martha Brae, Rio Bueno-White River and (Upper) Black River Watershed Management Units (WMUs) under SMLs and SEPLs / 165
Figure 19: Distribution Pattern of Caves across North-Central Jamaica / 165
Figure 20: Haul Roads and Dust / 167
**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 21:</td>
<td>Water Catchment, Unpaved Road and Mining Pit</td>
<td>168</td>
</tr>
<tr>
<td>Figure 22:</td>
<td>Community Water Catchments in Relation to Locations of Air Quality Monitoring Stations</td>
<td>169</td>
</tr>
<tr>
<td>Figure 23a:</td>
<td>Groundwater Flow Direction Base Map from WRA's GWIS Online Database</td>
<td>171</td>
</tr>
<tr>
<td>Figure 23b:</td>
<td>GOJ-owned Wells in Proximity to Alumina Processing Plants</td>
<td>171</td>
</tr>
<tr>
<td>Figure 24:</td>
<td>Water Quality Monitoring near Bull Savannah, St Elizabeth</td>
<td>174</td>
</tr>
</tbody>
</table>
List of Tables

Table 1: Access to Information (ATI) Requests Made by JET for Bauxite-Alumina Review (January–July 2020) / 2

Table 2: Acts, Orders and Regulations, and Other Documents Relevant to the Bauxite-Alumina Industry / 65

Table 3: Estimates of Emissions from UC Rusal’s Ewarton Plant and Surroundings / 78

Table 4: Dispersion Model Results for UC Rusal’s Ewarton Plant at the Pre-existing Environmental Monitoring Sites / 79

Table 5: Summary of Hourly Data (µg/m³) for Gases at Orangefield and Mud Stacking Monitoring Stations / 82

Table 6: Number of People Interviewed by Parish, Bauxite Company, and Occupation / 113

Table 7: Occupations / 113

Table 8: Population Change in Selected Towns, Jamaica / 122

Table 9: Agricultural Land vs Active Farmland in Jamaica, Manchester, St Ann and St Elizabeth / 123

Table 10: Potential Social Costs Imposed on Jamaicans by the Bauxite-Alumina Industry / 202–210

Table 11: Social Costs from Coal Mining in Cesar, Colombia / 212

Table 12: Potential Social Cost (Mortality and Morbidity) from Industry Emissions of PM_{2.5}, SO_{2}, and NO_{x} (USD2010) / 213

Table 13: Annual Health Effects Associated with Emissions of Ozone and Particulates from Ports and Goods-Movement in California / 214

Table 14: Estimated Value (2013 USD) of Ecosystem Services Provided Annually by Jamaica’s Forest Ecosystems: Average per Hectare and Country Total / 215

Table 15: Estimated Social Costs of CO_{2} Emitted by the Industry, for Range of Estimates of the Social Cost per Tonne of CO_{2} / 216

Table 16: The Social Costs of the Bauxite-Alumina Industry Exceed the Economic Benefits / 217
Acknowledgments

The Jamaica Environment Trust (JET) worked with our long-standing partners, the Environmental Law Alliance Worldwide (ELAW) to carry out this work. We also received funding from the Grodzins Fund and Jamaica Conservation Partners (JCP) and we are grateful for their support. We contracted experts in six subject areas to research and write each chapter and we thank them for their work, which was made much more difficult by the COVID-19 pandemic. Short author bios can be found on page 221.

We also thank the Jetters, especially Suzanne Stanley and Lauren Creary, for many months of persistent effort and creativity.

DISCLAIMER

All reasonable precautions have been taken by the Jamaica Environment Trust (JET) to verify the information contained in this publication. The published material is being distributed without warranty of any kind, either express or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall the Jamaica Environment Trust (JET) be liable for damages arising from its use.

The named authors alone are responsible for the views expressed in the chapters written by them. There is no warranty, express or implied, that the authors agree with conclusions made by JET or by other authors.
List of Acronyms

ALCAN   Aluminum Company of Canada
ALCOA   Aluminum Company of America
ALPART  Alumina Partners of Jamaica
ARDS    Acute Respiratory Distress Syndrome
ATI     Access to Information
BATCO   Bauxite and Alumina Trading Company Limited
BCDP    Bauxite Community Development Programme
BMI     Body Mass Index
BPO     Business Process Outsourcing
BRDA    Bauxite Residue Deposit Area
CAP     Clarendon Alumina Works
CBD     Convention on Biological Diversity
CCC     Cockpit Communities for Conservation
CCPA    Cockpit Country Protected Area
CCSG    Cockpit Country Stakeholders Group
CDC     Community Development Committee
CDF     Capital Development Fund
CITES   Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO₂     Carbon Dioxide
CO      Carbon Monoxide
DMT     Dry Metric Tons
ECA     Economic Cooperation Administration
EFJ     Environmental Foundation of Jamaica
EHU-MOH Environmental Health Unit, Ministry of Health
EIA     Environmental Impact Assessment
ELAW    Environmental Law Alliance Worldwide
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP</td>
<td>Environmental Permit</td>
</tr>
<tr>
<td>EPL</td>
<td>Exclusive Prospecting License</td>
</tr>
<tr>
<td>ESRI</td>
<td>Environmental Systems Research Institute</td>
</tr>
<tr>
<td>EVCA</td>
<td>Essex Valley Community and Associates</td>
</tr>
<tr>
<td>GAJ</td>
<td>General Alumina Jamaica, LLC</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GOJ</td>
<td>Government of Jamaica</td>
</tr>
<tr>
<td>GWIS</td>
<td>Ground Water Information System</td>
</tr>
<tr>
<td>HIA</td>
<td>Health Impact Assessment</td>
</tr>
<tr>
<td>HRA</td>
<td>Health Risk Assessment</td>
</tr>
<tr>
<td>IBA</td>
<td>International Bauxite Association</td>
</tr>
<tr>
<td>IGF</td>
<td>Intergovernmental Forum on Minerals, Metals and Sustainable Development</td>
</tr>
<tr>
<td>IMF</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>IPBES</td>
<td>Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services</td>
</tr>
<tr>
<td>JBI</td>
<td>Jamaica Bauxite Institute</td>
</tr>
<tr>
<td>JBM</td>
<td>Jamaica Bauxite Mining Limited</td>
</tr>
<tr>
<td>JCP</td>
<td>Jamaica Conservation Partners</td>
</tr>
<tr>
<td>JET</td>
<td>Jamaica Environment Trust</td>
</tr>
<tr>
<td>JLP</td>
<td>Jamaica Labour Party</td>
</tr>
<tr>
<td>JISCO</td>
<td>Jiuquan Iron and Steel Group</td>
</tr>
<tr>
<td>JMD</td>
<td>Jamaican Dollars</td>
</tr>
<tr>
<td>JSIF</td>
<td>Jamaica Social Investment Fund</td>
</tr>
<tr>
<td>LDUC</td>
<td>Land Development and Utilization Commission</td>
</tr>
<tr>
<td>LFMC</td>
<td>Local Forestry Management Committee</td>
</tr>
<tr>
<td>MGD</td>
<td>Mines and Geology Division</td>
</tr>
<tr>
<td>MOH</td>
<td>Ministry of Health</td>
</tr>
<tr>
<td>MOHW</td>
<td>Ministry of Health and Wellness</td>
</tr>
<tr>
<td>MOTM</td>
<td>Ministry of Transport and Mining</td>
</tr>
<tr>
<td>MOU</td>
<td>Memorandum of Understanding</td>
</tr>
<tr>
<td>MPF</td>
<td>Mining Policy Framework</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>NAAQS</td>
<td>National Ambient Air Quality Standards</td>
</tr>
<tr>
<td>NBL</td>
<td>Noranda Bauxite Limited</td>
</tr>
<tr>
<td>NEPA</td>
<td>National Environment and Planning Agency</td>
</tr>
<tr>
<td>NIEO</td>
<td>New International Economic Order</td>
</tr>
<tr>
<td>NJBP</td>
<td>Noranda Jamaica Bauxite Partnership</td>
</tr>
<tr>
<td>NMI</td>
<td>National Minerals Institute</td>
</tr>
<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>Nitrogen oxides</td>
</tr>
<tr>
<td>NRC</td>
<td>National Restoration Committee</td>
</tr>
<tr>
<td>NWU</td>
<td>National Workers Union</td>
</tr>
<tr>
<td>NRCA</td>
<td>Natural Resources Conservation Authority</td>
</tr>
<tr>
<td>OPEC</td>
<td>Organization of Petroleum Exporting Countries</td>
</tr>
<tr>
<td>PEFR</td>
<td>Peak Expiratory Flow Rate</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate Matter</td>
</tr>
<tr>
<td>PNP</td>
<td>Peoples National Party</td>
</tr>
<tr>
<td>RDA</td>
<td>Residue Disposal Area</td>
</tr>
<tr>
<td>RIAS</td>
<td>Regulatory Impact Analysis Statement</td>
</tr>
<tr>
<td>SCCO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Social Costs of Carbon Dioxide</td>
</tr>
<tr>
<td>SDC</td>
<td>Social Development Commission</td>
</tr>
<tr>
<td>SEA</td>
<td>Strategic Environmental Assessment</td>
</tr>
<tr>
<td>SEPL</td>
<td>Special Exclusive Prospecting License</td>
</tr>
<tr>
<td>SML</td>
<td>Special Mining Lease</td>
</tr>
<tr>
<td>STATIN</td>
<td>Statistical Institute of Jamaica</td>
</tr>
<tr>
<td>STEA</td>
<td>Southern Trelawny Environmental Agency</td>
</tr>
<tr>
<td>SO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Sulphur Dioxides</td>
</tr>
<tr>
<td>TCPA</td>
<td>Town and Country Planning Authority</td>
</tr>
<tr>
<td>TSP</td>
<td>Total Suspended Particles</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>USA, US</td>
<td>United States of America</td>
</tr>
<tr>
<td>USD</td>
<td>United States Dollars</td>
</tr>
<tr>
<td>US EPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>UWI</td>
<td>University of the West Indies</td>
</tr>
<tr>
<td>VOC</td>
<td>Volatile Organic Compounds</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
LIST OF ACRONYMS

WINDALCO  West Indies Alumina Company
WMU        Watershed Management Unit
WRA        Water Resources Authority
WRC        Windsor Research Centre
WTA        Willingness to Accept
WTP        Willingness to Pay
Executive Summary

This Executive Summary (Pages 1–36) was written by the Jamaica Environment Trust (JET). While it presents each chapter’s conclusions as arrived at by the authors, the framing and titling of those conclusions have been written by JET.

We made every reasonable attempt to ensure the contributors to this study are experts in their respective fields and that the information presented is accurate at the time of publication. We encourage readers to apply their own critical analysis and conduct their own research.

Overall, research for this study was constrained by the COVID-19 pandemic which made in-person interviews and visits to Government of Jamaica (GOJ) ministries and agencies difficult between March and August 2020. Some state agencies were helpful in organizing virtual or small, in-person meetings, but often respondents pointed to capacity challenges exacerbated by the pandemic.

We will begin by outlining obstacles experienced by most authors in conducting the study, and their common findings. A summary and the findings of each chapter is then presented. The Executive Summary is also available as a separate document without references, figures, tables or charts.
**LACK OF TRANSPARENCY**

**FINDING:** There are significant obstacles to members of the public using the Access to Information (ATI) Act to obtain information on the Jamaican bauxite-alumina industry; this could and should be improved by proactive disclosure of all public documents.

JET submitted 27 ATI requests to the GOJ, most commonly to three primary state agencies with oversight of the bauxite-alumina industry – the National Environment and Planning Agency (NEPA), the Jamaica Bauxite Institute (JBI), and the Mines and Geology Division (MGD) within the Ministry of Transport and Mining (MOTM). A few requests were also made to the Ministry of Health and Wellness (MOHW). Find a summary of these requests in Table 1 below.

Whilst the number of requests may seem modest, each contained a list of multiple documents, and in the case of NEPA, resulted in pushback due to what was described as the “voluminous nature” of the requests. Often, when requests were fulfilled, the responses raised questions and generated further requests. Only four of our requests were received within the statutory 30 days. Ten requests were extended to 60 days and five were only partially satisfied. At the time of writing, information contained in seven of the requests was neither provided, denied, nor was the request transferred to another agency. These requests have been submitted for internal review by agency heads, as provided by the ATI Act.

In conducting this study, JET and the authors were struck by the lack of basic information on GOJ websites, such as the Memorandum of Understanding (MOU) between the Natural Resources Conservation Authority (NRCA)/NEPA and the JBI, various permits and licenses governing Jamaica’s bauxite-alumina industry, enforcement notices, air quality testing results, and other types of public interest information. If GOJ commitments to transparency are to be adhered to, this information should be proactively disclosed.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Total No. Requests</th>
<th>Responses Received in 30 Days</th>
<th>Requests Completed</th>
<th>Requests Outstanding</th>
<th>Requests Under Internal Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEPA</td>
<td>12</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>JBI</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>MGD</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MOTM</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MOHW</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>27</strong></td>
<td><strong>4</strong></td>
<td><strong>15</strong></td>
<td><strong>12</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>
REGULATORY CAPTURE OF THE JBI

FINDING: The JBI operates as a pro-industry agency and it has failed to carry out its environmental regulatory function adequately. The JBI does not appear to see itself as having a responsibility to address public interest concerns in a transparent and user-friendly manner. We note that the draft of the new National Minerals Policy (2017–2030) contemplates a transition for the JBI into a National Minerals Institute which will focus on applied research, leaving environmental oversight of the industry to NEPA. We believe this would be a welcome change and hope it can be achieved in a timely manner.

The responsibility for environmental monitoring of the bauxite-alumina industry was delegated by the NRCA/NEPA to the JBI in 1994 via an MOU. This has been criticized by environmental NGOs, due to the perceived conflict of interest presented by an agency partly responsible for the advancement of the industry also functioning as its regulator. The 1994 MOU was renewed in 2013, and we did not receive any analysis of the performance of the JBI to justify or explain this renewal. Our study concluded that there is little evidence to indicate that the partnership between the JBI and NEPA has worked to the benefit of the environment or public health. The monitoring and enforcement concerns are covered in the regulatory chapter.

JET and the authors of the study experienced resistance to our requests for information and interviews from the JBI, which initially did not seem to understand the requirements of the ATI Act, refused to meet with some members of our research team – even virtually – and subjected one author to the requirement of submitting written questions, which were then followed by slow and incomplete answers. We were particularly disappointed to be denied access to minutes or records of the Bauxite Community Development Programme (BCDP) Community Council meetings, which the industry frequently cites as evidence of positive collaboration with communities. Letters from JET to the Chairman of the JBI, the Minister of Transport and Mining and the Prime Minister requesting their intervention to resolve these hurdles received no response.

LONG-STANDING COMMUNITY CONCERNS ARE DISCOUNTED BY THE INDUSTRY AND THE STATE

FINDING: Although Jamaican voices have consistently been raised over many years about adverse experiences caused by bauxite mining and processing, and related concerns for public health, we were only provided with one state-sponsored health impact assessment in connection with the expansion of a single facility (Jamalco in Clarendon). This displays an egregious lack of responsiveness by the GOJ to the health concerns of citizens.

To identify the primary concerns of community members related to the bauxite-alumina industry, most authors relied heavily on interviews, either face-to-face or e-mail interchanges, or stories contained in other studies and/or newspaper articles. A search of The Gleaner
archive for letters of complaints regarding the industry returned 721 hits. Many Jamaicans lamented bauxite’s harmful impacts to rural and community life, farming livelihoods, soil fertility, water supplies from catchments, damage to roofs, and experiences of noise, dust and illness caused by the industry. We found the response of the industry and the regulatory bodies generally to be unsympathetic; indeed, they were inclined to imply that these complaints were not genuine, made simply to get compensation, or alternatively, that any kind of dust could cause the impacts described. The industry also pointed to benefits provided to affected communities, such as scholarships, support for schools and community centres, and greenhouses, with the clear implication that these benefits outweighed the health costs and deterioration in rural community life. Despite these long-standing and vocal concerns, the GOJ does not appear to have implemented an ongoing health tracking survey for communities in proximity to the bauxite-alumina industry.

**THERE ARE SIGNIFICANT DATA GAPS AND LACK OF CLARITY**

**FINDING:** The authors were not able to assess the full impact of the bauxite-alumina industry due to significant data gaps which are outlined in each chapter. We can make no judgment as to whether these data exist and were simply not provided, or whether insufficient effort has been made by the GOJ to collect important data over the life of the industry. The figures presented on rehabilitation of mined-out pits, for example, vary from report to report from a low of 75 percent to a high of 85 percent. The lack of data hampers efforts, whether by regulators or the public, to verify industry claims.

---

**Chapter 1: Mining the Land: The Past and Future of the Bauxite-Alumina Industry in Jamaica**

**TINA RENIER AND JORDAN HOWELL**

**BEGINNINGS**

Chapter 1 outlines the history of the bauxite and alumina industry in Jamaica, from its beginnings in the United States of America (USA) in the 1880s, through technological improvements and growth driven by the demand for aluminum in World War II. Bauxite was discovered in Jamaica in 1942 and the island’s proximity to the US, along with the availability of suitable sites for ports, made it ideal for investment.

At the time of the bauxite-alumina industry’s initial expansion in Jamaica, the meaning of development was being contested by colonized and decolonizing states. The St Lucian economist W. Arthur Lewis argued that development for Jamaica required investing in both agriculture and industry – and the two had to work together.
EXECUTIVE SUMMARY

HEYDAY AND CONTESTATION

By 1957, Jamaica was the world’s largest producer of bauxite and this provided a powerful symbol of a world beyond the plantation, particularly for the first generation of nationalist leaders in Jamaica. There were still concerns that mining industries would not provide the number of jobs needed, and that greater employment gains were available in a modernized agricultural sector. Concerns were also raised that mining might pose a threat to sovereignty via external control of Jamaica’s resources.

Once mining began, however, discussions of alternative development pathways became muted, the debate shifted from whether bauxite should be mined to more concrete questions of how to increase foreign investment. The periods of highest economic growth in Jamaica in the second half of the twentieth century correspond to investment in large-scale construction projects in the bauxite-alumina industry – trams, ports, airports, railways, silos, equipment, and five refineries.

The People’s National Party (PNP) administration of the 1970s, led by Prime Minister Michael Manley, developed a “bauxite levy” to replace the pre-existing corporate tax system. Thousands of acres of land owned by the bauxite companies were purchased “back” by the GOJ during this period, and the industry was also partially nationalized. The levy – a 75 percent tax rate on the average price of aluminum – addressed a large deficit in Jamaica’s foreign exchange that had resulted from oil price shocks. The levy quintupled GOJ’s earnings on bauxite. The Levy Act also provided for the creation of a Capital Development Fund (CDF) into which revenues from the levy would be paid. These funds were used by the GOJ to buy land owned by the bauxite companies, acquire partial ownership of the companies, and to establish the Jamaica Bauxite Institute (JBI); however, most of the money paid into the CDF was used to finance the government’s budget, including many social democratic initiatives.

SLOWDOWN

In the 1960s, aluminium corporations began to pool capital to develop new deposits in Guinea, Brazil and Australia, and by the 1980s, Jamaica had lost its competitive position in the world aluminum market.

The bauxite levy and Manley’s democratic socialism were sometimes blamed for the slowdown of Jamaica’s bauxite-alumina industry through the 1980s; however, during the period there was also a search for cheaper labour and raw materials in Asia, Australasia, and Africa, which resulted in reorganised global supply chains. The International Monetary Fund (IMF) also adopted new austerity measures that were a barrier to the kind of development policies that W. Arthur Lewis and Michael Manley had envisioned.

Over the decades, investment in the Jamaican bauxite-alumina industry has increased production but reduced the number of those directly employed in the industry from a high of 6,900 in 1975 to roughly 4,000 in 2018. The number of wage workers has also continued to decline from 4,520 in 1975 to 1,429 in 2018, although employment in other categories grew.
Exports, particularly of alumina, have shifted toward Russia and China. The share of the bauxite-alumina industry in government revenues has declined from over 25 percent in the 1970s to under 3 percent leading up to the 2008 Global Recession, and since 2002, Jamaica’s bauxite levy has been replaced by a tax regime that links state revenues to company profits. Although industry production has expanded through new investment, yield per-ton has declined, and more mining and refining is needed to maintain revenues, leading to demands for greater concessions from the GOJ by the companies.

Historically, although the bauxite-alumina industry did not contribute significantly to the number of jobs created for Jamaicans, bauxite workers enjoyed higher wages, improved working conditions, and better prospects for job security. Strong trade union involvement in collective bargaining was primarily responsible for the “privileged worker” status experienced by bauxite employees in the past. In the 1950s, the National Workers’ Union (NWU) came to represent all bauxite workers in Jamaica, leading to the securing of decent wages, benefits, and improved working conditions, although labour agreements did include a ‘no strike’ clause.

By the early 1980s, the reorganization of the global aluminum industry had reduced the share of Caribbean bauxite producers, ushering in unstable employment, including restraint on wage increases, closure of plants, and worker layoffs. This led to the frequent worker strikes in the 1980s and in 1995. With over 4,000 workers demanding safer working conditions and higher wages, an MOU was signed in 1998 between the companies, the GOJ and the NWU, signalling a new phase in the industry with lower wages and more precarious working conditions. Despite the industry having a positive impact on labour relations during the boom years, currently, trade unions have lost the political control they once enjoyed.

THE SOCIAL COSTS

The crisis in the aluminum industry in the 1980s began to raise questions about the social costs of mining bauxite. Economist George L. Beckford organized a study of the impact of Jamaica’s bauxite-alumina industry on the environment, the first of its kind. Beckford argued that for many Jamaicans, the land possessed a deep political, economic, and spiritual significance tied to struggles for freedom from chattel slavery. In the post-emancipation period, formerly enslaved people had acquired small plots of land to grow food for subsistence and trade. By 1938, there were 80,000 freeholds registered in Jamaica, averaging just over two acres each, and many farmers considered this family land to be inalienable.

Before Jamaica’s legislature signed the Minerals (Vesting) Act, 1947 and Mining Act, 1947 into law, the Aluminum Company of Canada (ALCAN) and Reynolds Jamaica Mines had begun purchasing properties in St Ann and Manchester. As early as 1942, prospecting and land acquisitions had become not just a nuisance, but a threat to post-plantation rural economic life.
Beginning in the 1940s, Jamaican farmers signed petitions, wrote letters to newspapers, and held community meetings to discuss and contest the effects of bauxite mining on their communities. The rise and expansion of the industry displaced alternative ways of engaging with the land. Although the bauxite companies frequently documented and publicised their agricultural initiatives, resettlement programmes and land rehabilitation efforts, the industry never acknowledged the pressure from rural communities that had produced these compromises.

The authors of this chapter contend that it is difficult to measure the scale and effect of bauxite mining on rural Jamaica. George Beckford estimated that by 1979, when the Aluminum Company of America (ALCOA) and Alumina Partners of Jamaica (ALPART) had joined Reynolds Jamaica Mines, ALCAN, and Kaiser in buying up land, the companies owned more than 210,000 acres in the parishes of Manchester, St Elizabeth, St Ann, Trelawny, and Clarendon. Over time, the government began to claw back the land owned by the companies; yet, Geologist Arthur Geddes estimated in 1990 that mining had already caused extensive damage to the natural ecology of at least 60,000 acres. At the same time, more than 200 million tons of caustic red mud had been produced by 1990. Renier and Howell conclude that the decrease in government revenue on each ton of bauxite mined incentivised an expansion in production and continued environmental degradation.

**COCKPIT COUNTRY**

As it relates to Cockpit Country, the current Jamaica Labour Party (JLP) government, led by Prime Minister Andrew Holness, agreed to prohibit mining in Cockpit Country in 2017, but environmentalists, farmers, and Maroon leaders have contested the government’s designated Cockpit Country Protected Area (CCPA) boundary. The cratered and cavernous landscape of wet limestone forest is one of the most biodiverse parts of the island, and it was in Cockpit Country that Maroons, whose presence in Jamaica antedates British colonization, forced the British to sign a peace treaty in 1739. The boundary dispute has served as a catalyst for deeper debates about the future of the bauxite-alumina industry in Jamaica and Maroon sovereignty.

**BAUXITE’S FUTURE – 2020 AND BEYOND**

The global economic slowdown of 2008 forced deep cuts in production and employment. Doors were shut to refineries in Ewarton and Nain, which eliminated nearly 1,000 jobs and associated community services. In the decade since the crisis, production has slowly picked up, refineries at Ewarton and Nain have reopened, and exports have climbed to their pre-recession highs. Since 2010, the JBI reports that the total number of jobs has grown from 2,189 to 4,028, but the number of wage workers has remained stagnant, failing to recover most of the losses from the recession.
In 2016, UC Rusal, a Russian corporation, sold its share of the ALPART refinery at Nain in St Elizabeth to the Jiuquan Iron and Steel Group (JISCO), a Chinese mining conglomerate. Today, UC Rusal, JISCO, the Noble Group and Glencore (New Day/Noranda) are the principle investors and partners with the GOJ in the bauxite-alumina industry. As COVID-19 threatens another global economic slowdown, it is time once again to evaluate the future of the industry in Jamaica.

Economist Michael Witter has pointed to the threats posed by bauxite mining to Jamaica’s food economy, soil fertility, and water supplies. His analysis centres the historical, cultural, environmental, and political economic stakes of mining in Cockpit Country, and Witter reminds us that expansion in the bauxite-alumina industry not only ties the lives of Jamaicans to cyclical crises in the world economy, but also that its expansion undermines alternative farming economies that have “sustained the country through all economic crises.” In the context of the current COVID-19 pandemic, the chapter concludes that focus on wages and foreign exchange alone cannot tell us whether the benefits of the bauxite industry outweigh the costs.


ANTHONY GREENAWAY

OVERVIEW

Chapter 2 describes the evolution of the regulatory framework governing the bauxite-alumina industry, from the Mining Act of 1947, through various pieces of legislation which incentivized the industry, to the establishment of the JBI in 1976, and the promulgation of the NRCA Act of 1991 (with subsequent amendments). The chapter not only looks at the scope of the laws, guidelines, and regulations governing the industry, but also assesses how they have been implemented using two case studies – UC Rusal’s Bayer Plant at Ewarton in St Catherine, and the mining operations of Noranda in St Ann and Trelawny. The draft Minerals Policies of 2011 and 2017 are reviewed, as well as a 2020 study by the Intergovernmental Forum on Minerals, Metals and Sustainable Development (IGF) on Jamaica’s readiness and capacity to implement the IGF’s Mining Policy Framework.
A Multidisciplinary Review of the Bauxite-Alumina Industry in Jamaica

EXECUTIVE SUMMARY

ADEQUACY OF THE REGULATORY FRAMEWORK

**FINDING:** While various methods of oversight and moral suasion were applied to the industry in the early days, it was not until 2015 that the regulatory framework for the mining industry was finally adequate and enforceable by law. The bauxite-alumina industry therefore operated for 45–65 years under minimal or deficient environmental legislation, but the current regulatory framework, if followed and adhered to, seems adequate for its purpose. The IGF review found the regulations to be overlapping, sometimes conflicting, and in need of review.

When the Permit and Licence Regulations of the NRCA Act were passed in 1996, the bauxite-alumina industry was “grandfathered” in – meaning that the new requirements did not apply to pre-existing mining operations. It was not until 2006 that the NRCA (Air Quality) Regulations 2006 were passed. These regulations specify when an air pollutant discharge licence is necessary, and the requirements for applicants. Until 2015, the regulators relied on the submission of information by the bauxite companies under Section 17 of the NRCA Act and in some cases, companies are still making these submissions, despite now having permits and licences.

PERMITTING AND LICENSING

**FINDING:** The procedures in place for preparing, reviewing, issuing, and monitoring environmental permits and licences are not being conducted with sufficient attention to detail.

Detailed review of the permits and licenses for the two case studies (UC Rusel’s Bayer Plant at Ewarton – bauxite processing, and Noranda’s bauxite mining area in St Ann) revealed many inaccuracies, including one permit being so deficient that it had to be revised and reissued by NEPA in 2020.

DISPERSION MODELLING AND AIR QUALITY MONITORING

**FINDING:** Jamaica’s air quality regulations rely on dispersion modelling to identify pollutants which should be monitored, those which are projected to exceed air quality standards (thus triggering a compliance plan), and where monitoring sites should be located. The two case studies suggest, however, that modelling is not being used in accordance with the Guideline Document and its results have been ignored. There are significant weaknesses in monitoring and enforcement of regulations and licences – this was also a finding of the IGF report.

Expected emissions from all sources must be disclosed to assist in NEPA’s calculation of the fees companies must pay. These emissions are then used as inputs for a dispersion model, which predicts how the pollutants will be dispersed by the wind, and where compliance
monitoring sites should be located. Monitoring becomes required if the maximum modelled concentrations at ground level are greater than 75 percent of the concentrations permitted by the National Ambient Air Quality Standard (NAAQS). Where predicted emissions from sources and fugitive emissions exceed the standards, compliance plans must be submitted and approved to bring emissions into compliance.

With regard to the modelling which is meant to guide the monitoring of air quality, our review of two case studies found that the dispersion model results seemed to have little bearing on the actual monitoring sites selected and therefore gave no guidance as to compliance to the NAAQS. Indeed, few, if any, sites were within the prevailing wind plume from emissions sources.

In the case study of Noranda’s mining operations, the boundary of Special Mining Lease (SML) 165 was used as the “fence line,” in order to locate compliance monitoring sites, so all suggested compliance sites were outside the lease boundary. Using the concept of a “fence line” is suitable for a processing facility, where it can reasonably be assumed that the public does not have access inside the “fence line.” This approach is not, however, suitable for mining in a rural area as there are many small communities inside the boundary. In fact, the guidelines require the placement of sites within “all areas accessible to the general public,” which would be the entire lease area. We also found no evidence that monitoring sites were being moved as mining areas within the lease area changed.

For both case studies, there were no background sites or compliance sites, therefore modelling results and data collected were not verified.

**FINDING:** The licence requirements for air quality monitoring in the Noranda mining areas were not fully adhered to.

Noranda’s licence for SML 165 and 172 requires an air quality monitoring plan and ambient air monitoring be conducted for Total Suspended Particles (TSP) and Particulate Matter (PM), specifically PM$_{10}$ for “24 hours every six days”. The ATI request for the monitoring plan had not been responded to at the time of writing.

The ATI request to NEPA for air quality data relevant to SML 165 and 172 for 2016 through 2019 returned only TSP data for Calderwood, Clydesdale, and Green Hill. No PM$_{10}$ data was received. The JBI’s explanation for this omission varied: “It is common to focus on PM$_{10}$ in urban areas . . . and utilize the TSP in rural areas . . .” and; “As the network goes through an approval process between government regulators, it is not considered deficient for Noranda to not have PM$_{10}$ monitoring in the mining areas.” In a follow-up e-mail, they added, “The license AQ00020 (sic) gives the two (2) options and does not prescribe that both MUST be used”.

NEPA did not offer an explanation for why PM$_{10}$ was not required to be monitored by Noranda’s licence.

---

1 Personal e-mails from S. Barnett, General Manager, JBI, 2020
The air pollutant discharge licence requiring monitoring for PM$_{10}$ was issued by the NRCA/NEPA and monitored by both NEPA/JBI. Our study was not able to determine why monitoring for PM$_{10}$ was required in the licence if this was to be optional.

**AIR QUALITY STANDARDS**

**FINDING:** Jamaica’s air quality standards are known to be outdated and, with respect to Particulate Matter (PM), are inadequate to protect public health – the bauxite-alumina industry could and should be held to a higher standard.

In Jamaica, the bauxite-alumina industry is only required to monitor for TSP and occasionally for PM$_{10}$. According to the US Environmental Protection Agency (EPA), best practice has long required monitoring for PM$_{2.5}$, in the absence of which it is not possible to assess the impact of PM on human health. TSP was removed from the US criteria pollutants in 1987. Further, bauxite-to-alumina processing emits caustic aerosols and there is no legal requirement to quantify or monitor such aerosols in Jamaica. Indeed, the many drafts of the pending National Minerals Policy and the JBI’s mandate call for the industry to conform to international best practices, which the industry has shown willingness to do. Our study was not able to determine why a higher standard has not been required by the regulators.

---

**Chapter 3: A Healthy and Productive Environment?” The Public Health Impacts of the Bauxite-Alumina Industry in Jamaica**

**PATRECE CHARLES**

**OVERVIEW**

Chapter 3 explores the public health impacts of the bauxite-alumina industry, using complaints from residents in different parts of the island reported in the media, and by reviewing three studies on the impact of the Jamalco refinery at Hayes in Clarendon on the health of nearby communities. The three studies are:

- A 2007 study conducted by Patrece Charles, the author of this chapter, entitled: *The Reported Respiratory Illnesses in Communities within the Parish of Clarendon, and its Association with Environmental Conditions, Particularly Bauxite Activity* (Charles 2007);
- A 2008 *Health Impact Assessment* (HIA) requested by the Ministry of Health (MOH) and conducted by The University of the West Indies (UWI) and Yale University for the Jamalco facility in Clarendon due to a planned expansion (Jamalco 2008);
- A 2015 health survey commissioned by the Jamaica Environment Trust (JET) and carried
out by Professor of Public Health, Dr. Homero Silva, entitled: *Strengthening the Capacity of Jamaican Communities to Protect their Environmental Rights: Health Survey of the Mining Communities of Ten Miles, Bull Bay, St Thomas, Hayes and New Town, Clarendon, and Control Communities of Albion, St Thomas and Lionel Town* (JET 2015).

The findings of the chapter were limited by lack of health data from medical doctors, recent air quality data, and the age of the reviews – two were more than 12 years old.

**PUBLIC HEALTH RISKS OF BAUXITE MINING AND PROCESSING ARE WELL-KNOWN**

**FINDING:** The risks posed by the main pollutants from the bauxite-alumina industry are well-known and well documented.

The main pollutants caused by bauxite-alumina industry are described in Chapter 3. Particulate Matter (PM$_{10}$ and PM$_{2.5}$) is a common air pollutant, consisting of solid and liquid particles suspended in the air. PM is transported by the wind from excavation, blasting, and transport. Fugitive dust is generated by tailings facilities, stockpiles, waste dumps, and haul roads. Exhaust emissions arise from mobile sources (cars, trucks, heavy equipment) and gases from fuel combustion and mineral processing.

PM$_{10}$ and PM$_{2.5}$ include inhalable particles that are small enough to penetrate the respiratory system and their health impacts are well documented. According to the World Health Organization (WHO), there is no “safe level” for PM$_{10}$ and PM$_{2.5}$, and PM$_{2.5}$ (fine particles) presents a stronger risk factor than PM$_{10}$. Exposure to both PM$_{10}$ and PM$_{2.5}$ can cause emphysema, pneumonia, tuberculosis, cancer, acute respiratory distress syndrome (ARDS), respiratory distress syndrome, pulmonary oedema, and asthma. Diseases such as these, which result in reduced oxygen being delivered to the tissues of the human body, can result in damage to every major organ.

Other air pollutants, such as sulphur dioxide, cause corrosion to building materials, including “zinc” roofs, soiling of personal property (such as clothes hung out to dry) and damage to crops and vegetation.

**COMMUNITY VOICES IGNORED**

**FINDING:** Community complaints began in the early days of the industry but have produced little change in lived experiences.

Complaints by residents who live in proximity to bauxite mining areas, Residue Disposal Areas (mud lakes), haul roads and processing facilities frequently and consistently complain of asthma in children, allergies, damage to roofs, contaminated water supplies, damaged personal property, lack of soil fertility, impacts on crops, noxious smells, and dust. Communities have also contested the amount of compensation given for so-called “dust nuisance,” how it is distributed and to whom, also citing the industry’s failure to meet promises.
Executive Summary

We were provided with only a single public health impact study on the bauxite-alumina industry commissioned by the GOJ.

**Finding:** The GOJ has failed to take adequate steps to track or investigate the impacts of the bauxite-alumina industry on public health over the industry’s almost 70 years. Owing to this lack of data, no firm conclusion can be drawn on its impact.

Despite long-standing community concerns and well-documented health impacts of pollutants released by the bauxite-alumina industry, the GOJ provided our researcher with only one Health Impact Assessment (HIA). This was in the context of a planned expansion to the Jamalco alumina refinery at Hayes in Clarendon, in 2008.

The HIA was conducted by The University of the West Indies (UWI) and Yale University. This important document was very difficult to access, requiring ministerial intervention, despite the fact that conducting the HIA was a requirement of the NEPA permit for the Jamalco efficiency upgrade. The HIA was provided without the appendices, which limited the depth of our review. It is unclear whether the findings of this study were ever released to the public. One government source, who declined to be named, insisted that the bauxite companies resisted the release of the study.

The 2008 HIA described the demographic profile, health conditions, mortality, and morbidity patterns in communities within a 15-kilometre radius of the Jamalco refinery and control communities. The study found:

- Self-reported health symptoms collected during the personal interview process suggested a belief that plant-related health impacts were occurring. The study suggested that these complaints were an effort to get compensation.
- There was no statistically significant difference in objective measures of health outcomes between the exposed and control groups, so there was no scientific basis for the belief that the Jamalco facility was causing public health impacts in the areas studied.
- Emissions to ambient air from the proposed expansion was determined to be unlikely to have significant adverse impacts on human health.

The 2007 Charles study investigated the pattern of selected reported respiratory illnesses in communities at specified intervals within a 10-kilometre radius of the Jamalco plant. Types of air pollution and their sources were identified, as well as reported respiratory illnesses and potential sources, compared to control communities. The Charles study found:

- Thirty-six (36) percent percent of adults surveyed perceived both the bauxite facility and the roads to be the major contributors of air pollution within a six-mile radius of the refinery.
- The average levels of PM$_{10}$ exceeded the national acceptable average of 50 µg/m$^3$ at one to six miles from the bauxite processing plant. Exceedance of PM$_{2.5}$ was observed within...
the one to three and one to ten-mile radii. Further investigation revealed that mile ten was located within a rural area and the seasonal burning of sugar cane was the source of the PM$_{2.5}$ at mile ten.

- 37 percent of adults and 21 percent of children living within six miles of the facility suffered sinusitis. Asthma afflicted 23 percent of adults and 26 percent of children. Allergies were markedly more prevalent among those who lived closest to the plant than in control groups.
- Particulate Matter (both PM$_{10}$ and PM$_{2.5}$) measured within the study area contained alumina and sodium particles which were both associated with bauxite mining and processing.

The Charles study recommended that an objective epidemiological study should be conducted to determine any deviations in the norm of the health status of communities impacted by industrial activities, specifically the bauxite-alumina industry. To the best of our knowledge, this has not been done.

The 2015 JET health survey was conducted in selected mining communities in Jamaica by Dr Homero Silva, a public health specialist and lecturer at the University of Technology, Jamaica (UTech, Ja.), as part of an on-going project funded by the Inter-American Foundation to empower mining communities to protect their rights to a healthy environment. Two of these communities were Hayes and New Town in Clarendon (Group 1), in proximity to the Jamalco alumina refinery. Control communities (Group 2) were Lionel Town in Clarendon and Albion in St Thomas.

The incidence of eczema, hives/rashes, asthma, allergic conjunctivitis, hay fever/allergic rhinitis, wheezing, headache, eye symptoms, cough, shortness of breath, Body Mass Index (BMI) and hypertension were all investigated.

The JET study did not carry out any monitoring or testing of air quality but did evaluate the adequacy of Jamaican air quality standards in comparison to WHO standards.

The JET study found:

- Sixty-four point seven (64.7) percent of the respondents from Hayes New Town rated the air quality as unacceptable, compared to one percent in the control communities.
- With the exception of hives/rashes and BMI, it was highly likely that mining and quarrying operations were having an adverse impact of varying degrees on the health of residents.
- Jamaican ambient air quality standards were inadequate to protect public health.

---

2 The PM$_{1.0}$ standard was adopted from the United States Environment Protection agency (US EPA) standard, which determined that the annual fine particle standard (set in 1997) was not adequate to protect public health as required by law. In 2012, the US EPA strengthened the annual fine particle standard by revising the level from the current level of 15.0 μg/m$^3$ to 12.0 μg/m$^3$. 
**EXECUTIVE SUMMARY**

**EITHER “IT’S NOT US”, OR “IT’S NOT THAT BAD . . .”**

**FINDING:** The industry has not so far accepted responsibility for impacts to air quality and, therefore, public health.

The industry’s response has been (a) it’s not our dust, there’s lots of dust from other sources, e.g. cane fires, (b) deflection about the benefits provided to communities from the industry, as if this should eradicate the public health concerns; and (c) denial of the experience of communities, while at the same time paying “dust nuisance” compensation to those living within a specified radius of the plant.

---

**Chapter 4: “New terrain, far from fambly an fren”: The Social Impact of the Bauxite-Alumina Industry in Jamaica**

**HORACE LEVY AND PETA-ANNE BAKER**

**OVERVIEW**

Chapter 4 explores the social dimension of the impacts of the bauxite-alumina industry on Jamaican communities, primarily in the populated, rural, hilly areas where mining takes place. The authors examine the effect of resettlement on the lives and livelihoods of small farmers as they see it, relate the experiences of those living in areas affected by the industry, investigate the impacts of mining on livelihoods and community, evaluate the response from mining communities to the measures that the companies agreed to, including the emergence of Community Councils, and review other social consequences. In-person interviews were constrained by the COVID-19 outbreak, but through visits by telephone and online methods, 57 people were interviewed from nine areas affected by four bauxite companies. Farmers accounted for 32 respondents and the other interviewees were from a range of occupations, including education. Very few respondents were from areas close to processing facilities, so this chapter focuses primarily on the industry’s social impact in rural communities near open-pit mining operations. Interviewees are not named except in a few cases, due to fears of victimization. The researchers were unable to source data on displacement/relocation numbers or reductions in population size in bauxite areas from the Statistical Institute of Jamaica (STATIN) or the JBI, and did not interview representatives from the two bauxite companies (UC Rusal and Noranda) to which interview requests were made, due either to outright refusal (Noranda) or repeated delays (UC Rusal).
RELOCATION OF SMALL FARMING COMMUNITIES

FINDING: Many resettled people found the experience extremely disruptive and painful. While a few were able to continue farming, most found themselves in semi-urban situations and/or in lower level bauxite jobs, resulting in reduced small farming production.

Open cast mining of bauxite in Jamaica occurs in the populated countryside, often on hillsides or valley bottoms, on land held by large and small farmers who are typically the descendants of formerly enslaved people who had been pushed to these areas after Emancipation in 1838. With the exception of Reynolds Jamaica Mines, which acquired land from large estates, it was these small farmers who the bauxite companies had to resettle. Historically, there was resistance to resettlement from some individuals – termed “hold-outs” – which led to relocation of entire communities.

The JBI was established by the GOJ in 1976 to carry out regulatory, monitoring, advisory and research functions of the bauxite-alumina industry in Jamaica. The JBI was also tasked to manage dispute mediation between companies and workers and communities, with the objective that bauxite companies should have the land, but with the least disruption of community life. The JBI proposed and negotiated a model resettlement programme with many communities, although in most cases the company made the final decisions. The resettlement experiences in various communities in St Ann, St Elizabeth and Trelawny are described in this chapter.

Over the years, the experiences of Jamaican communities resettled by the bauxite-alumina industry have varied. The cohesive community of Village in eastern St Ann included about 15 “hold-out” families. After decades, resettlement of the entire community to Schwallenburg was successfully negotiated in 1981. The relocated residents received concrete and steel houses, as well as employment opportunities with ALCAN. The community of Mocho in Clarendon put up greater public resistance. After confrontation and legal action, resettlement eventually occurred in the late 1970s. In Lime Tree Garden in St Ann, many families were reluctant to sell their land. Eventually, 60 households were moved in the early 1980s by Kaiser en bloc to Retreat, only seven miles away by road and a mile away from Brown’s Town, in order to preserve access to friends and family and a rural town. It was only after years, however, that facilities such as water and electricity were provided. Some Lime Tree Garden residents were relocated to Trelawny’s distant Fontabelle and Windsor, with vastly different topography and crops.

In general, relocated communities in St Ann, St Elizabeth and Trelawny were often dissatisfied with the fertility of the soil in the new area, access to schools and clinics, and the loss of their fruit trees. They framed displacement as “having to start life over.” Those who stayed behind, close to the mining areas, suffered negative impacts from mining, while some who accepted resettlement welcomed freedom from the dust and noise, and better facilities, such as concrete houses, indoor plumbing, and kitchens. Interviewees also pointed to delays in providing promised titles to new land. More recently, Noranda’s offers to buy the land of small farmers near Watt Town in St Ann are regarded as below current market prices.
RURAL POPULATION DECLINE

**FINDING:** Small farming communities insist they suffered because of bauxite mining, losing size and sense of community. We were not able to find data on displacement, resettlement, or population decline of the mining communities.

According to the Agricultural Census 2007 (STATIN), “active farmland” declined across the country by 22.2 percent between 1996 and 2007. The 30 percent decline in St Ann and the 22.5 percent decline in St Elizabeth (11.4 and 9.2 percent of the national total respectively) therefore contributed significantly to the national decline, amounting to about 20 percent of the total.

The national decline in active farmland is generally attributed to the rural-to-urban trend occurring globally, due to the pull of urban social amenities and employment opportunities. While rural-urban drift cannot entirely be attributed to the impact of bauxite mining, farmers are adamant that fertile farmland (and therefore farming) has been reduced because of bauxite mining, which probably pushed many towards urban areas.

The authors of Chapter 4 were unable to source numbers on population decline due to relocation because of bauxite mining, but they offer the experience of Lime Tree Garden as a typical example. According to resident Alvin Gallimore, Lime Tree Garden was a district of over 3,000 people, reduced to a village of roughly 600. Attendance at the primary school shrank from 480 students in the 1970s to about 170 currently.

ADVERSE SOCIAL OUTCOMES

**FINDING:** Interviewees believed that mining had a role in adverse social trends (increased poverty, crime, gambling) but this could not be proved.

Interviewees believed the removal of farmland from farming and consequent loss of livelihoods have had negative social and economic impacts. Respondents complained of increased poverty and social ills, although outcomes varied depending on the existence of alternative employment opportunities (such as tourism in St Ann), the length of time mining had occurred and its extent, and existing community cohesiveness. However, petty theft, loss of community, and gambling are islandwide problems for Jamaica, so the authors were unable to conclusively link these effects to the impact of bauxite mining.

COMPANY RESPONSE: EFFECTIVENESS OF RECLAMATION EFFORTS

**FINDING:** Farmers were adamant that soil fertility was lost because of bauxite mining, and not restored by reclamation.

After mining is completed, reclamation is required by the Mining Act to the level of agricultural or pastoral productivity or of utilization for afforestation purposes or other uses
approved by the Commissioner or the Town and Country Planning Authority. This chapter looked at the lands held by Kaiser, later Noranda, in St Ann, and by JISCO, formerly ALPART, in St Elizabeth and Manchester, and by Jamalco in Manchester and Clarendon. Farmers reported that the amount of topsoil replaced was too shallow and unable to resist heavy rainfall, unsuitable for most crops, especially fruit or other trees with deep roots but, to some extent, suitable for pasture. Government inspectors were criticized for failure to supervise reclamation contractors adequately. A 1981 survey reported 82 percent of farmers perceiving mined-out land to be worse than pre-mined.

COMPANY RESPONSE TO DUST AND OTHER QUALITY OF LIFE IMPACTS

FINDING: Communities affected by dust found the “dust nuisance” compensation offered by bauxite companies to be inadequate – between JMD7,000 and JMD8,000 per household per incident. At 2020 rates of exchange, this is between USD50 and USD55.

Interviewees consistently complained about changes to climate, including reduced rainfall, due to removal of trees. They deplored the impacts of dust from the “mud lakes,” haul roads, loading at ports, and from the mining itself because they were sure the dust affected their crops and quality of life. They distinguished between the types of dust – red and white. The red dust came from the mines and roads, while the white dust came from plant emissions. The red dust was believed to have almost destroyed citrus production in parts of St Ann, South Manchester and North Clarendon. The white dust was reported to affect human health and “burn” sweet peppers, tomatoes, and other produce.

Bauxite-alumina companies do provide compensation for what is called “dust nuisance” to those living within a certain proximity, but respondents complained the compensation was too low for the range of impacts they said they experienced, which, along with public health, included damage to crops, roofs, clothes drying outdoors, and water stored in tanks (collected via open rainwater catchments).

COMPANY RESPONSE – DIRECT BENEFITS TO COMMUNITIES

FINDING: Communities saw and valued the benefits provided by the bauxite companies at a community level, but we were not able to evaluate relative weights assigned to benefits vs. costs. Communities also appreciated the national benefits of the industry but maintained that insufficient benefits were returned to the communities in which bauxite-alumina companies operate.

Companies have provided a range of direct benefits to mining communities. These have included replacement of pit latrines with flush toilets in schools; tuition grants and scholarships; support for income generating projects such as chicken and goat rearing, bee keeping,
and other types of small businesses; technical skills training opportunities; and assistance for sports, e.g. the provision of playing fields.

With funding from the Jamaica Social Investment Fund (JSIF), the JBI spearheaded the construction of greenhouses in Manchester and St Ann to compensate for some of the farming losses associated with bauxite mining there. One hundred and sixty farmers in eight communities have benefited at a cost of JMD245 million over the lifetime of this project which began in 2014. This has not been without its problems, however, as some Community Council members reported non-functioning greenhouses – 24 out of 24 in one location for 18 months, and three out of three for four years – although new greenhouses are set to be constructed. Greenhouses are easily damaged in high winds, and the farmers may lack resources to complete repairs themselves.

Communities clearly value these initiatives, but it was not possible to evaluate the relative weights assigned to benefits vs. costs, with individuals often expressing a lack of choice – the mining was going to happen regardless, and they sought to secure at least some benefits. Requests to review the minutes of the Community Council meetings to inform an assessment of the value of the projects, and how well they were implemented and maintained, were denied by the JBI.

Those community members who appreciate the benefits offered by the industry by way of employment, foreign exchange earnings, sports, training, scholarships, greenhouses, and other initiatives are nonetheless critical of the failure of successive governments to channel sufficient funds back into mining communities.

**COMPANY RESPONSE – THE EMERGENCE OF COMMUNITY COUNCILS HAS BROUGHT GAINS FOR COMMUNITIES, INCLUDING AVENUES FOR MEDIATION AND COMPROMISE**

**FINDINGS:** The creation of Community Councils was a major achievement with its many activities and the fostering of democratic approaches. They were not, however, successful in restoring agricultural productivity to the land or eliminating pollution impacts.

The first Community Council emerged in 1990. It was born at the ALPART Sports Club in St Elizabeth following a protest of 2,000 people at the plant gate over dust from a “mud lake.” This first Council grew to represent 45 communities and was followed two years later by another in South Manchester representing 33 communities. Through its Bauxite Community Development Programme (BCDP), the JBI then aligned with community interests and promoted another 15 councils of 17 that were eventually launched in other bauxite areas. The JBI maintains that 15 Community Councils are still active, and that prior to COVID-19, they were still holding monthly meetings. The authors contacted nine Community Councils.

The Councils have provided an avenue for local people to be heard by the companies and have fostered democratic processes in the participating communities. For the companies, the
Councils have helped avert strikes or productivity losses, and provided a forum for mediation. Our study found that over the years, much depended on whether the Chairperson of the Council was from the community or was a company representative. Some residents felt that some Chairpersons acted in their own interests, rather than for the good of the community.

The Councils have produced other community-based organizations, such as the non-profit Essex Valley Community and Associates (EVCA), which enabled plant workers to get construction contracts funded by the company and contributed to student tuition and back-to-school needs.

The spirit and intention of the Councils has been to defend two main community interests – the restoration of mined-out areas to their original productivity and the control or elimination of dust pollution to protect public health and livelihoods. While there have been efforts to mitigate dust pollution and some compensation was (and still is) offered, our respondents felt the Councils have so far failed to protect broader community interests.

**COMMUNITY LIFE IN ST ELIZABETH OUTSIDE THE AMBIT OF THE BAUXITE-ALUMINA INDUSTRY**

**FINDING:** The farming communities of St Elizabeth provide an opportunity to compare economic and quality of life outcomes with those affected by bauxite mining or processing, and this research should be conducted.

Most of the land in St Elizabeth is untouched by mining, because after mining a limited area in this agricultural parish, ALPART turned to the South Manchester plateau for its ore and JISCO has so far continued there. For many farmers and small business people in St Elizabeth, the bauxite-alumina industry is of lower value compared to farming. Where mining has not interfered, they contend, it is small farming that brings better income and quality of life. These small farmers are those in the farming belt to the South of the parish around Junction, Top Hill and Ballards Valley, as well as those in the South of the Essex Valley, around Comma Pen and New Forest. St Elizabeth respondents said that tradesmen, such as welders, masons and carpenters, can earn more working for other types of business, compared to bauxite workers. Farmers now use technology their parents did not have access to – the low-tech mist-blower, plastic water tanks, weed whackers, drip irrigation tubing – as well as traditional dry grass mulching to make a prosperous living from a few acres. The current demand in the parish is for land and irrigation systems.

**ASSESSING SOCIAL IMPACTS OF INDUSTRY**

**FINDING:** State agencies responsible for protecting the public interest have not carried out the necessary data collection or research to assess the impacts of this major industry on rural communities, and they have not provided strong oversight and guidance to the bauxite-alumina industry. Owing to this failing from the very institutions established
to protect the public interest, the rural communities interviewed were adamant that the industry has inflicted clear and long-lasting damage on small farmers, their culture, and potential for enriching the agriculture of Jamaica and the country’s prospects for self-reliance.

The authors of this chapter contend that any government engaging foreign transnationals to develop a major industry has a basic duty to assess the social impact on its citizens. In the case of the bauxite-alumina industry, such an assessment would track the number of farmers, the effects on farmers, the size and productivity of their plots, any exodus to urban centres, and alternative livelihoods taken up. It would also track differences in these parameters from community to community and from company to company, as well as any accompanying changes in population, community structure and lifestyles, or other indicators of vibrant rural life. While vocal complaints, over many decades, from communities about the bauxite-alumina industry’s impact on their lives underscore the urgency for such assessments, Levy and Baker were not able to discover how many people had even been displaced by the industry.

In the view of the authors, resistance to such vital work has come from the very agencies responsible for the public interest, particularly the JBI. The JBI’s published research has focused on the financial side of Jamaica’s bauxite-alumina industry, and to some extent its social benefits, such as greenhouses, with little focus on the social impacts.

Chapter 5: Degradation of Ecological Heritage – The Impact of Bauxite Mining on Karst Ecosystems in Jamaica

SUSAN KOENIG

OVERVIEW

This chapter reviews the impact of open-pit bauxite mining on Jamaica’s natural environment, specifically the removal of agricultural vegetation or native forests, impacts to soils, the physical reshaping of landforms, and the changes to ecological processes. The processes considered are formation of new soils, regulation of microclimates, movement of water within and beyond mining areas, and the growth of new vegetation. These processes provide ecosystem services of value to humans, such as food, water supplies and climate regulation, and mining can arrest any of them. The extent to which ecosystem services can or have been rehabilitated to a functional, self-sustaining condition in Jamaica has never been rigorously assessed in the over 70 years of bauxite mining on the island. Moreover, because much of the historic and current mining in Jamaica occurs in areas where the native forest covering the ore had already been converted, mostly to agricultural-pastoral
activities, assessing the impacts of deforestation on forest-dependent biodiversity was beyond the scope of this review.

Because of the extensive data gaps, the author of Chapter 5 was restricted to a web-based literature review to determine to what extent the characteristics of karst systems are being considered by authorities to minimize and/or eliminate environmental degradation caused by bauxite mining in Jamaica.

**ABSENCE OF CRITICAL DATA FOR MINED-OUT ORE BODIES**

**FINDING:** Spatial-based analysis and field verification surveys of rehabilitated mined-out pits were not possible owing to absence of ore-body boundary data.

The original approach of this research was to: (a) review existing literature to identify post-mining rehabilitation practices from the inception of the industry in Jamaica; (b) obtain printed maps or electronic files of spatially-explicit, geo-referenced boundaries of all bauxite ore bodies which have been mined-out in the parish of St Ann; (c) obtain records of the reclamation status and rehabilitation land cover status for every mined-out ore body in St Ann; and (d) undertake field assessments to evaluate the current land cover status of rehabilitated ore bodies since certification by the Commissioner of Mines.

While the Mines and Geology Division (MGD) was able to provide data on the rehabilitation status (including land cover designation) of mined-out ore bodies under current Special Mining Leases (SMLs), the Division was unable to provide boundary data for other mined-out ore bodies. A request to the JBI for boundary data remained unanswered at the time of this report. This precluded computer-based spatial analyses and verification field surveys.

**THE EARLY DAYS**

**FINDING:** Bauxite mining interests gained the upper hand very early and this has remained the case, even as social and environmental values have changed.

Jamaican bauxite has unusual properties relating to its susceptibility to erosion, water absorption, slickness, and texture. Although large reserves on the island were quickly confirmed, mining did not proceed immediately, because overseas plants at that time did not have the ability to process Jamaican bauxite, which has a very fine grain. There was strong interest in exporting bauxite from Jamaica, owing to post-World War II industrial expansion.

Legislation was passed in 1947 to vest the ownership of ore bodies in the Crown along with regulations to govern exploration and mining on the island. Mining and exploration leases were issued for up to 40 years, which locked in practices that later became contested, as social and environmental values changed.

ALCAN and Reynolds Jamaica Mines began purchasing the largest bauxite-bearing
properties in Manchester and St Ann in 1944 and 1945, and the third entrant, Kaiser Bauxite Company, obtained access to some 136,472 acres (55,228 hectares) or 5.7 percent of Jamaica’s land area. This was followed by the construction of refineries which could handle the qualities of Jamaican bauxite to process bauxite ore into alumina using the Bayer Process. From its first export in 1952 through 2018, approximately 626 million metric tonnes (by dry-weight) of bauxite-bearing earth have been extracted from Jamaica.

**HOW BAXITE IS MAPPED, EXTRACTED, AND REHABILITATED**

**FINDING:** The process of extracting Jamaican bauxite has changed little since the 1940s and has harmful effects on the land, ecosystems, and ecological processes.

The positions of ore bodies are mapped and numbered on topographic maps, initially by hand, and then tracked as they are mined-out, rehabilitated, and certified. Archiving this mapped information is critical to ensure compliance with mining regulations and to ensure that new mining leases are not granted on already mined-out ore bodies. From the early 1970s, Geographic Information System (GIS) software meant that ore body data could be computerized, and since at least 2000, GIS technology has been used in Jamaica.

Field surveys and subsequent mining reveal the complex variations of ore body size and shape which result from the pockets, sinkholes, and troughs of the underlying karst surface of the White Limestone Formation in which Jamaica’s bauxite deposits occur.

Once the sequence of mining is determined, a network of spur and haul roads is mapped and constructed to connect pits to the mine terminus.

Before mining commences, surface vegetation is stripped away, and the topsoil and remaining overburden are mechanically removed to expose the bauxite ore. The Mining Regulations, 1947 (last updated in 2006) stipulate that “topsoil to a depth of not less than fifteen centimetres” must be removed and stacked aside for subsequent return to the pit after mining operations are over. Guidelines created by the National Restoration Committee (NRC) recommend that stripping should not be less than 30 centimetres (12 inches) but legal enforcement will be to the regulations, not to guidelines. Once all overburden is removed, the ore is mechanically extracted down to the limestone substrate.

After commercially extractable bauxite is removed, the resulting steep-sided depressions must be smoothly graded and unsightly mounds and dumps avoided. Backhoes scrape down nearby limestone hillsides to generate fill material for the void created by mining, making the depressions steeper-sided and increasing the surface area of the original ore body, while decreasing forested areas on the hillsides. This increase to the original ore body is called “swell” and, while averaging 60 percent, can exceed 100 percent of the surface area of the pit. To reclaim the pit, sometimes twice as much land must be disturbed.

Reclaimed pits remain identifiable by their vertical faces. Current reclamation guidelines specify that “vertical faces shall not exceed three metres (10 feet)”, but an exemption may be
granted by the Commissioner of Mines. Once the contours of the re-shaped pit are set, the
stockpiled overburden, described as “topsoil,” is returned by heavy mechanized equipment.
Because of the increase in surface area from pre-mined to post-mined, the depth of soil will
always be thinner unless topsoil from somewhere else is used. Critically, while the Regu-
lations specify that prior to mining, topsoil to a depth not less than fifteen centimetres must be
removed, the Regulations do not explicitly state depth requirements for soil reconstruction
during rehabilitation, only that the topsoil removed must be replaced.

There is no legislative requirement to rehabilitate haul roads, nor any forest disturbed by
road construction or pit reclamation, although appropriate conditions could and should
be required by both NEPA and the Commissioner of Mines. There are no indications that
areas of forest-covered limestone hillside destroyed during haul road construction and/or
pit reclamation have ever been accounted for under the “every hectare of land disturbed for
mining” rehabilitation requirements, even though there is an agreed policy of “no net forest
loss” caused by mining.

**EXTENT OF DISTURBANCE OF LANDFORMS**

**FINDING:** In the absence of GIS data for ore bodies and haul roads, the author could not
calculate or independently verify claims made by the JBI as to how much of Jamaica’s
land surface has been impacted by bauxite mining, or quantify the effects of creation of
forest fragments on hillsides. An argument could be made that the default assumption
should be that the entire area of all Special Mining Leases (SMLs) issued since 1947, or 17
percent of Jamaica’s land surface, has been or will be directly and indirectly impacted.

At the time of writing, the MGD had not provided any geo-referenced spatial data under an
Access to Information (ATI) request for GIS shapefiles of the boundaries of all mined-out
bauxite ore bodies for the period October 13, 1947 to February 29, 2020, although the shape-
file extension *.shp appears on maps used for certification results at least as early as 2000.

Without these maps or electronic files, the public (or, indeed, NEPA) cannot independently
verify what percentage of “every hectare disturbed by mining” has actually been rehabilitated
in accordance with The Mining Regulations. At a minimum, nearly one quarter of mined-
out ore bodies have not been reclaimed since bauxite mining began in Jamaica.

Spatially explicit, geo-referenced data on bauxite reserves which the Cartographic Unit at
the JBI reportedly maintains must have been provided to the bauxite companies because they
would have needed this data to construct volumetric models, to calculate bauxite tonnage
and thickness, to develop and report their mining schedules to the JBI, and to map surface
land ownership.
ASSESSING LAND USE CHANGES

FINDING: In the absence of GIS files and maps discussed above, we could not assess the extent of land use change caused by bauxite mining.

Until maps and GIS files become available, and with every mined-out ore body identified by its uniquely assigned alpha-numeric coding, it is impossible to assess land use changes over the short or long term. Additionally, assessments of whether natural forest regeneration is occurring in any areas planted with Napier (Elephant) Grass (*Pennisetum purpureum*) cannot be undertaken without the mapped locations of rehabilitated pits.

ASSESSMENT OF THE NATIONAL RESTORATION COMMITTEE (NRC)

FINDING: The National Restoration Committee took too long to be established (2009), has failed to designate “no mining” areas or areas to be reforested, and has not met since 2016. It exists in name only.

The National Restoration Committee (NRC) was created in October 2009, due to the recognition that there had been varying levels of compliance with rehabilitation regulations and guidelines. It is chaired by the Commissioner of Mines, with representation from industry, academia, and government. At the time of writing, the NRC had not met since 30 June 2016.

Although the problems associated with the return of only 15 centimetres of soil were known since experimental field trials were conducted by ALCAN in the late 1960s, the NRC has not addressed this issue.

The NRC is yet to present a comprehensive list of trees suitable for reforestation or designated areas to be reforested. The Forestry Department’s policy objective to strengthen the capacity of the NRC to address requirements for restoration into forest cover, and to have Forest Reserves and specially-identified Forest Management Areas declared as “no go areas” for the purpose of mining, has yet to be communicated in any meeting of the NRC.

Within the rehabilitation guidelines prepared by the NRC, the terms “biodiversity,” “functional forest,” “ecosystem,” “karst,” or “watershed/water catchment” do not appear, thus failing to establish the conditions for new development and maintenance of healthy soils for agriculture and forest communities.

CHANGES IN SOIL STRUCTURE AND FUNCTION, IMPACTS ON FORESTS

FINDING: Bauxitic soils can retain considerable amounts of water, which in turn allows the growth of large trees and forests on bottomlands. This function is lost when soils are removed – the extent of this loss cannot be calculated in the absence of maps/GIS data for mined-out ore bodies. There has been a near-total absence of effort to rehabilitate ecological processes, or to restore any kind of functional forest to mined-out land.
During exploration and mining, company representatives describe a “nuisance” water-holding capacity in Jamaican bauxite. This results from the particle size, particle shape, and particle density of the bauxite.

This water-holding capacity drives the topographic variation seen in the species composition and physical structure of tropical karst limestone forests around the world, including in Jamaica. This variation shows:

- the largest trees are found in bottomland depressions and valleys, where deep clays and organically derived soils accumulate;
- trees become smaller in stature as one ascends the slope to the hilltop/ridgeline; and
- species composition also varies with topography, soil and limestone porosity, and exposure to wind, with those species adapted to drier conditions found on slopes and hilltops.

Studies in the Brazilian Amazon, South America, Australia, and other places have revealed the importance of water held deep in the soil for the survival of forests occurring on karst landforms during drought conditions. Trees use a deep network of fine roots to extract this water from depths of at least 11 to 18 metres.

Other than studies of nutrient cycles which examined the upper 10–15 centimetres of topsoil, and although Jamaica’s Forestry Department collects measurements of “Effective Soil Depth” during biophysical inventories, no published information was found on the deep root architecture of Jamaican trees. The author assumes, however, that the roots of Jamaican trees on karst limestone function as elsewhere.

The elimination of the structural/functional component of bauxite ore, which had the capacity to hold 19–25 percent water, means that:

- we have already lost the extent and complexity of pre-Columbian forests in Jamaica;
- even if post-mining rehabilitation to functioning forests of native tree species were to become an objective, the best that could be achieved is the smaller-stature forests of peripheral limestone hills, due to the loss of the water holding capacity of the soil;
- with smaller trees, the capacity to capture and sequester carbon, both above-ground and below-ground in roots and in the soils, is forever reduced on the island; and
- until maps and/or GIS polygons of mined-out ore bodies are made available, we cannot tell how much capacity for carbon sequestration has been lost due to mining.

**TREE PLANTING AND AGRICULTURE ON RECLAIMED BAUXITE LANDS**

**FINDING:** The majority of rehabilitated mined-out ore pits have not met the standard of restoring agricultural productivity. Attempts at restoring tree crops or forests are limited. Based on rehabilitation data provided by MGD, under the currently active SMLs, less than 0.5 percent of mined-out ore bodies have been planted with a forest land use designation.
Regardless of whether attempting rehabilitation of native forest, the production of biofuels or commercial forestry of hardwoods and agricultural fruit trees on reclaimed bauxite land, planting must either be done in the rainy season or irrigated, otherwise seedlings die. If watered, seedling survival improves but growth is stunted. The reason is simply that post-mined soils are too shallow for trees. Research has shown that only grass will establish on 15 centimetres of reconstructed soil. Farmers agree that 15 centimetres of reconstructed soil can produce grass to maintain a few tethered cows, but root crops, legumes, and cash crops require soil greater than 30 centimetres in depth.

Most nutrient recycling occurs in the upper 15 centimetres of topsoil, so why has this proved inadequate? The quality of the soil material stockpiled and returned during reclamation is also important, as well as the fact that this material is returned to a compacted limestone substrate rather than to a moisture-holding bauxite foundation.

When the stored topsoil is eventually returned to a reclaimed pit, it is mixed with larger fragments of limestone pebbles and rocks. The reconstructed material is physically bulkier, has larger pore spaces, and therefore is unable to retain water as well as un-mined topsoil.

Beyond changes to water-holding capacity, soil degrades while stockpiled owing to losses of organic inputs from plants, and changes in soil microorganisms and soil fauna. Even after 20 years post-mining, a study of soil fertility in reclaimed pits found indicators of reduced soil quality compared to un-mined soils.

**GROWING GRASS IN PERPETUITY AND FACILITATING THE SPREAD OF INVASIVE SPECIES**

**FINDING:** The construction of artificial ponds to provide irrigation to greenhouses and the use of Napier grass in reclamation are in contravention to Jamaica’s responsibilities under the 1992 United Nations (UN) Convention on Biological Diversity (CBD).

Rehabilitation efforts in Jamaica include a shift to the construction of greenhouses in reclaimed pits, but greenhouses are susceptible to strong winds and Jamaica is in the hurricane belt. External water storage is also needed, which has been created by placing impermeable liners at the bottoms of reclaimed pits to create artificial ponds. This creates conditions for ponds to become breeding reservoirs for disease-transmitting mosquitoes and invasive alien cane toads. The latter ranks in the top 10 of the world’s 100 most invasive species.

Since 2003, Napier grass has been the primary post-mining treatment utilized. Napier grass is tolerant of drought conditions and able to grow on marginal, well-drained soils. The land use is then designated as “grass” or “pasture.” For an estimated 60 to 70 percent of pits which have been rehabilitated under the currently-active Special Mining Leases, Napier grass was planted purportedly to stabilize the movement of reclaimed soil, but no published data could be found to verify this claim.

The classification of Napier grass as “pasture” is misleading. While young growth can be harvested and fed to cattle as fodder, mature plants are nutritionally inadequate for
maintaining animals. The use of Napier grass does not, therefore, represent compliance under the Mining Regulations for pastoral productivity.

While it has been suggested that Napier grass is a “pioneer species” and therefore, useful in establishing processes of natural regeneration of forest, this grass is globally recognized as an invasive species. In Jamaica, NEPA designates Napier grass as a “Category 2 – Highly Invasive” species.

Promoting the usage of invasive alien plants, with no succession planning to ensure there will be turnover to native species, is counter to Jamaica’s responsibilities to the Convention on Biological Diversity (CBD) and directly contradicts the goals of the country’s National Strategy and Action Plan on Biological Diversity.

SOIL MANAGEMENT AS AN ELEMENT OF REHABILITATION

**FINDING:** Virtually no attention is paid to the rehabilitation of the processes which produce healthy soil.

There are no published figures for natural rates of soil formation in Jamaica, but it is thought unlikely to exceed one millimetre per year. Soil serves as the foundation for terrestrial ecosystems – whether agrarian or forest – so a soil management plan is a critical element in reclaiming surface-mined lands. In Jamaica, efforts can barely be described as salvage. At an absolute minimum, rehabilitation needs to be directed towards ensuring that the processes which enable soil development, create the conditions for vegetation establishment, and ensure vegetative survival and growth during natural drought cycles, are functioning before certification is granted, if the objective is to rehabilitate pre-mining productivity.

To achieve environmentally sustainable, healthy soils, Jamaica must shift from the inadequate quantity metric of 15 centimetres to one of quality. This would almost certainly require that an ore body is not mined-out to the underlying limestone, as is currently practised.

THE KARST WATER CYCLE – IT’S COMPLICATED

**FINDING:** Claims that there have been no short- or long-term impacts to underground water in karst landscapes have not been supported with the required data layers.

Only one field study was found tracing the movement of rainfall through the above-ground limestone hillsides and bauxite-filled doline and cockpit karst depressions in North-central Jamaica. That study was unable to detect dye-traced water after it penetrated the surface of the bauxitic material.

Karst hydrodynamics are complex. Water percolating through soil eventually reaches the underlying limestone, with its myriad fissures, cracks, and conduits. If there is any slope associated with the underlying geology, horizontal movement of water can be exceptionally rapid through the subterranean network of conduits and caves.
Where mining has occurred and the buffering function of thick bauxite deposits has been reduced or eliminated, rainfall will always enter the subterranean limestone conduits more rapidly than to un-mined areas. There will be a flash movement of a “packet” of water through the aquifer rather than a steadier, lower-energy discharge rate that will flow for a longer period after it stops raining. The total volume of water discharged may be identical in an un-mined vs. mined karst landscape; the difference is how long that volume remains available for usage by all communities – natural and human – both locally where the rain fell and at the wider scale of the watershed.

In order to estimate the localized and cumulative impacts of bauxite mining, a model would require GIS data on location, depth, and volume of every bauxite deposit extracted from the landscape, the *in-situ* moisture gradient of every ore body prior to mining, the network of haul roads, the land cover prior to mining, daily rainfall data, and daily surface river discharge rates.

**WATER STORAGE AND DUST**

**FINDING:** Although the absence of surface water is one of the defining characteristics of karst landscapes, there has been a fundamental failure to appreciate how intercepted rainfall is stored in these areas, and it has not been studied.

While some dust is generated during the excavation and loading of trucks, anywhere from 78 to 97 percent of dust is generated along unpaved haul roads. Depending on many variables, fugitive dust of the size to cause respiratory problems in humans can travel at least 30 metres beyond its source and will remain on a surface until washed-off, blown further afield, or it settles in a water catchment.

In nature, epiphytic tank bromeliads (wild pines) catch, condense, and retain rainfall in the cup-shaped base of the plant providing habitat for organisms with an aquatic stage in their lifecycle, food for larger predators, and a source of drinking water for other animals. Tank bromeliads are a key component of the ecological food web in karst landscapes. We were not able to discover any research on the condition of bromeliad communities in proximity to haul roads.

Humans in karst landscapes also use a variety of rain-interception and water-storage facilities. There are at least 98 hillside water catchments within current Special Mining Leases (SMLs) and an additional 29 within a one-kilometre radius of the leases. Together, these serve 90 major communities and countless smaller villages. As best as can be determined, not a single public water catchment has been monitored for mining-derived fugitive dust. If water quality or storage capacity is compromised, it is the responsibility of Municipal Corporations, not the bauxite companies, to address the problem.
BEYOND THE MINES: CONTAMINATION OF KARST GROUNDWATER AND SURFACE RIVERS

FINDING: Although improvements have occurred during the life of the industry, the management of the waste generated by alumina processing is not conducted according to international best practices, and causes impacts to ground water and surface rivers in Jamaica.

The Bayer Process used to extract alumina from bauxite ore produces a toxic slurry of bauxite waste residue (red mud), which is highly alkaline, highly saline, has high sodicity⁴, and a higher concentration of certain heavy metals.

In the earliest period of bauxite processing in Jamaica, the toxic slurry was discharged directly into mined-out pits near the factories. Up to the mid-2010s, it was estimated that approximately 350 million tonnes of bauxite residue would have been produced in Jamaica, but there was little documentation of “red mud” disposal practices from the 1950s to the 1980s in Jamaica, resulting in contamination of groundwater.

The liquid waste was deposited in man-made settling ponds and lakes which originally had unsealed clay substrates. Eventually, substrates were sealed, but during high rainfall events overtopping as well as breakaways of embankments occurred. If the slurry of bauxite residue was not fully neutralized before being discharged into the “mud lakes” there was contamination of surface water bodies and ground water, either via overtopping or vertical drainage through the underlying limestone.

Since the mid-1980s, dry stacking by the Robinsky disposal system has been used at Ewarton in Jamaica. This involves evaporating the bauxite residue slurry to a density of at least 48 percent solids (compared to 18 to 20 percent solids with lake storage), depositing it on a land surface, and then allowing it to further evaporate/consolidate before a successive layer is deposited. A slope eventually forms, allowing rainwater to run off – but to where? – and minimizing liquid stored in the disposal area.

BEYOND THE MINES: RESIDUE DISPOSAL AREAS – DUST AND REMEDIATION

FINDING: Some remediation has been attempted but there are still considerable dust impacts from mud lakes and dry stacks which require management oversight from the companies. It does not appear that the desired end state of remediation has been defined.

The surface of “mud lakes” and “dry stacks” must be kept moist either by rainfall or sprinklers, otherwise surfaces dry out and Jamaica’s fine bauxite dust becomes airborne. The 2008 global recession resulted in reduced management and oversight by bauxite companies in Jamaica, and these residue disposal areas became dust bowls, impacting nearby communities.

The long-term solution is establishing permanent vegetation cover on all bauxite residue

⁴ Presence of sodium attached to clay in soil
disposal areas (BRDAs) and vegetation remediation efforts have been underway since the mid-1990s on a small subset of the old residue storage ponds near Kirkvine in Manchester and more recently, at the Mount Rosser “mud lake” near Ewarton. This “lake” was created through the damming of a valley in 1959 and has been undergoing drainage and remediation under a closure process guided by Natural Resources Conservation Authority (NRCA) (Wastewater and Sludge) Regulations, 2013. These regulations, which identify red mud as “industrial sludge,” govern the removal of infrastructure and contamination but do not define any end state criteria.

Defining an end state is critical. A 2005 vegetation assessment for the Kirkvine Pond #6 which was planted with five species, has been described as comparable to a dry limestone forest in Jamaica. Even while species diversity was poor, the centre of the pond had open patches of ground, and most species occurred at the edges of the pond where soil types were different, suggesting that re-vegetation was creeping in from the peripheral forest found naturally on the adjacent hillside. Maximum root depth of trees halted at 1.4 metres below the surface, which reveals the importance of reconstructing soils post-mining to a depth greater than 15 centimetres if trees are to be the desired end-state, while also indicating that the functional hydrology of the Kirkvine rehabilitation effort remained compromised.

The potential for bioaccumulation of toxic elements, especially heavy metals, should also be given attention for ensuring the long-term safety of environmental and public health.

INFORMATION ON COMMUNITY WATER SUPPLIES, LEVEL AND QUALITY

FINDING: The only easily accessible online data on water quality is 20 years out of date. Real time data on aquifer water quality have never been easily available to the public. Data on ground water levels are easily accessible up to the end of 2019.

In 1994, the JBI was delegated responsibility by the NRCA to monitor water quality in collaboration with the Underground Water Authority, the precursor to the current Water Resources Authority (WRA). Although the JBI’s website confirms that it is engaged in water quality monitoring, no monitoring data, quarterly summary statistics, or annual quantitative reports on water quality parameters could be located on the JBI’s website. Submitting ATI requests to the JBI for monitoring data was beyond the scope of the study.

WRA’s online Ground Water Information System (GWIS) includes a comprehensive database of the >1000 wells drilled in Jamaica, and the WRA has claimed to provide online data on quality and quantity of surface and underground water for the public. According to the GWIS, of the 150 wells owned by bauxite companies, only 19 have been monitored for water quality for at least one year, and all 19 are associated with the Nain plant in St Elizabeth. Water quality data for 18 of these 19 wells end on 31 December 1999. Similarly, of the more than 70 wells owned by the GOJ which are within 15 kilometres of the “down aquifer” flow of the alumina factories, only six had water quality reports available on the GWIS database.
Five of the six are associated with Nain, while the sixth well would have been affected by the now-derelict Revere facility. The Nain wells are part of the set of Pepper wells which provide water for Mandeville, the capital of Manchester Parish.

Ground water levels, in contrast, are much more consistently reported. The GWIS online database has data through 2019 for ground water levels of 43 company-owned wells.

**A Legacy of Damage and Sustained Abuse of the Land**

**Finding:** Jamaica’s Charter of Fundamental Rights and Freedoms guarantees all its citizens “...the right to enjoy a healthy and productive environment free from the threat of injury or damage from environmental abuse and degradation of the ecological heritage.” Since bauxite mining began in Jamaica long before there were regulatory requirements for descriptions of environmental conditions prior to mining leases being issued, the true and complete extent to which Jamaica’s ecological heritage has been damaged can never be fully known. The absence of data, of course, does not mean that irreversible damage has not occurred, and mining industry stakeholders acknowledge there is a legacy of damage and sustained abuse, from the nearly one-quarter mined-out ore bodies which have yet to be reclaimed, to inadequate storage of bauxite residue.

**Finding:** Until bauxite mining in Jamaica is evaluated within a holistic framework of karst characteristics and processes – the distributions and functions of soils, the surface and subsurface movements of water, the adaptations of plants and animals to karst geology and hydrology – the distributions and functions of soils, the surface and subsurface movements of water, and the ecosystem services of karst landscapes, such as Cockpit Country, will never be effectively protected from mining impacts.

---

**Chapter 6: The Social Costs of Bauxite-Alumina Production in Jamaica**

**Ernie Niemi**

**Overview**

The bauxite-alumina industry generates important economic benefits for Jamaica: industrial products exported to the global economy, jobs for workers, sales and income for local vendors, and revenue for the government. The industry’s contribution to Gross Domestic Product (GDP), a common measure of the cumulative benefits, is about USD1 billion per annum. The industry also potentially imposes many social costs (or externalities) on
Jamaicans. Chapter 6 provides an overview of these costs, but there was insufficient data to quantify them except for two types – increases in human illnesses and premature deaths from specific air pollutants, and intensification of the climate crisis from emissions of carbon dioxide. These two costs alone total USD4.7 billion–USD19 billion per annum.

**WHAT ARE SOCIAL COSTS AND HOW ARE THEY MEASURED?**

Social costs are also called externalities. These are costs which are not borne by the industry’s owners but instead by the society at large, as well as future generations.

Examples of social costs are loss of life or illness due to pollution, reduction in quality of community life caused by displacement of families or entire communities, and degradation of natural or cultural resources. There are also increased risks posed by accidents, spills, or failure of dams/mud lakes.

Economists assess social costs in one of two ways: (a) measuring Willingness to Pay (WTP), which investigates how much a person would pay to eliminate harm from an industry, or (b) measuring Willingness to Accept (WTA), which looks at how much compensation individuals want from an industry if the harm is to continue.

**SOCIAL COSTS IMPOSED BY THE BAXITE-ALUMINA INDUSTRY ON JAMAICANS**

**FINDING:** The considerable social costs imposed by the industry have not been fully described or quantified.

Chapter 6 presents a partial list of the many ways in which the bauxite-alumina industry imposes social costs on Jamaicans because of its activities. These include:

- Displacement of families and communities, which causes breakdown of community life, loss of livelihoods, reduction in subsistence food, and loss of asset value (home, land).
- Noise and light pollution, which reduces quality of life through loss of sleep.
- Transportation along haul roads causing dust, resulting in public health impacts, and damage to water catchments, crops, and property.

See Table 10 on pages 202–210 for the full list.

**QUANTIFYING THE SOCIAL COSTS**

**FINDING:** Jamaica has not developed a comprehensive estimate of the social costs of the bauxite-alumina industry, but some global information is available.

Some social costs are more easily measured than others. For example, increased health care costs due to illness caused by an industry can be counted. Many social costs, however, are more difficult to measure, because they are not traded in markets and have no price. These
include the pain and suffering that people endure when they are made ill by air pollution, as well as reductions in well-being that result from degradation to the environment.

**ILLUSTRATION OF THE SOCIAL COSTS OF COAL MINING IN CESAR, COLOMBIA**

**FINDING:** The costs of mining and producing coal in Colombia in 2012 exceeded the benefits.

Researchers recently developed sufficient data to estimate many (but not all) of the social costs imposed on the local community and the nation by coal mining in Cesar, Colombia in 2012 (See Table 11 for details). Overall, the estimates of social costs on Colombians are USD110.10–161.01 per tonne of coal mined and exported. The market price per tonne of coal in 2012 fluctuated between USD90.3 and USD100.57 per tonne, so the costs of producing coal exceeded the benefits.

**HUMAN HEALTH COSTS OF AIR POLLUTION IN JAMAICA**

**FINDING:** Estimated health costs for Jamaica are USD2.9 billion-USD13 billion (three pollutants only).

Data from Jamaica and the USA provide initial estimates of the human-health-related social costs resulting from the bauxite-alumina industry’s air emissions. The Jamaican industry emits about 4,500 tons of PM$_{2.5}$ (Table 12), which was determined by adjusting data for the emissions of PM$_{10}$ (particulates, with diameter of less than 10 micrometres) and assuming that PM$_{2.5}$ constitutes two-thirds of PM$_{10}$ emissions. Data from the U.S. show the social costs resulting from each ton of each pollutant emitted into the atmosphere, and these figures are used to estimate the social costs for emissions in Jamaica. The social cost for PM$_{2.5}$ emissions is USD120,000–USD750,000. The health-related social cost per ton yields the social cost per annum for each pollutant: USD540 million–USD3.4 billion for PM$_{2.5}$. New research has shown that these estimates for PM$_{2.5}$ are understated. Overall, the estimated social costs (mortality and morbidity) of the Jamaican bauxite-alumina industry’s emissions of three pollutants (PM$_{2.5}$, SO$_2$ and NO$_x$) are between USD2.9 billion and USD13 billion annually, not including PM$_{2.5}$ from dust on the haul roads.

**VALUE OF ECOSYSTEM SERVICES**

**FINDING:** Jamaica’s forests provide value of approximately USD52 million per annum.

Chapter 6 describes a range of ecosystem services, including provision of fresh water for crops, industry and domestic use; regulation of flooding; habitat for animals used as food for humans (such as fish); opportunities for recreation; carbon capture and storage; and many others.
Research conducted for the World Bank estimated the WTP value of four types of ecosystem services provided by Jamaica’s forests: recreation, habitat and species protection, non-wood forest products, and water. The estimates indicate that each year, these four ecosystem services have a value of about USD154.20 per hectare (2013 dollars), and this value, applied across all the country’s forests, totals about USD52 million (Table 14). These estimates indicate that the present value of these services would total about USD2,340 per hectare.

**CLIMATE-RELATED SOCIAL COSTS**

**FINDING:** The social cost of carbon for the bauxite-alumina industry in Jamaica is between USD0.8 billion–USD6.5 billion.

In 2012, the bauxite-alumina industry emitted 1,791,827.91 tonnes of CO$_2$ as it produced 9,372,801 tonnes of bauxite, or about one tonne of CO$_2$ for every five tonnes of bauxite. In 2018, the industry produced 10,272,268 tonnes of bauxite, indicating that the industry’s CO$_2$ emissions had risen to 1,963,780 tonnes.

Each tonne of CO$_2$ emitted will intensify the damage from the climate crisis (global warming, ocean acidification, etc.) for decades. The social cost of carbon dioxide (SCCO$_2$), is expected to total USD417 per tonne CO$_2$ (tCO$_2$). Other estimates are up to eight times higher.

Combined, these numbers show that the social costs resulting from the CO$_2$ emissions of the bauxite-alumina industry are at least USD0.8 billion–USD6.5 billion per annum from direct emissions from the burning of fossil fuels.

**SOCIAL COSTS FROM DEGRADATION OF BIODIVERSITY**

**FINDING:** Greater benefits would be earned from protection or restoration of biodiversity than any activity which degrades it.

The Government of the United Kingdom (UK) recently assessed the economic costs resulting from actions that degrade biodiversity. The assessment concluded that actions that conserve or improve biodiversity have an average rate of return on investment of about 19 percent, whereas actions that degrade biodiversity or prevent its conservation have an average rate of return of about five percent.
CONCLUSION

FINDING: The social costs of the bauxite-alumina industry far exceed its economic benefits to Jamaica. Using only two categories of social costs, the industry’s social costs exceed the economic benefits by at least USD2.7 billion – 18 billion per annum.

The bauxite-alumina industry imposes social costs on Jamaicans in many ways. Currently available data support quantification of just two categories of social costs – human health costs and the social cost of carbon. The health cost represents those costs associated with increases in human illness and premature death resulting from the industry’s emissions of harmful airborne pollutants: PM$_{2.5}$, SO$_2$, and NO$_x$. The human health costs resulting from the industry’s emissions of these three air pollutants are about USD2.9 billion–USD13 billion per annum.

The social costs resulting from the industry’s annual emissions of carbon dioxide are about USD0.8 billion–USD6.5 billion.

Combined, these two categories of social costs total about USD4.7 billion–USD19 billion per annum. The actual total social costs from the industry’s operations are much larger, insofar as currently available data are not sufficient to support quantification of several categories of costs.

The contribution of the bauxite-alumina industry to Jamaica’s GDP is about USD1 billion per annum, estimated at 5 percent of GDP of USD27 billion in 2018.
Introduction

DIANA McCaulay

The Jamaica Environment Trust (JET) has been working on the environmental and public health impacts of the bauxite-alumina industry since 2003. In our role as environmental advocates, we have responded to concerns from community members all over the island regarding their health, reduced quality of life, and loss of small farming livelihoods. We have reviewed Environmental Impact Assessments (EIAs), attended many public and stakeholder meetings, produced a health impact study on mining communities in 2015, reviewed best environmental management practices for the mining and quarrying industry in Jamaica in 2016, and conducted an ongoing Save Cockpit Country campaign since 2006. As we carried out this work, we were struck by the lack of accessible and comprehensive information on the costs and benefits to Jamaica of bauxite mining and processing. In this context, a multi-disciplinary study of the industry was proposed at a September 2019 stakeholders’ meeting. In collaboration with the Environmental Law Alliance Worldwide (ELAW), one of JET’s long-standing partners, we contracted experts to interrogate six aspects of the bauxite-alumina industry. These were: its history; regulatory framework; impacts on public health, society and the natural environment; and its social costs or externalities. This document is the outcome of that work.

Bauxite mining began in earnest in Jamaica in the 1950s and has without question been an important contributor to the island’s economy, but its costs have not been sufficiently investigated or quantified. This study seeks to fill that gap. This work had its origins in concern for a specific place – Cockpit Country – and a reader will see this framing and focus in many chapters. Cockpit Country is the largest remaining natural forest in Jamaica, located in the island’s west-central interior. It is a repository of extraordinary biological diversity, a sanctuary for endangered species, and sits over a large aquifer which stores and releases fresh water via almost 40 rivers, streams, springs, upwellings, glades, and ponds. It has been estimated that the rivers which are fed by this aquifer supply about 40 percent of western Jamaica’s freshwater needs. Cockpit Country also has historical and cultural significance for Jamaicans, as it is the place where the Windward Maroons fought the British to a treaty in 1739.
The Cockpit Country Protected Area (CCPA) was announced by the Prime Minister, the Most Hon. Andrew Holness, in November 2017, along with assurances that no mining would be allowed within its boundaries. At the time of writing, however, an ongoing ground-truthing exercise to settle the boundary of the protected area has not yet been completed. The protected area has therefore not been declared under law, a Special Mining Lease has already been issued for an area in the Northeast which remains contested as to whether it is inside or outside Cockpit Country, and a required Environmental Impact Assessment (EIA) has not been completed.

Other communities in the South and Southwest have also insisted that they do not want bauxite mining in proximity to their communities and have resisted the setting out of the ground-truthing markers, even removing some, along with many different types of rally, protest, and media campaign in 2018 and 2019. Groups who have long worked in the area, such as Windsor Research Centre (WRC) in the North, Southern Trelawny Environmental Agency (STEA) in the Southeast, and the Cockpit Country Stakeholders Group (CCSG), have continued their efforts to get Cockpit Country protected, presenting the Prime Minister
with a petition with over 35,000 names in 2017. New groups and social media coalitions have also formed, such as the Cockpit Country Local Forest Management Committees (LFMC), Cockpit Communities for Conservation (CCC), Cockpit Country Warriors, and Protect Cockpit Country. We hope our study will be a useful resource for decision makers and all Jamaicans who would like to see this vital natural, cultural, and historical area protected, as well as for communities in other parts of Jamaica affected by the bauxite-alumina industry.

Our approach to this body of work included a call for proposals in March 2020, followed by shortlisting, interviews, and contracting. Short biographical statements from the authors are included at page 221. Authors had considerable latitude in their approach and for the most part, their words are their own, but JET has edited for readability and repetition between chapters. JET was also responsible for seeking information from state agencies, using the Access to Information (ATI) Act, as well as review, editing, and graphic design. A draft version of this document was shared with a list of stakeholders, provided at page 223, but no input was received within deadlines.

While every effort has been made to ensure the accuracy of the information presented in our study, there were many questions which remained unanswered at the printing deadline, and important information was either unavailable or not provided to us. We will do our best to update and correct any errors of fact pointed out to us by using errata for the printed document and corrections for the electronic version.

We do not claim our study covers every aspect of the bauxite-alumina industry and most, if not all chapters, were hampered by lack of data. We did not, for example, investigate loss of biological diversity due to bauxite mining or processing. We did not include a chapter on the risks presented by the “mud lakes” or Bauxite Residue Disposal Areas (BRDAs), or their impacts on surface water. We are aware that rehabilitation of the “mud lake” at Mount Rosser is underway, but this was not described in any depth in this study. Our review of environmental regulatory practice was limited to case studies of two bauxite operations – one mining and one processing facility.

The main findings are presented in an extensive executive summary on pages 1–36.

Chapter 1, written by Tina Renier and Jordan Howell, traces the history of the bauxite-alumina industry from the discovery of bauxite in Jamaica in 1942, through bauxite’s heyday in the late 1950s and 1960s when Jamaica was the world’s largest producer of bauxite, to the social and economic benefits provided to the country by the bauxite levy instituted in the 1970s. Reiner and Howell describe the struggles of rural communities for access to land, the importance of the industry in nurturing a vibrant labour movement, and the loss of Jamaica’s competitive advantage in the 1980s. Over the next 40 years, the industry underwent a series of major transformations, with reduced employment and trade union influence, the replacement of the levy with a tax regime, declining contributions to government revenues, and adverse impacts to the environment. The global recession of 2008 had severe effects, with plant closures and loss of jobs and, at the time of writing, the impact of the COVID-19 pandemic is unknown.
Chapter 2 on the regulatory framework was written by environmental and industrial chemist, Anthony Greenaway. It outlines the evolution of the many laws, guidelines, and regulations governing bauxite mining and processing, from the Mining Act in 1947 to the Natural Resources Conservation Authority (NRCA) Act in 1991 and its several subsequent amendments. It also includes an in-depth look at the on-the-ground practice of permit issue, modelling, monitoring, and enforcing the regulations, particularly the role of the Jamaica Bauxite Institute (JBI) and the National Environment and Planning Agency (NEPA).

Public health specialist, Patrece Charles, wrote Chapter 3 on the bauxite-alumina industry’s impacts on public health, using three existing studies on the health of communities in proximity to one of the bauxite processing facilities. These studies were her own PhD research in 2007, a Health Impact Assessment of Clarendon communities conducted by the Ministry of Health in 2008, and a study carried out by JET in 2015 comparing the health outcomes of mining communities, including one in proximity to bauxite processing, with control communities.

Chapter 4 explores the social impact of the bauxite-alumina industry and was written by civil society advocate Horace Levy and sociologist Peta Anne Baker, using interviews with affected residents – often members of Community Councils – as well as other academic studies and reports. The authors explore both the positive and negative roles of the industry – fostering the development of collective bargaining to improve workers’ rights in Jamaica and providing benefits to communities, such as water supplies, various grants to individuals and families, support for community assets, and the building of greenhouses, but also the decline of small farming livelihoods and rural quality of life.

Chapter 5 investigates the impacts of the bauxite-alumina industry on the natural environment and was written by wildlife ecologist and Cockpit Country resident, Susan Koenig, of Windsor Research Centre. Dr Koenig takes an in-depth look at the imperfectly understood complexities of karst systems and landforms, especially the water-retaining qualities of bauxitic soils, and the effectiveness of the legislation, approach, and practice regarding rehabilitation efforts after mining is over.

Natural resource economist, Ernie Niemi, wrote Chapter 6 on the social costs of the bauxite-alumina industry, outlining some of the principles and challenges in assigning costs to a wide range of externalities, referring to the few studies that have been done in Jamaica and using comparative figures from other countries and industries to illustrate just how large these uncounted costs are.

We hope that this report, *Red Dirt: A Multidisciplinary Review of the Bauxite-Alumina Industry in Jamaica*, will continue an important conversation on the past, present, and future of one of Jamaica’s important economic activities, particularly with regard to the as yet unsettled protection of Cockpit Country, and in the larger context of the undeniable adverse impacts to Jamaica’s land and people, and the climate emergency.
According to the Jamaica Bauxite Institute (JBI) the bauxite companies which are currently operating in Jamaica are as follows:

**ALUMINA PARTNERS OF JAMAICA (ALPART)** is located at Nain, St Elizabeth, in the South of Jamaica. The company was first established in the early 1960s by the union of three companies (Anaconda, Kaiser Aluminum, and Reynolds Metals). Since then, it has undergone several partnership and ownership changes, the last of which took place in 2017, resulting in full ownership of the company being transferred to Jiuquan Iron & Steel Company (JISCO). The refinery was closed in 2009 in the wake of the global financial crisis. In June 2017, the refinery reopened with its new owners, JISCO, at the helm. The ALPART facility has a capacity of 1.65 million tonnes, which makes it the largest refinery in Jamaica. It is currently closed, due to the COVID-19 pandemic.

**JAMALCO** is located in Clarendon and is a joint venture between General Alumina Jamaica LLC (formerly known as Aloca Minerals of Jamaica, LLC) and Clarendon Alumina Production Ltd. (a wholly owned Government entity). Effective 1 December 2014, the Noble Group acquired ALCOA Minerals of Jamaica from ALCOA. As a result, the Clarendon Alumina Works refinery and related mining and port operations, which continue to be carried out under the name “Jamalco,” is owned 55 percent by General Alumina Jamaica LLC (GAJ) and 45 percent by Clarendon Alumina Production Ltd (CAP). Initially, only bauxite was mined and exported from the Rocky Point port in Clarendon, with the first shipment of bauxite leaving from that port for the United States of America (USA) in May 1963. The first shipment of alumina took place nine years later in May 1972, following the construction and opening of the refinery. The refinery has undergone upgrading over the years, with the latest done in 2007. The current design capacity of the Jamalco refinery is 1.416 million tonnes per annum.

**NORANDA JAMAICA BAUXITE PARTNERS II**, formerly St Ann Bauxite Jamaica Limited and prior to that Kaiser Jamaica Bauxite Company, is a partnership between Noranda Bauxite Limited (NBL), a Jamaican limited liability company, and the Government of Jamaica (GOJ). Noranda Bauxite Limited has a 49 percent interest in the partnership and holds and operates the physical mining assets and operations. The GOJ owns the remaining 51 percent. A concession from the GOJ permits Noranda Bauxite Limited to mine bauxite in Jamaica through
2030. Bauxite is mined at St Ann and the ore is transported via railway to Port Rhoades. There, it is dried and shipped to its customers. A considerable portion of the bauxite mined at St Ann is shipped to the Gramercy refinery in Louisiana, where it is refined into alumina. Major expansion work in 2011 resulted in a production capacity boost from 4.5 million tonnes of bauxite ore per annum to 5.4 million tonnes per annum.

**WEST INDIES ALUMINA COMPANY (WINDALCO)**, formerly Jamalcan, is owned by United Company (UC) Rusal. The entity comprises two alumina plants – Ewarton Works in St Catherine and Kirkvine Works in Manchester. The company owns bauxite mines in Schwallenburgh (Ewarton) and Russell Place (Kirkvine) and farms in Manchester and St Ann. Shipments depart Jamaica from its shipping port, Port Esquivel, on Jamaica’s South coast. Alumina processing started at Kirkvine Works in December 1952. With the growing demand for alumina in the 1950s, Kirkvine Work’s production capacity was expanded in a series of construction programmes, from 220,000 tonnes per annum in 1954 to 550,000 tonnes by 1968. In 1956, construction work began on a second alumina plant at Ewarton in St Catherine. The plant’s initial design capacity called for 250,000 tonnes of alumina per annum, with provision for further expansion in its design. Alumina was first produced at Ewarton Works in October 1959. Today, Kirkvine Works is in a decommissioned state after production ceased during the first half of 2009 when depressed market conditions emanating from the global financial crisis rendered operations unviable. Ewarton Works, which also closed in 2009 but reopened in 2010, remains operational. Ewarton Work’s production capacity stands at 600,000 tonnes of alumina per annum.
1. Mining the Land
The Past and Future of the Bauxite-Alumina Industry in Jamaica
TINA RENIER AND JORDAN HOWELL

“The story of the Jamaican people is essentially the story of a struggle for land. It is this simple fact that underlies the impact of bauxite mining and alumina production on the lives of the Jamaican people.”
—George L. Beckford

OVERVIEW

For nearly seven decades, extracting, processing, and exporting bauxite and alumina has transformed Jamaica. The origins of Jamaica’s bauxite-alumina industry can be traced to the 1940s, when three North American aluminum corporations – the Aluminum Company of Canada, Reynolds Metals, and Kaiser Aluminum – incorporated Jamaican bauxite into an already globalized complex of mines, refineries, and smelters. This paper examines not only how the aluminum industry has transformed Jamaica’s economy, society, and environment, but also how Jamaicans have shaped the trajectory of the global aluminum industry.

We begin by placing the development of the bauxite-alumina industry in Jamaica within the longer history of the North American aluminum industry. We then turn to a discussion of economic development. Here we consider how Jamaican politicians hitched the island’s economy to the bauxite-alumina industry, and explore the long-term consequences of this development policy. We then consider the history of the industry from the perspective of labour. Since the 1950s, thousands of workers have dug up and refined bauxite into alumina, propelling the industry’s post-war growth. Though many commentators have pointed to the benefits and high wages in the bauxite-alumina industry as evidence that it was a privileged sector of the economy, it is important to emphasize, as we argue, that wages and workplace benefits were won through unionization and collective struggle.
Although one cannot understand the history of the bauxite-alumina industry in Jamaica without attending to labour and development policy, it is important to pull back and consider the wider social and natural worlds in which the industry was embedded. In our final section, we consider these wider worlds with an eye to the future. The growth of the industry transformed the lives of many Jamaicans who had never worked in the industry, including the urban residents of Mandeville and Kingston, many of whom mining displaced, and the rural farmers of Gibraltar who have lived with the vibrations, dust, and noise of mining for decades. To understand the contemporary conflict over mining in Cockpit Country, we must place discussions of foreign exchange and wages within this wider field of vision. We must read the visions of development the industry embodied alongside the visions of the industry’s critics, and both in light of the ways mining and refining bauxite has transformed social, political, and environmental relations in Jamaica. Although struggles over workplace conditions and the right to land have often been placed at the margins of debates about the industry’s future, we argue that they should be at the centre.

ORIGINS

The aluminum industry emerged in Pittsburgh in the heat of the United States’ own industrial transformation. In the 1880s, the Mellon Family funnelled money into the Pittsburgh Reduction Company, a small firm that had developed an electrolytic reduction process –
known as the Hall-Héroult process – to produce aluminum (Chandler, 1977; Sheller, 2014). The Hall-Héroult process requires running large amounts of electricity through a molten bath in order to split bonded aluminum oxide (alumina) into free-floating aluminum metal. Owing to a patent on the Bayer Process required to refine bauxite into alumina, the Pittsburgh Reduction Company had to purchase its alumina from the Pennsylvania Salt Company (Smith, 1988). As a result of the patent, alumina accounted for nearly half of the total cost of producing one ton of aluminum (Skrabec, 2016, 60).

Once the patent expired on the Bayer Process, and the smelting of aluminum proved profitable, the Pittsburgh Reduction Company integrated backward into mining and refining bauxite. In 1903, the Pittsburgh Reduction Company built its first alumina refinery in East St Louis, Illinois, in order to process the bauxite that the company mined first in Arkansas (1899), and later in Surinam and Guyana (Smith, 1988; Storli, 2013). With this backward integration into mining and refining complete, the Pittsburgh Reduction Company rebranded itself the Aluminum Company of America (ALCOA) in 1907. In 1928, Arthur Vining Davis officially spun ALCAN (then Aluminum Limited) off from the parent company ALCOA, in order to operate ALCOA’s international operations, with the exception of ALCOA’s operations in Surinam.

Military demand for aluminum during the Second World War transformed the industry (Evenden, 2011; Sheller, 2014). As the Allied powers constructed thousands of airplanes to fight the war, the production of aluminum in North America increased nearly fivefold. While wartime conditions stimulated demand, they also strained traditional supplies and made South American ore liable to enemy attack. When bauxite was discovered in Jamaica in 1942, state planners and corporate investors began to see the island as the future bedrock of the North American aluminum industry (Davis, 1989; Ingulstad, 2013). Despite differences between Jamaica’s bauxite and deposits found in Arkansas and South America, which required investing in novel refining processes, Jamaica’s deep ports and proximity to the United States (US) made it an ideal site for corporate investment. Owing to fears about ALCOA’s monopoly power, which had only grown during the war, the US government provided Reynolds Metals and Kaiser Aluminum with loans and government-financed plants built during the war in order to produce a competitive aluminum industry (Smith, 1988). Both Reynolds and ALCAN drew on loans from the US government to develop their operations in Jamaica (Davis, 1989; Ingulstad, 2013). By 1957, Kaiser Aluminum and Reynolds Metals had become major competitors to ALCOA in the US, and Jamaica the world’s largest producer of bauxite.

**DEVELOPMENT**

After the first shipment of bauxite left the Reynolds’ port at Ocho Rios in 1952, bauxite mining and alumina refining in Jamaica expanded at a breakneck pace. The industry’s exceptional growth placed it at the centre of debates about the island’s economic develop-
ment. But we must unpack the link between bauxite mining and development. After the Second World War, the meaning of development was hotly contested, particularly across the formerly colonised and decolonising world (Escobar, 1995; Cooper, 2010; Macekura & Manela, 2018). A central problem concerned the meaning of industrialisation, particularly in plantation societies, whose profits depended first on enslavement and then on the unequal integration of racialised labour in the world economy. Across the British West Indies, the Labour Rebellion of 1938 shook the foundations of plantation society. As a result of the Rebellion, Whitehall commissioned a study of social and economic conditions in the British Caribbean, the result of which was the Report of the West India Royal Commission (Moyne Report), published in 1945. The report is perhaps the single most important document for understanding colonial economic policy in the British West Indies after the Second World War. The Moyne Report argued ultimately that agriculture, not industry, provided the most promising path to development in Jamaica.

The prospect of a future bauxite and alumina industry served, in many respects, as a foil to the Moyne Report’s pessimistic conclusions about the impossibility of industrialisation in the British West Indies. Mining and alumina refining, which no one could deny were industrial activities, provided a powerful symbol of a world beyond the plantation, particularly for the first generation of nationalist leaders in Jamaica. But was this industrialisation? According to the St Lucian economist, W. Arthur Lewis, it was not. True, Lewis’s views on “industrialisation by invitation” have often been cited as an endorsement of foreign investment in the bauxite-alumina industry. Yet, Lewis’s views were considerably more complicated (Figueroa, 2004). “Those who speak as if the choice in the West Indies lay between agricultural development and industrial development,” Lewis argued, “have failed completely to understand the problem” (Lewis, 1950).

Lewis proposed a two-horned policy that began with agriculture. First, the government should fund an industrial development corporation to “go into one of the dry and undeveloped plains, sink money in irrigation, offer guaranteed prices on long contracts, supply seeds, fertilisers, mechanical equipment and whatever other capital is required by the farmers” (Lewis, 1947). At the same time, this agricultural policy had to be supplemented with labour-intensive manufacturing. Lewis expressed concern that mining industries – which had become increasingly capital intensive – could not produce the number of jobs needed to complement improvements in agricultural efficiency. Mining also posed a threat to sovereignty, in Lewis’s view, because it was very easy for corporations and foreign investors to maintain control of resources they had secured, particularly under colonial conditions (Lewis, 1950). For Lewis, then, capital-intensive mining was not the kind of industrialisation he envisioned as a supplement to coordinated agricultural development.

Although Lewis presented strong arguments against a view of industrialisation that was not grounded in agricultural transformation, his broader vision received little traction within policy-making circles. Whitehall was not exactly willing to open its purse to policies Lewis endorsed, particularly if it did not benefit – or worse, harmed – the metropole. This reflected Jamaica’s unequal integration within the British Empire. Once mining began, sustained
discussions of alternative development pathways were few and far between. The debate shifted from whether bauxite should be mined to more concrete questions of how to increase foreign investment and secure greater rents from the industry (Davis, 1989).

The periods of highest economic growth in Jamaica in the second half of the twentieth century corresponded to investment in large-scale construction projects in the bauxite and alumina industry, as ALCAN, Reynolds, Kaiser, ALCOA, Revere, and Anaconda invested in trams, ports, airports, railways, silos, mining equipment, and refineries (Barclay and Girvan, 2013). In the 1950s and 1960s, each of the companies established ports to ship bauxite or alumina – Reynolds at Ocho Rios, Kaiser at Discovery Bay, Port Kaiser (near Alligator Pond), ALCAN at Port Esquivel, and ALCOA at Rocky Point. In order to refine bauxite, the corporations built five alumina refineries in Jamaica, first ALCAN at Kirkvine (1952) and Ewarton (1959), then ALPART (Kaiser, Reynolds, Anaconda) at Nain (1969), Revere at Maggotty (1971), and lastly ALCOA at Halse Hall (1973). The construction of this extractive infrastructure led to short-term economic booms. Yet despite this economic growth, Jamaica’s revenue from bauxite and alumina production remained weak.

As part of the non-aligned movement, Jamaican leaders in the 1970s sought to upend the unequal integration of peripheral countries in the world economy. Michael Manley’s People’s National Party (PNP) administration developed a levy to replace the corporate tax system, purchased back thousands of acres of land owned by the bauxite companies, and partially nationalised the industry. These domestic efforts built on Manley’s own union organising work for the National Workers Union (NWU) in the bauxite-alumina industry, but also on an increasingly militant and global anticolonial front, in which Manley played an important role (Bogues, 2001). The levy proposal – a 7.5 percent tax rate on the average price of alumina – addressed a large deficit in Jamaica’s foreign exchange that had resulted from oil price shocks (Davies, 1984). In 1973, OPEC’s production embargo succeeded in quadrupling oil prices, which significantly impacted non-oil rich states such as Jamaica. The levy quintupled earnings on bauxite, as revenues increased from USD26.95 million in 1973 to USD179.99 million in 1974 (Francis, 1981).

Section 12 of the Levy Act, passed in 1974, provided for the creation of a Capital Development Fund (CDF) into which revenues from the levy would be paid. The Levy Act made the Prime Minister responsible for the administration and management of the Fund (Davis, 1989). Money paid into the CDF was used directly to buy back land owned by the bauxite companies, to acquire partial ownership of the companies, and to establish the Jamaica Bauxite Institute (JBI) (Davis, 1989). Money from the CDF also went directly into financing alternative aluminum production ventures, such as JAVEMEX, an agreement between Jamaica, Venezuela, and Mexico that ultimately fell through. However, most of the money paid into the CDF was used to finance the government’s budget. The Manley administration drew directly on funds from the levy to meet debt obligations and to finance social democratic initiatives, such as adult literacy programmes, housing construction for working people, agricultural initiatives, a national minimum wage, and paid maternity leave (Davis, 1989; Barclay, 2010; Meeks, 2017). In 1975, for instance, nearly 80 percent of the revenue...
generated from the levy went into the general budget. Over the next 14 years, about 60 percent of the levy funds went into the general budget (Davis, 1989, 329).

The levy was the link that tied Manley’s domestic democratic socialist agenda to his participation in a broader global anticolonial front. In 1974, Third World leaders in the United Nations General Assembly announced a New International Economic Order (NIEO), through which they aimed to combat persistent economic colonialism after the end of formal empire (Adler, 2018; Getachew, 2019). Across Latin America, Asia, and Africa, post-colonial states remained subject to what Norman Girvan called “corporate imperialism,” as multinational corporations – most of which remained headquartered in North America and Europe – continued to dominate key economic activities. The founders of the NIEO sketched an outline for an alternative world, “structured by equitable interdependence rather than hierarchical dependence” (Getachew, 2019, 167). The formation of the International Bauxite Association (IBA) – a cartel of bauxite-producing states modelled on the Organization of Petroleum Exporting Countries (OPEC) – was an attempt to put these ideas into practice across bauxite-producing states, including Australia, Guinea, Jamaica, Yugoslavia, and Guyana. Jamaica played a key role both in spearheading the NIEO and in directing the International Bauxite Association.

Although the levy and Manley’s democratic socialism have sometimes been blamed for the slowdown of Jamaica’s bauxite-alumina industry through the 1980s, recent historians have drawn attention to the importance of the neoliberal counter-reaction to Third World internationalism and post-war development policies (Stephens and Stephens, 1985; Slobodian, 2018). Financiers and political leaders across the North Atlantic began a profound structural transformation of the world economy that integrated the American state and American business into the global economy in new and deeper ways (Panich and Gindin, 2012). In search of cheaper labour and raw materials, corporations reorganised global supply chains and replaced labour with machines. At the behest of global financial elites, the International Monetary Fund (IMF) adopted new austerity measures that put a global chokehold on the kind of development policies that W. Arthur Lewis and Michael Manley had envisioned (Henke, 1999; Harvey, 2005; Getachew, 2019). The decision to raise interest rates in the United States to combat inflation – the so-called Volcker Shock – made developing world debt burdens untenable. Jamaica’s negotiations with the IMF in the 1970s, the subject of intense political debate and outbursts of violence, was a dress rehearsal for repeated “structural adjustments” that have restricted developing economies across the world (Getachew, 2019).

The aluminum industry also underwent a restructuring in this period. Trading of the light metal began for the first time on the London Metal Exchange, which upended nearly a century of price stability in the industry. In the 1960s, aluminum corporations began to pool capital together as “conglomerates” to develop new deposits in Guinea, Brazil and Australia (Sheller; 2014; Bertilorenzi, 2016). Australia’s preference for increasing production, combined with Brazil’s refusal to join the International Bauxite Association, hamstrung efforts to restrict supply and therefore raise prices on the OPEC model. By the 1980s, Jamaica had lost its competitive position in the world aluminum market.
Over the last 50 years, Jamaica’s bauxite-alumina industry has undergone a series of major transformations. As the gravity of the global aluminum industry shifts towards Asia, investment in the industry has increased production but reduced the number of those directly employed in the industry from a high of 6,900 in 1975 to roughly 4,000 in 2018. The number of wage workers has continued to decline from 4,520 in 1975 to 1,429 in 2018. Exports, particularly of alumina, have shifted toward Russia and China. Since 2002, the levy has been replaced by a tax regime that links state revenues to company profits (Canute, 2002). The share of the bauxite and alumina industry in government revenues has declined from over 25 percent in the 1970s to under three percent leading up to the 2008 Global Recession. Although production has expanded through new investment, the yield per-ton has declined. This means that more mining and refining is needed to maintain revenues. As Lou Ann Barclay and Norman Girvan argue, the “pendulum of bargaining power has swung sharply.” The Jamaican government in the new millennium has had to provide the same kinds of concessions made in the 1950s to incentivise foreign investment in the industry (Barclay and Girvan, 2013).

LABOUR

None of these economic transformations could have been possible without Jamaican workers. The bauxite-alumina industry is a unique sector in Jamaica’s economy because mining multinational corporations operated as “social enclaves” which employed less than one percent of the labour force (Beckford, 1987). Between 1952 and 1967, no more than 5,000 workers were
employed in the bauxite-alumina industry because it was a highly mechanised sector that requires technical skills and higher education (Tramm, 1977). Although the industry did not contribute significantly to the number of jobs created for Jamaicans, bauxite workers enjoyed higher wages, improved working conditions, and better prospects for job security (Young, 1965). Strong trade union involvement in collective bargaining was primarily responsible for bauxite workers’ enjoyment of a ‘privileged worker’ status in the Jamaican economy (Gordon, 1978). Collective bargaining refers to any agreement usually made between an employer’s federation and trade unions to set out the basic terms for all associations and their workers. In the 1950s, the National Workers Union (NWU) came to represent all bauxite workers in Jamaica. The NWU was able to secure decent wages and working conditions for bauxite workers because of the high profits gained from the bauxite boom of the 1950s and 1960s. Collective bargaining in Jamaica’s bauxite-alumina industry also had external influences from North-American labour practices which prioritized a broad social benefits package for workers (NWU Research Department, 1982, pp. 5–6).

In 1953, the National Workers’ Union initiated negotiations with ALCAN Jamaica Limited. The union had called on the expertise of English arbitrator George F. Honeyman to facilitate the collective bargaining process. Honeyman granted a 37 percent increase for workers at the bottom half of the wage scale and a 10 percent increase for workers at the top half of the wage scale. Labour agreements were signed between the NWU, ALCAN Limited, Kaiser, and Reynolds from 31 December 1955 to 1 February 1957. The ALCAN agreement awarded the highest increase in wages for the top half and bottom half of workers, in which the top half of workers received a 16 percent increase in wages while the bottom half received a 31 percent increase in wages. Under the ALCAN agreement, workers were entitled to paid sick leave, eight paid holidays and two weeks’ paid vacation of each calendar year. The provisions for workers in the Kaiser agreement were similar to the ALCAN agreement. The Reynolds agreement granted only a 10 percent increase for the top half of its workers while granting 16 percent for the bottom half of its workers and a five-stage procedure to voice worker grievances. In the 1957–1959 negotiations between the GOJ and bauxite mining multinational companies, agreements were amended after re-negotiating royalties and income taxes. Workers were entitled to 11 paid holidays, paid sick leave, two weeks paid vacation leave, and a 26 percent wage increase for the top half of its workers and a 24 percent wage increase for the bottom half of its workers. Kaiser introduced a severance pay and a pension plan while there were no major changes to the Reynolds agreement, except for the fact that there was a 26 percent wage increase in the top half of workers and a 30 percent wage increase for the bottom half of workers. Between 1963 and 1968, the NWU had advocated for extensive revision of labour agreements, such as: reviewing the controversial “no strike action” clause and establishing worker-management committees to create good relations between workers and management in bauxite companies. The recommendations resulted in ALCOA and ALCAN agreements making more provisions for paid sick leave, paid holidays, vacation leave, and offering career advancement opportunities for workers based on years of experience. The
controversial “no strike” clause was unchanged in labour agreements, however, because bauxite mining companies wanted to prevent production slowdown.

There was a radical change in the unequal bargaining relations between trade unions and bauxite mining multinational corporations following the election of democratic socialist Prime Minister Michael Manley in 1972. Manley developed strong connections with the Caribbean Mine Workers and Metal Workers’ Federation to promote a compromise between the interest of workers and capitalists (Bogues, 2002). As Prime Minister of Jamaica, Manley repealed the Masters and Slaves Law which represented the continuation of racial oppression and servitude of Black Jamaican workers. His efforts to create equitable employment relations is seen in the strengthening of union participation in politics and the passage of major labour laws, such as the 1974 Employment Act, 1974 Holiday with Pay Act, and the 1975 Industrial Disputes Act (Hague and Fletcher, 2002).

The closure of North American aluminum companies, spiralling debt, and failed nationalization policies drastically reduced the share of Caribbean bauxite producers in the early 1980s. These issues have presented a new yet challenging context for trade unions to operate in (Central Intelligence Agency, 1986; Nelson, 1991). Precarious employment arrangements in Jamaica’s bauxite-alumina industry encompassed restraint on wage increases, closure of plants, worker layoffs, and strong disregard for voice mechanisms in companies. This led to the frequent worker strikes in the 1980s and in 1995, with over 4,000 workers demanding safer working conditions and higher wages (Munroe, 2002). A Memorandum of Understanding (MOU) signed in 1998 between the companies, the government and the trade union signalled a new phase in the industry with lower wages and more precarious working conditions (Canute, 1998). Bauxite mining and processing had a positive impact on labour during the early years of the global bauxite boom but currently, trade unions have lost the political control they once enjoyed (Le Franc, 1987, Morris, 2002).

**LAND**

The crisis in the aluminum industry in the 1980s – which deeply affected workers and the broader Jamaican economy – raised important questions about the social costs of mining bauxite. Environmental issues became central to discussions about the past and future of the bauxite-alumina industry. With a team of researchers at the University of the West Indies at Mona, economist George L. Beckford organized a study of the impact of Jamaica’s bauxite-alumina industry on the environment, the first of its kind. Beckford had a capacious understanding of the environment, what he called Jamaica’s “manscape.” It included not just nature, but the way that humans relate to nature through their activities, and the power relations that structure human interactions with nature. For many Jamaicans, Beckford argued, the land possesses a deep political, economic, and spiritual significance tied to struggles for freedom. These struggles had their origins in enslavement on the African continent. As Beckford put it, “it is through the land that we were subsequently to free
ourselves from plantation slavery and develop as an independent peasantry” (Beckford, 1987). Understanding the bauxite-alumina industry, Beckford thought, required moving beyond dollars and cents. One had to root its history in the longer struggle for freedom “through the land” in Jamaica.

When ALCAN and Reynolds began prospecting for bauxite during the Second World War, Jamaica’s colonial government required companies to purchase properties they intended to mine. Before Jamaica’s legislature signed the Minerals (Vesting) Act, 1947 and Mining Act, 1947 into law, ALCAN and Reynolds had already begun purchasing properties in St Ann and Manchester (Davis, 1989; Sachak, 1987). As early as 1942, prospecting work and land acquisitions became not just a nuisance but a threat to rural economic and political freedom in Jamaica. In the century after emancipation in 1838, formerly enslaved people and their ancestors acquired small plots of land – both for dwelling and for farming – in order to free themselves from the violence of the plantation. These plots provided land on which to grow food for subsistence and trade within the island’s many markets, as women travelled from the countryside to Falmouth, Brown’s Town, and Kingston to trade goods grown in rural areas. While many men continued to work on plantations for wages, the land provided a site of autonomy for men and women to build new forms of kinship that had been denied to enslaved people. By 1938, there were 80,000 freeholds registered in Jamaica averaging just over two acres (Post, 1978). Many farmers considered this family land to be inalienable. It held burial grounds and fruit trees, marking and rooting the struggle for freedom “through the land.” It sustained circulatory migration, as Jamaicans travelled to work on the Panama Canal, in the cane fields of Cuba, or the banana plantations of Costa Rica (Besson, 2002). These plots of land provided the foundation for new forms of grassroots politics that took root after emancipation, including community meetings and petitioning (Sheller, 2000). In dispossessing Black farmers of their land, mining threatened the ways of life they had carved out beyond the plantation.

Jamaican farmers did not passively accept prospecting work and land acquisitions. Beginning in the 1940s, Jamaican farmers signed petitions, wrote letters to newspapers, and held community meetings to discuss and contest the effects of bauxite mining on their communities. Those who wrote petitions to government officials and letters to newspapers often stressed ties of kinship to family land, the land’s spiritual and historical significance, and the diversity of crops harvested. In a letter to Public Opinion in January 1957, S. A. Gordon of Keith described the effects of bauxite mining, and the cattle operations of bauxite companies, on Home Castle tenant farmers. “For more than a century,” Keith wrote, “these holdings have been handed down from fathers to sons.” Among the crops grown by the farmers were breadfruit, pimento, and coffee. According to Gordon, the evicted tenants faced a stark choice: “emigrate or starve.” The landlord, Allan Lopez, had taken the tenants to court in Brown’s Town for refusing to give up their tenancies after he had sold his property to Reynolds Metals. According to Public Opinion, court records confirmed the sale was conditional upon the property being “delivered free of tenants.” Such struggles over land, which often led to displacement and emigration, were not exceptional but rather typical of the expansion
of the industry in Jamaica. The rise and expansion of the industry displaced alternative ways of engaging with the land, particularly those rooted in opposition to the island’s plantation system. Although the bauxite companies frequently documented and publicised the agricultural initiatives, resettlement programmes, and land rehabilitation efforts, they never acknowledged the pressure from rural communities that had produced these compromises.

It is difficult to measure the scale and effect of bauxite mining on rural Jamaica. Beckford estimated that by 1979, when ALCOA and ALPART had joined Reynolds, ALCAN, and Kaiser in buying up land, the companies owned more than 210,000 acres of land in the parishes of Manchester, St Elizabeth, St Ann, Trelawney, and Clarendon (Beckford, 1987). The elaborate schemes of resettlement and agriculture that the companies developed on the land they owned became the basis of government programmes on land initiatives spearheaded by the Manley administration in the 1970s. Over time, the government began to claw back the land owned by the companies. Geologist Arthur Geddes estimated in 1990 that mining had caused extensive damage to the natural ecology of at least 60,000 acres of land. At the same time, more than 200 million tons of caustic “red mud” had been produced by 1990 (Girvan, 1990). The decrease in government revenue on each ton of bauxite mined, which has incentivised an expansion in production, has meant continued environmental degradation.

THE FUTURE OF BAXITE MINING IN JAMAICA AND COCKPIT COUNTRY

In the last two decades, Noranda Jamaica Bauxite Partnership (NJBP) – a partnership between the Jamaican government and the Glencore-owned mining company Noranda – has conducted mining operations in the vicinity of the roughly 530-square-kilometer region known as Cockpit Country. Although the current Jamaican government under the administration of Prime Minister Andrew Holness has agreed to prohibit mining in Cockpit Country, environmentalists, farmers, and Maroon leaders have contested the government’s proposed boundary. What the government has designated as “Cockpit Country Protected Area,” they urge, does not correspond with what area locals understand to be Cockpit Country. As Esther Figueroa argues, it is “. . . the smallest of all boundaries that were proposed by stakeholders” (Figueroa, 2019a). The cratered and cavernous landscape of wet limestone forest is one of the most biodiverse parts of the island. It is also central to the struggle through land, as Beckford put it, for freedom. It was in the mountainous interior of Cockpit Country that Maroons, whose presence in Jamaica antedates British colonization, forced the British to sign a peace treaty in 1739. Maroon leaders from Accompong have frequently decried bauxite mining in Cockpit Country as a threat to Maroon sovereignty (Baldwin-Jones, 2011; Connell, 2017). In August 2019, Maroon leaders from Accompong sounded the Abeng horn outside Jamaica’s parliament, a powerful symbol of opposition to government encroachment. The boundary dispute has served as a catalyst for deeper debates about the future of bauxite mining in Jamaica, particularly in the wake of the global financial crisis of 2008.

After the commodities boom of the late 1990s lifted the industry, the global economic
slowdown of 2008 forced deep cuts in production and employment. Within a year, total exports of bauxite (including refined alumina) were nearly cut in half from a near all-time high of 14 million tons. The doors were shut to refineries in Ewarton and Nain, which eliminated nearly 1,000 jobs and community services, such as road maintenance and school funding, which the companies provided. In the decade since the crisis, production has slowly picked up (JBI, 2020). New staff positions have been created, refineries at Ewarton and Nain have reopened, and exports have climbed back to their pre-recession highs. Since 2010, the JBI reports that the total number of jobs has grown from 2,189 to 4,028, including salaried workers, wage earners, management and expatriates (JBI, 2020). Yet the number of wage workers has remained stagnant, failing to recover most of the losses from the recession. This change in the nature of workplace organization merits further analysis beyond the scope of this study.

In 2016, UC Rusal, a Russian corporation, sold its share of the ALPART refinery at Nain in St Elizabeth to JISCO, a Chinese mining conglomerate (Aluminim Insider). Today, Rusal, JISCO, Noble Group, and Glencore (Noranda) are the principle investors and partners with the Jamaican government in the bauxite and alumina industry. As COVID-19 threatens another global economic slowdown, it is time once again to evaluate the future of the bauxite-alumina industry in Jamaica.

How can we begin to weigh the future wages earned and revenue generated by mining and refining bauxite against social and environmental costs? W. Arthur Lewis did not consider the environment in the capacious way of George L. Beckford. Yet in Lewis’s early conceptions of industrialisation, he insisted that industrialisation could not stand on its own. It depended upon a broader agricultural base. Development in the West Indies, Lewis thought, required maximising the space available for agriculture and rendering agriculture as efficient as possible. Lewis understood that both the plantation and resistance to the plantation had shaped the history of agriculture in the West Indies. These ways of living on the land depend on a delicate balance between human work and nature, a balance that many argue is disturbed by mining. As Michael Witter puts it, “the damage to the food economy, and the likely destruction of some of the soil and water that supports it, which have sustained the country through all economic crises, will be much greater than the short-term gains from bauxite production and exports, not to mention the threat to the basis of the culture that defines us” (Witter, 2019). Witter’s analysis centres the historical, cultural, environmental, and political economic stakes of mining in Cockpit Country. It reminds us that expansion in the bauxite industry ties the lives of Jamaicans to cyclical crises in the world economy, while undermining alternative farming economies that have “sustained the country through all economic crises.” As a global pandemic grips the world, Witter’s insight could not be more prescient. In order to make a robust and informed decision about the future of bauxite mining in Jamaica, we must better understand how mining affects the political and economic autonomy of rural communities, Jamaica’s food security, and Cockpit Country’s environment. The value of wages and foreign exchange alone cannot tell us whether the benefits of mining outweigh the costs.
REFERENCES


ANTHONY GREENAWAY

“Well done is better than well said.”
—Benjamin Franklin

BACKGROUND

Jamaica’s bauxite-alumina industry had its beginnings in the early 1940s when Sir Alfred Da’Costa, a farmer and businessman, found bauxite to be within the soils of his Lydford, St Ann property. Since then, bauxite deposits have been identified in several parishes (Figure 1) and in the early 1950s the processing of bauxite to alumina began. In the early years, there was minimal legislation in place to guide the industry, especially on environmental issues. Gradually over the years, legislation and the associated regulations have been introduced.

The industry has played an important role in the economy of the country and given the large reserves of bauxite, this will continue for many years. The latest draft of Jamaica’s National Minerals Policy, 2017–2030, indicates the reserves to be possibly 1, 100 million tonnes¹, an amount which could sustain the industry for between 50 and 100 years, depending on extraction rates (p13). The Policy, however, also identifies that a weakness of Jamaica’s minerals industry is the “high levels of environmental impact” (p19). Approximately 90 percent of the value of Jamaica’s minerals industry come from the bauxite-alumina industry (p14).

¹ Quantities in official documents are sometimes referred to as tons (2,000 US lbs) or tonnes (2,204.6 US lbs), which has led to some of the inconsistencies in numbers.
Figure 1: Map of Jamaica showing the locations of bauxites and the processing plants and ports
OBJECTIVES

This review was undertaken to identify how the legislative framework has evolved since the beginnings of the bauxite-alumina industry in Jamaica and to assess the effectiveness, implementation of, and compliance with the components of the laws and regulations that address environmental issues. The chapter is presented in three parts:

- Introduction of the policies and relevant acts and regulations.
- Evolution of the early legislation and implementing authorities to what pertains currently, including attempts to bridge the gaps in the regulations while trying to limit the industry’s negative environmental impacts.
- Assessment of the effectiveness of the present legislative framework in ensuring minimal negative environmental impacts by considering some of the requirements placed on the industry, and how those requirements are being administered and complied with.

METHODOLOGY AND LIMITATIONS

Information for this chapter is from documents downloaded from websites of the ministries, authorities, and industrial stakeholders; answers to written questions sent to the National Environment and Planning Agency (NEPA) and the Jamaica Bauxite Institute (JBI); meetings with NEPA personnel and reviewing documents in their library; documents and data received through Access to Information (ATI) requests; and from the author’s experience having worked on Jamaican environmental issues and alongside Jamaica’s bauxite-alumina industry for over 40 years.

The relevant acts and regulations were obtained from GOJ websites; reviewing them identified the environmental requirements that companies need to meet, mainly via permits and licenses. The permits and licenses, along with application forms and other supporting documents, had to be obtained using ATI requests, a process that usually takes at least 30 days. The information received then defined requirements in greater detail, requiring additional ATI requests. Often, the information was difficult to understand, leading to requests for clarifications from the relevant authorities.

This study has therefore been confined to the information that was obtained within the study timeframe. This has limited the extent of the assessment of the effectiveness of the implementation of legislation. We were only able to review one mining activity and one processing plant, and our study was further limited to the environmental impacts of discharges to the atmosphere. While these limitations clearly place constraints on the drawing of general conclusions about the environmental impacts of the industry islandwide, the information reviewed pointed to many issues, especially in the way authorities implement the regulations and how they subsequently monitor compliance.

THE BAUXITE MINING AND PROCESSING INDUSTRY

Jamaican bauxite deposits can be mined by removing a thin layer of topsoil from the underlying bauxite deposits and then excavating the fine particle-sized bauxites down to the limestones that define the mining pits. Jamaican bauxites normally contain about 22 to 24 percent moisture. The mined bauxite is then transported to the processing areas by trucks, conveyors, or aerial ropeways. If the bauxite is to be shipped without being processed to alumina, the ore is dried to about 16 to 17 percent moisture.

The technology for processing bauxite to alumina, the Bayer Process, involves the heating under pressure of suitable bauxite in caustic soda (sodium hydroxide) to dissolve the alumina minerals (the digestion unit), the separation of the insoluble residues from the produced concentrated sodium aluminate liquor (the “red mud” circuit), the precipitation of alumina from the concentrated liquor (the precipitation unit), and then the return of the now dilute liquor to the digestion process. The “red mud,” after being extensively washed to recover as much caustic soda as possible, is disposed of in a hazardous waste facility (“red mud lake” or “mud stacking area”) while the produced alumina is heated (calcined) to drive off water and then transported to the ports. Bayer Process plants operate their own power generation and wastewater treatment plants.

All these mining and processing operations have the potential to pollute the environment.

POLICIES, ACTS AND REGULATIONS

Policy Framework

Jamaica is in the final stages of adopting a long-term (2017–2030) National Minerals Policy. This follows on previous drafts (2008, 2011) which never reached the stage of adoption. This Policy will be Jamaica’s first long-term policy for the minerals sector, a sector dominated by the bauxite-alumina industry, and when adopted will reflect the importance of the sector to national development. The vision stated in this draft is that by 2030, Jamaica’s mineral sector will be “a primary contributor to sustainability, globally competitive and co-existing with competing interests in the wider economy.” The vision in the 2011 draft was: “a modern, diversified, efficient Minerals Industry which protects environmental integrity and socio-cultural values, adds significant value to the economy, is based largely on the manufacture, local use and export of value-added products, import substitution, has strong and properly structured institutions and co-exists with competing interests in the wider economy” (National Minerals Policy, 2011, p. 37). This change seems to indicate that environmental and socio-cultural issues are of lesser importance now than previously. The 2017 draft Policy does not, however, ignore environmental issues. It states: “Investors in the sector will be required to comply with internationally and locally recognized codes of practices, guidelines, standards, regulations and legislations for the maintenance and improvement of the environment.”
The 2017 draft Policy has six broad goals. Goal 3, which focuses on environmental issues, is: “To improve occupational health and safety, community relations and environmental stewardship throughout the sector” (p36).

To meet Goal 3, the GOJ intends to adopt three policy positions:

- design and implement appropriate policies that will ensure the minerals sector does not negatively impact the environment;
- require the implementation of international best practices for environmental stewardship, community relations and occupational health and safety standards; and
- ensure appropriate land management uses and restoration practices are observed.

The policy positions, actions, and strategies for Goal 3 and other goals identify multiple actions relating to mining, mineral processing, and rehabilitation of mined-out land, which, if implemented and enforced should protect the environment and public health while maximizing the economic value of the industry.

Goal 4 calls for increased efficiency within the sector and a focus on applied research. A key strategy is to establish a National Minerals Institute (NMI) to lead research, development, and innovation. The NMI will build on the experience and resources of the JBI, the Mines and Geology Division (MGD), and tertiary institutions, to streamline government agencies and reduce duplication. Goal 4 also calls for the promotion of quality assurance standards, streamlining management, and improving the capacity of government laboratories to meet internationally recognized certification. Effecting these plans should ensure that a sound scientific approach will be taken when setting environmental monitoring requirements, and that data generated will be fit for the purpose and its interpretation in keeping with the objectives of the monitoring programmes.

The bauxite-alumina industry, however, operates under several constraints, including high energy costs, decreasing quality of remaining bauxite deposits, aging infrastructure, and a poor reputation tied to rehabilitation of mined-out lands and concern for the environment. These factors must be recognized in planning for the industry’s continued inclusion in Jamaica’s sustainable development.

The IGF Assessment

In June 2020, the Intergovernmental Forum on Minerals, Metals and Sustainable Development (IGF) published an assessment of Jamaica’s readiness and capacity to implement the IGF’s Mining Policy Framework (MPF) (Crawford et al., 2020). The IGF is a non-profit organization based in Canada “which supports 75 nations committed to leveraging mining for sustainable development to ensure negative impacts are limited and financial benefits are shared.” (Crawford et al., 2020, p. 2). IGF’s MPF was developed by its member states and “presents the standards and good practices, which, if integrated into mining law, policy, institutions and regulations, can help countries optimize mining’s contribution to sustainable development and poverty alleviation.” (Crawford et al., 2020, p. 31). The assessment, which
considered Jamaica’s existing legislation, “evaluated the degree to which the standards and practices of the MPF were integrated into existing national laws and policies.” (Crawford et al., 2020, p. 31). The fact that the GOJ requested the assessment suggests that they are at least considering aligning Jamaica’s mining activities with international best practices, sustainable development, and poverty reduction.

The assessment is organized under the six themes of the Mining Policy Framework (MPF): legal and policy framework, financial benefit optimization, socioeconomic benefit optimization, environmental management, post mining transition, and artisanal and small-scale mining. The first five themes are relevant to bauxite mining. The conclusions relevant to the study are:

- the first national mining policy, which is in its final stages of development, largely reflects international best practices;
- mining permits and licenses cover the various segments of mining and require environmental permits which in turn can require environmental impact assessments;
- air quality related to the bauxite and alumina sector is monitored;
- water quality standards are largely consistent with international standards;
- mining companies are required to submit environmental management plans; and
- mining and mine closure and rehabilitation plans are required by mining leases.

The Assessment also concluded, however:

- the legal and policy framework is outdated;
- the institutional structures are overlapping, convoluted, and possibly conflicting;
- environmental management standards for surface and groundwater are not strictly monitored and enforced; and
- mine closure legislation is outdated and does not adequately address all environmental, social, and economic issues.

The assessment report should be consulted for further detail (Crawford et al., 2020).

While both the present study and the IGF report cover legislation and policy issues that presently relate to mining, this chapter goes further to consider the adequacy of the various legislation and policies that have been applied to both the mining and processing components of the bauxite-alumina industry since its inception, and investigates the current effectiveness of the practical application of the legislation.

**The Legislative Framework for the Bauxite-Alumina Industry**

The laws and regulations governing the bauxite-alumina industry today (Table 2 and the IGF assessment report; Crawford et al., 2020) have evolved significantly since the industry’s early days, particularly as it relates to environmental issues. The Mining Act of 1947 and its regulations defined the requirements for prospecting and mining, required mining companies to have mining leases and rehabilitate all lands affected by mining once mining
The Evolution of the Legislation and Authorities for the Bauxite-Alumina Industry

The bauxite-alumina industry has been subject to the Mining Act (1947) from inception. Once permission under the Town and Country Planning Act (1958) to undertake the mining and/or processing activities is granted, the Commissioner of Mines can grant licences to prospect and mine under the Mining Act. In the early days prior to the promulgation of the NRCA Act (1991), the only formal environmental requirements were those to rehabilitate mined-out land to the satisfaction of the Commissioner of Mines.

The role of the Commissioner of Mines and the Mines and Geology Division (MGD) of (presently) the Ministry of Transport and Mining (MOTM) has remained mostly unchanged. The Commissioner can grant Exclusive or Special Exclusive Prospecting Licences (EPLs and SEPLs) and then, if asked by a holder of a prospecting licence, Mining Leases (ML) and Special Mining Leases (SML). SEPL and SML are granted if there are expected extra difficulties with the prospecting and/or mining and hence increases in the associated costs. The Mining Act requires regular reporting on the prospecting and mining and data on the quality of the ore bodies. A mining area lessee is required to extract at least a stated minimum tonnage of bauxite per annum. Royalties and taxes are calculated from the data submitted. Importantly, possible changes can be made to the area within which mining is permitted – the area can be increased (or decreased) if the amount of bauxite within the initial lease area proves to be less (or more) than the initially expected amount. The regulations and the granted leases give detail to these requirements, including the construction of roads within the area.

The Mining Act regulations (Sections 53–55) require all land disturbed by mining to be restored, “as nearly as may be practical, to its former level of agricultural or pastoral productivity or of utilization for afforestation or other uses” within three years of the cessation of mining. Mining in a mining pit is considered to have ceased after six months of inactivity. Once an area has been restored, the Commissioner of Mines certifies, upon application from the lessee, that the rehabilitation has been satisfactorily completed. By early 2017, of the 13,714 hectares (1.4 percent of the total area of Jamaica) that required rehabilitation since the start of the minerals industry, 86 percent or 11,656 hectares have been certified by the Commissioner as having been satisfactorily restored (National Minerals Policy 2017–2030 (draft), p. 29).3

---

3 This estimate conflicts with other estimates of 75 percent reclaimed. See Drakapoulos (2018).
Table 2: Acts, Orders and Regulations, and Other Documents Relevant to the Bauxite-Alumina Industry

<table>
<thead>
<tr>
<th>Act, Order, Regulation</th>
<th>Date (Latest revision)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining (Safety and Health) Regulations</td>
<td>1977 (1979)</td>
<td>Details how mining operations must be conducted to ensure the safety and health of mine workers.</td>
</tr>
<tr>
<td>Clean Air Act</td>
<td>1964 (1973)</td>
<td>Allows inspectors to enter premises if excess emissions to the atmosphere are apparent and can require the implementation of best practicable methods.</td>
</tr>
<tr>
<td>Natural Resources Conservation Authority (NRCA) Act</td>
<td>1991</td>
<td>Requires all enterprises, constructions, and developments listed in the regulations to have permits to operate and, if discharges of effluents are likely, licences to discharge effluents (section 12, however, only applies to discharge to waters, on the ground or into the ground, not to the atmosphere).</td>
</tr>
<tr>
<td>Natural Resources Conservation (Permits and Licenses) Regulations and Amendment</td>
<td>1996 2015</td>
<td>Details the procedures for applying and maintaining permits and licences.</td>
</tr>
<tr>
<td>Natural Resources Conservation (Prescribed Areas) (Prohibition Category of Enterprise, Construction and Development) Order and Amendment</td>
<td>1996 (2000) 2015</td>
<td>Details the enterprises, constructions, and developments for which permits to operate are required. Mining and processing of minerals have been in the Order since 1996. The Order only details the procedures for new activities, those that already existed on 1 January 1997 were exempted within the Order but not within the 1991 Act. Exemption of “existing” activities removed.</td>
</tr>
<tr>
<td>Natural Resources Conservation Authority (Air Quality) Regulations</td>
<td>2006</td>
<td>Details for when licences to emit pollutants to the atmosphere are required. Guides when and what type of monitoring and data reporting may be required. An associated document gives extensive guidance on the implementation of the regulations. The granted licences give specific details.</td>
</tr>
<tr>
<td>Natural Resources Conservation (Wastewater and Sludge) Regulations</td>
<td>2013</td>
<td>Identifies when licences to operate wastewater (sewage and trade effluents) may be required. Indicates the operation, maintenance, and effluent quality monitoring and the reporting on such that may be required. Granted licences give specific details.</td>
</tr>
</tbody>
</table>

Table 2 continues
### Act, Order, Regulation

<table>
<thead>
<tr>
<th>Act, Order, Regulation</th>
<th>Date (Latest revision)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRCA-JBI MOU and revision</td>
<td>1994 2013</td>
<td>Delegates many of the environmental, operational, and community monitoring requirements for Jamaica Bauxite Institute (JBI).</td>
</tr>
</tbody>
</table>

### ENVIRONMENTAL STANDARDS

<table>
<thead>
<tr>
<th>Standard</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRCA sewage and trade effluent, and wastewater and sludge standards</td>
<td>2013</td>
<td>Part of the wastewater and sludge regulations.</td>
</tr>
<tr>
<td>Jamaican National Ambient Air Quality Standards (NAAQS): Criteria pollutants</td>
<td>1996</td>
<td>For TSP, PM10, lead, SO2, Ozone, CO and NO2, the pollutants to which ambient air quality standards apply.</td>
</tr>
<tr>
<td>Jamaican National Ambient Air Quality Standards (NAAQS): Priority pollutants</td>
<td>1996</td>
<td>An Appendix to the Air Quality Regulations; long list of organic and inorganic pollutants (benzene, dieldrin, formaldehyde, phenol, arsenic, mercury, are examples). No standards set, but guideline concentrations given for use, if necessary.</td>
</tr>
</tbody>
</table>

### ADMINISTRATIVE OR FINANCIAL ACTS AND COMPANIES

<table>
<thead>
<tr>
<th>Act</th>
<th>Date (Latest revision)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minerals (Vesting) Act</td>
<td>1947 (1973)</td>
<td>Details the payment of royalties to owners of land where minerals are mined.</td>
</tr>
<tr>
<td>Bauxite and Alumina Industries (Encouragement) Act and Amendment</td>
<td>1950 (2001) 2019</td>
<td>Exempts the industry from various taxes and duties.</td>
</tr>
<tr>
<td>Bauxite (Production Levy) Act</td>
<td>1974 (2003)</td>
<td>Details payments companies are required to make based on their production levels.</td>
</tr>
<tr>
<td>Jamaica Bauxite Institute (JBI)</td>
<td>1976</td>
<td>A government owned institution that serves as technical advisor to the GOJ, oversees the operations of mining and processing companies and ensures the following of good environmental practices including the rehabilitation of mined-out lands.</td>
</tr>
<tr>
<td>Jamaica Bauxite Mining Ltd. (JBM). Bauxite &amp; Alumina Trading Company Ltd. (BATCO)</td>
<td>1975 1977</td>
<td>Interrelated Government-owned companies established to administer the GOJ’s equity and serve as its trading arm in the bauxite-alumina industry.</td>
</tr>
</tbody>
</table>

---

4 TSP – Total Suspended Particles; PM<sub>10</sub> – Particular Matter less than 10 microns; SO<sub>x</sub> – sulphur dioxide; CO – carbon monoxide; NO<sub>x</sub> – nitrogen dioxide.
New Agencies in the 1970s – the Jamaica Bauxite Institute

In the mid-1970s, the GOJ, in an effort to maximize the nation’s benefits from the bauxite-alumina industry, established three interrelated limited liability companies (Table 2): (i) Jamaica Bauxite Institute (JBI), (ii) Jamaica Bauxite Mining Ltd. (JBM), and (iii) Bauxite and Alumina Trading Company Ltd. (BATCO).

The JBI, established in 1976, is required to work with the industry to assist in its development and to monitor the performance of the companies and their compliance with regulations. Their primary focus for the future is to “enhance the competitive position of the local industry through greater productivity and a stable industrial climate, and to facilitate additional investment and the modernization of plants, consistent with sound environmental practices” (JBI, 2020)⁵.

In 1990, the “JBI established an Environmental Technical Committee, comprising members from the bauxite and alumina companies and the relevant government agencies, for the purpose of establishing environmental standards for the Bauxite-Alumina industry” (NRCA-JBI MOU, 2013). The JBI was unable to provide any documents to indicate that the committee completed this task.

In 1994, the National Environment and Planning Agency (NEPA) entered into a Memorandum of Understanding (MOU) with the JBI which delegated to the JBI the responsibilities for monitoring the environmental impacts of the industry. NEPA is an Executive Agency founded in 2001 to carry out the technical and administrative mandate of the Natural Resources Conservation Authority (NRCA), the Town and Country Planning Authority (TCPA), and the Land Development and Utilization Commission (LDUC). The NEPA-JBI MOU was updated in 2013 after the two entities agreed that the JBI had “performed acceptably” (NEPA-JBI MOU 2013, p. 4) under the first MOU. No information was provided as to how this was assessed.

Under the present MOU, NEPA retains extensive responsibilities for managing and monitoring the industry while the JBI is charged with:

- assisting companies with applying for and complying with permits and licences;
- monitoring air and water quality;
- responding to spills and environmental incidences;
- assisting with emergency response planning;
- supporting general public education and good community relations;
- planning and coordinating environmental performance monitoring meetings with relevant government, local government, and industry stakeholders; and
- submitting quarterly and annual reports to NEPA on activities covered by the MOU.

⁵ https://jbi.org.jm/about_jbi/
Permitting Requirements under the NRCA Act

In 1991, the Natural Resources Conservation Authority (NRCA) Act was passed, which significantly enhanced attempts to protect Jamaica’s natural environment from unsustainable development. The regulations pertaining to the NRCA Act were not, however, promulgated until late 1996. These are the Natural Resources Conservation (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order, 1996 and The Natural Conservation (Permits and Licences) Regulations, 1996. Initially, mining and quarrying applications were considered by the Quarries Advisory Committee under Section 6 of the Quarries Control Act, with representation from several government agencies including from the NRCA and later, NEPA.

The NRCA Act requires permits (Section 9) to “undertake in a prescribed area any enterprise, construction or development of a prescribed description or category” and licences (Section 12) to “discharge on or cause or permit entry into waters, on the ground or into the ground, of any sewage or trade effluent or any poisonous, noxious or polluting matter”, but it was not until late 1996 when the Order and Regulations were promulgated that the necessary details were available to bring these sections into focused effect. The Order includes mineral and mineral processing endeavours in its list of categories of enterprise, construction, and development, thus requiring the bauxite-alumina industry to obtain permits or licences to cover its mining and mineral processing activities. Also in the list are sewage treatment facilities, power generating stations, and wastewater treatment plants, all of which are generally located on the premises of bauxite-alumina processing companies. Each, therefore, requires a separate environmental permit or licence.

While the 1996 Order stated that permits were required for the listed categories, it did not specifically address those that were in existence before the 1st day of January 1997. There was therefore no instruction on how these existing activities, which included all the bauxite mining and processing activities, were to comply with the Act’s requirement for permits. It was not until the Order was amended in 2015 that this apparent exemption of the pre-existing bauxite-alumina operations from permits was removed. When asked about this anomaly, NEPA indicated that Section 17 of the Act was applicable and used between 1991 and 2015.

Section 17 requires “owners or operators of various facilities that treat sewage and industrial wastes, dispose of solid wastes, abate air pollution or control pollution to submit to the NRCA, when asked, information relating to the performance of the facility, the quantity and condition of effluent discharged and the impact of discharges on any affected area.” To show that this approach was in fact taken, NEPA provided several quarterly reports from Noranda, for the period 2009–2015 and one for the final quarter of 2019 which were headed “Information on Pollution Control” and stated “information required on this form must be completed and submitted in accordance with Section 17 of the NRCA Act 1991.”

6 Noranda is the company that exports bauxite, mined in St Ann and Trelawny, from Discovery Bay.
The same form is used for all companies. The information required on the form covered products produced, raw materials used in the production and maintenance processes, water supply and use, effluents from the process, wastewater and sewage treatments, and solid and hazardous wastes, among others. These reports did, to some extent, cover discharges but seem to have left the companies to operate as they saw fit. It was never made clear why, in 2019, the companies were still being required to submit such reports, when they were by that time required to have discharge licences and operating permits.

When the JBI was asked about the apparent anomaly, between the 1991 NRCA Act and the 1996 Order and its 2015 amendment, they did not mention Section 17 but instead wrote, “To be literal, the plants were not required to have environmental permits up to 2015 strictly speaking . . .” and added that, “where any new version of an existing industry was proposed, implemented etc., a permit application was advised (by NEPA/JBI).” The JBI also indicated that “the change alone” would not be permitted “but the entirety of the project/activity since start of operations” would be. If mining and processing companies made changes to their operations they would have been required to get permits and, according to the JBI, this began in 1995. NEPA concurred with the use of this approach.

The JBI’s annual reports each include an appendix which lists the permits and licences that they have on file. The earliest entry in the 2019 report’s list is for 1995 when ALPART was issued a permit (02P95) to “undertake hazardous waste storage, treatment and disposal system” but no details are given as to the type of wastes. A similar permit (01P97) was issued to WINDALCO, Ewarton in 1997 but again no details are given. In 1998, the WINDALCO, Kirkvine processing plant was issued permits to remove oxalate from the processing liquor and to undertake a double digestion project, both of which relate to the Bayer Process plant, but there is no evidence of this resulting in a permit being issued for the Bayer plant in general. In 1999, Jamalco was issued a permit (071P99) for the construction and operation of a temporary stack for #3 boiler at their refinery, but this does not seem to have resulted in a permit to operate the power plant or the refinery. So, while it appears that permits relating to changes within the processing plants had been issued since 1995, there is no evidence of these having triggered permits for the entire processing activity.

**Licensing and Monitoring of Emissions to the Atmosphere**

It is of note that the NRCA 1991 Act and the 1996 Order and Regulations do not speak specifically to licences for discharges to the atmosphere. The JBI, when asked about this, responded that “the intent of the Act certainly would not exclude air emissions” and pointed to Section 38 of the Act which permits the Minister “to make regulations to establish ambient air quality

---

8 ALPART was, at that time, the company operating the Bayer Plant in Nain, St Elizabeth.
9 WINDALCO was, at that time the company operating the Bayer Plants at Ewarton and Kirkvine.
10 Jamalco operates the Bayer plant at Hayes, Clarendon.
standards and an air pollution monitoring system and index”\(^{11}\) and suggested that this led to the preparation of the NRCA (Air Quality) Regulations which were promulgated in 2006. NEPA also pointed to Section 38.\(^ {12}\)

The NRCA (Air Quality) Regulations 2006 specify when an air quality licence will be necessary and details the requirements licencees must meet. Applications for permits require calculations of the expected emissions from all relevant sources (power plant and kiln stacks, bauxite storage piles, mud lake and mud stacking surfaces, vehicles, and equipment, etc.). The calculated emissions and subsequent monitoring data are used to guide the fees that companies pay for discharging to the atmosphere, with the fees being stated in the discharge licence.

The calculated emissions are also used as inputs to a dispersion model which predicts how the pollutants are dispersed by the wind and where compliance monitoring sites should be located. Monitoring becomes required if the maximum modelled concentrations at ground level are greater than 75 percent of the concentrations permitted by the National Ambient Air Quality Standards (NAAQS). Separate monitoring of emissions from stacks may also be required. Where predicted emissions from sources and fugitive emissions exceed the standards, compliance plans must be submitted and approved. The compliance plans indicate how the emissions will be reduced to bring them into compliance with standards. Whenever monitoring is required, approved sampling and analysis procedures must be used, and NEPA personnel may participate in or conduct the sampling and analyses. Data from the monitoring must be submitted monthly throughout the life of the licence, with additional compliance plans, if necessary. Considerable guidance on this process is given in the NRCA Ambient Air Quality Guideline Document (2006) (Claude Davis and Associates, 2006) and an associated Staff Guidance document. These documents also assist NEPA and the JBI staff when they assess applications for, and compliance to atmospheric discharge licences.

**Licensing and Monitoring of Liquid Discharges**

The NRC (wastewater and sludge) 2013 Regulations detail the requirements for discharging liquid and solid wastes to the environment and supersede the 1996 NRCA (permits and licences) Regulations. Bauxite processing plants use steam for heating purposes and hence generate large amounts of condensate which must be treated prior to discharge. Licences must be obtained to operate such treatment plants and to operate any sewage treatment plants on site. Detailed records of operations and maintenance must be kept, and compliance plans may be required. Treatment plants must measure flow through the plant and effluents must meet either the trade or sewage effluent standard. Operators may be required to monitor and regularly report on effluent quality and any spills or leaks must be reported.

\(^{11}\) Personal e-mails from S. Barnett, General Manager, JBI, 2020 to the author.

\(^{12}\) Personal discussions between the author and NEPA personnel, 2020.
Summation

Presently, bauxite mining and processing companies must still obtain permission to develop areas for mining and mineral processing according to the Town and Country Planning Act, and obtain prospecting permits and mining leases according to the Mining Act 1947 (last amended in 2006) and are also required to secure:

- permits to construct and operate their mineral processing facilities (the Bayer Plants and the bauxite drying plants) with the associated hazardous wastes (red mud) facilities, wastewater treatment plants, power plants, and transport and shipping facilities by the NRCA Act and its 1996 Regulations and Order, both last amended in 2015;
- licences to discharge trade effluent on land or into the ground by the NRCA Act and its 2013 NRC (wastewater and sludge) Regulations; and
- licences for emissions to the atmosphere guided by the NRCA 2006 Air Quality Regulations.

These requirements are supported by atmospheric, ambient water, trade effluent, and wastewater and sludge quality standards.

While the establishment of the JBI and the NRCA Act and its various regulations have brought significant advances in the regulatory framework to the bauxite-alumina industry, the length of time it has taken to reach this stage is of concern. Despite the industry beginning in the 1950s, with the JBI being established in 1976 to ensure, amongst other things, sound environmental practices, and the NRCA Act coming into effect in 1991, it was not until 2015 that bauxite-alumina companies were required to have permits to operate (though some did start to obtain permits in 2008, and possibly earlier). Discharges to the atmosphere did not come under regulations until 2006 and discharges of trade effluent not until 2013. Despite all of the financial and encouraging legislative attention and support given to the bauxite-alumina industry through institutes and companies (Table 2), the industry operated for 45–65 years under minimal or deficient environmental legislation.

While it is encouraging that suitable legislation applicable to the industry now seems to be in place, it is disturbing to see the term “grandfather clause” along side some of the permits in the JBI’s 2019 Annual Report on the industry. This suggests the authorities are still having to rely on the intent of some aspects of the legislation.

Moreover, the relevant Ministers and, in the case of the Mining Act, the Commissioner of Mines, can amend any regulation or order with reasonable cause. This needs to be carefully monitored by regulators and the public to ensure that environmental protection and public health are not sacrificed for economic goals.

---

13 Grandfather clause is a term indicating exemption from the requirements of a piece of legislation.
THE EFFECTIVENESS OF THE LEGISLATION – THE NEED FOR ATTENTION TO DETAIL

As indicated above, the legislation in place from 2015 seems fit for the purpose of managing the impact of the bauxite-alumina industry on the environment and public health. The intent of the legislation, however, can only be achieved if the requirements of leases, permits and licences are implemented, monitored, and enforced.

The number of leases, permits and licences covering the five currently operational mining and processing facilities is very large. In addition, the permits and licences require the companies to comply with all information submitted with the applications for the permits or licences. These are generally extensive documents and to review all of them and the information and data relating to them was beyond the scope of this study. This section will consider only aspects of one mining operation (Noranda) and one bauxite-to-alumina processing plant (UC Rusal, WINDALCO, Ewarton) to illustrate the present status of the effectiveness of the legislation, and will be limited to discharges to the atmosphere and air quality.

Permits and licences are prepared by NEPA and reviewed by other interested parties, including the JBI, prior to being issued. They must be accurate if they are to be effective. During the information gathering stage of this study, many documents were requested from authorities through the ATI Act process and others were downloaded from websites. Several errors were detected in the information received.

For example, Environmental Permit No. 2016-14017-EP00212 granted to UC Rusal for the construction and operation of their Ewarton Bayer Process plant, obtained through a September 2017 ATI request, contained so many errors as to be irrelevant to the operation of the plant. These errors or questionable details included:

- A reference to the application and associated documents submitted in 2014, but the application and associated documents were submitted in 2016.
- Frequent references to a power generation facility (see Special Conditions 3, 4, 9, 12, 13, 16, 28, 39, 40 and 46) including the requirement for a fence to prevent crocodiles entering the facility, which is clearly irrelevant to the Ewarton processing plant, all of which suggested that the permit was for a power plant and not the Bayer plant.
- Frequent references to land clearing and the construction of the facility (Special conditions 3, 9, 11, 12, 13, 23–31 and 33–35) despite the Ewarton plant having been in operation since 1968.

This initial permit was incompletely developed from one previously prepared for the construction and operation of a coastal power plant.

The JBI is required to “conduct audits of the permits and licences on a routine basis” (NEPA-JBI MOU, 2013, part 5.0 of section 3.2.3.1) and the required environmental management is based on the content of the permit and the documents the company submitted during the application process. The JBI was asked to give information about the auditing process and
responded that it involved “asking the questions of – is the project description unchanged; and are specific conditions being met.” They added, “Each operational area (refinery/plant, mines, port) may have several permits – the auditing could be ad-hoc – i.e. several permitted activities visited, review on biannual review meetings, or targeted to specific activities of concern (in development or in operation) or en bloc for full facility audits”.14 Between June 2017 and May 2019, the JBI conducted four audits at the UC Rusal Ewarton Plant that included Environmental Permit No 2016-14017-EP00212 in their scope. In the June 2017 audit, the JBI found the specific conditions in the original permit to be applicable except for two sections (39 and 40) that spoke to a plant closure plan for a power plant rather than a Bayer Process plant. NEPA subsequently issued an amended permit in June 2018 which corrected these two sections.15 In their 23 September 2020 e-mail, the JBI indicated that a reference to a power plant in Old Harbour had also been detected in their 2017 audit, but NEPA does not seem to have corrected that.

If the required oversight activities (reviewing and auditing) were done, why were the mistakes in the issued permit described above not detected before it was issued, and only three of the mistakes detected during the audits over the three years between then and now? Given that the company operated during those years without realizing the permit was inappropriate, the permit would seem to be irrelevant to its day-to-day operation. How many other permits (and licences) contain errors? This lack of attention to detail makes a mockery of the permitting process and calls into question the seriousness with which environmental permits are regarded by both the regulators and the companies.

A corrected Environmental Permit (EP) was issued in 2020 after the errors had been pointed out to NEPA during this study. We are left wondering why NEPA failed to inform us of the 2018 amendment to the permit during our recent discussions.

Other minor errors detected include:

- In the 2013 version of the NEPA-JBI MOU, section 3.2.1 has been lifted directly from section 4 of the 1994 MOU, but the sections referred to in 3.2.1 retain the numbering from the 1994 agreement which bear no relationship to that of the 2013 agreement. This document was jointly prepared by the two parties and according to its content the parties meet every six months to monitor the progress of the agreement and to amend it, if appropriate, and meet every three years to undertake a full review of the agreement; such meetings if held should have identified and corrected the errors in the MOU. No changes have been made to the MOU since it was adopted in 2013.
- In license 2008-06017-AQ00002, 2015-2020, section J is repeated as section M and there are no sections K or l.
- In permit 2016-06017-EP00152, relating to bauxite mining by Noranda, section Special Conditions 17 refers to AQ00001 which is relevant to Noranda’s Discovery Bay operations, not their mining operations.

---

14 Personal e-mails from S. Barnett, General Manager, JBI, 24 July 2020 to the author.
15 Personal e-mails from S. Barnett, General Manager, JBI, September 7 & 23, 2020 to the author.
• In permit 2016-06017-EP00154, relating to the clearing of land for mining by Noranda, section Special Conditions 14 refers to AQ00001 which is relevant to Noranda’s Discovery Bay operations, not their land clearing operations.

From these examples, it appears that the procedures in place for preparing, reviewing, and implementing environmental permits and licences are not being conducted with sufficient diligence.

**The Access to Information Process**

When conducting this review, 27 ATI requests were made to NEPA, the JBI, the Ministry of Health and Wellness (MOHW), and MGD, many asking for multiple documents. This was almost certainly overwhelming, particularly for NEPA. Many of the documents requested could and should routinely and proactively be posted on the relevant websites. These include: prospecting and mining leases, operating permits and discharge licences and the documentation submitted with the applications for them, mining, environmental management and facility compliance and closure plans, MOUs, and monthly, quarterly and annual reports including data from the monitoring activities. In fact, the NRCA Act (Section 21 of the Permitting and Licensing Regulations) makes provision for information to be provided to the public via public registries during reasonable working hours. Proactive and online access to public documents would allow much greater transparency and reduce the need for voluminous ATI requests.

The information received through these ATI requests was occasionally, at least in part, in error and often difficult to work with. In data files, there were a few obvious data entry errors and uncertainties as to which parameters were being reported. There was no information on data quality. Data within spreadsheets were often linked to spreadsheets in other files and so copying or working with them required special care. The Noranda mining plan 2015–2019 identified ore bodies by number, but there was no information, such as a map, to link the ore body number to its location, so a further ATI request was required. The organization of information and data within spreadsheets occasionally changed from year to year, making it very difficult to merge the data to allow for trends to be plotted. Tables reporting information for the various plants differed in format and extent of content. The file names were often less than informative. One file was received twice (same file name) but one document had ten more pages (one section) than the other. Many other examples will be pointed out when considering the data for the Noranda and UC Rusal, WINDALCO, Ewarton operations. Often, the information obtained could only be understood by someone with specialized knowledge. These errors and/or deficiencies, apart from being annoying and time wasting, suggest a lack of due diligence by those responsible for managing and/or providing the information. It is particularly disturbing that the data entry errors are not apparently detected by the persons interpreting them. More care needs to be taken to ensure that data and information given to the public is correct and easily understood.
In discussions with NEPA about some of these hurdles, it became apparent that there is often delay and incomplete responses from the technical staff members to the ATI officer, and the latter is not in a position to assess the accuracy or completeness of the information provided.

**TWO CASE STUDIES – PROCESSING BY UC RUSAL AT EWARTON, ST CATHERINE AND MINING BY NORANDA, ST ANN AND TRELAWNY**

The UC Rusal Bayer Plant at Ewarton was selected to investigate the effectiveness of the application of the legislation with respect to the alumina extraction process, as it is one of only two plants currently operating; Jamalco at Hayes, Clarendon being the other.

Noranda’s activities in SML 165, 172 and 173 areas in St Ann and Trelawny were selected to investigate the effectiveness of the application of the legislation with respect to mining due to the present high interest in the possible impacts of mining in Cockpit Country.

Water quality data did not become available within the timeframe of this study, so the study has been largely limited to the effectiveness of the air quality requirements.

These case studies consider:

- how air quality monitoring sites and the pollutants to be monitored are decided upon by looking at the predictions of the air dispersion model calculations (required by the legislation) and comparing them to the actual monitoring sites selected by the authorities; and
- actual monitoring data, to see if they are fit for the purpose of ensuring compliance to the National Ambient Air Quality Standards (NAAQS).

Jamaica’s NAAQS identifies two sets of pollutants: criteria pollutants for which there are set maximum concentrations, and priority pollutants for which there are guideline concentrations (Table 2). Criteria pollutants come from many sources, while emissions of priority pollutants are not as common.

Particulates are considered as criteria pollutants and in the NAAQS are divided into Total Suspended Particles (TSPs) and PM\(_{10}\) (particulate material less than 10 microns, i.e. 10 millionths of a meter). The United States Environmental Protection Agency (US EPA) in its Integrated Science Assessment of Particulate Matter (PM) (EPA, 2019) gives evidence that PM\(_{2.5}\) (particulate material less than 2.5 microns) is the only particulate parameter that is a reliable indicator of possible respiratory illnesses. EPA replaced TSP with PM\(_{10}\) in their standards in 1987 and added PM\(_{2.5}\) in 1997. Without PM\(_{2.5}\) data one cannot assess the impact of particulates on human health, a stated objective of the air quality regulations and of the environmental responsibility of the JBI (author’s emphasis).
Case Study 1: UC Rusal, WINDALCO Plant, Ewarton

UC Rusal’s, WINDALCO, Ewarton processing plant (referred to as the Ewarton Plant, Figure 2) is presently subject to four permits (the bauxite processing plant, the power plant, the storage of sodium hydroxide, the preparation of a mud stacking area) and three licences (to operate a wastewater treatment plant, to discharge trade effluent, to discharge to the atmosphere). There are also permits and licences relating to the operation of the mud stacking and mining areas, and maybe others. The plant has been operating since 1968.

Requirements of the Emissions to the Atmosphere Licence

The discharge to the atmosphere licence, 2008-14017-AQ00020, is relevant to all permits within the boundaries of the processing plant. Applications for atmospheric discharge licences require applicants to present estimates of all expected emissions from the various sources (mines, stockpiles, roads, stacks, engines, power houses, etc.) within the geographical area relevant to the permit. These emission estimates are used as input to an atmospheric dispersion model and are, according to the Air Quality Guidelines, “necessary to properly...
assess” the “impact on human health and the environment” (Claude Davis and Associates, 2006).

The atmospheric dispersion model identifies the sites in the area, outside of the perimeters of the plant, where the maximum ground level impact for each pollutant is expected to be, and gives the predicted pollutant concentrations at those sites. For the pollutants whose concentrations exceed 75 percent of the relevant National Ambient Air Quality Standards (NAAQS), a compliance plan is required. The compliance plan must detail the actions the company will take to reduce its emissions so that the pollutant does not exceed the standard. Monitoring will be required for such pollutants. This information is then considered by NEPA, the JBI, the relevant company and the Environmental Health Unit of the Ministry of Health and Wellness (EHU-MOHW), and an agreement is reached as to the parameters to be monitored and the locations of the monitoring stations. According to the air quality regulation guidelines (Section 4.3) monitoring stations should assess compliance, population exposure, background levels, and any “special purposes”\(^\text{16}\).

The Air Quality Guidelines Document (prepared to assist companies and NEPA staff members) also says that each source will generally have a minimum of three monitoring stations: two compliance stations near the sites with maximum predicted ground level concentrations downwind of the source, at least one population exposure station, and one background station. Any one site can serve more than one function (Section 4.5 of the Air Quality Guidelines Document). Many assumptions and approximations are included in the model and multiple practical issues have to be taken into account, so compromises do have to be made in deciding upon the final monitoring sites.

The dispersion model applied to emissions from the Ewarton Plant predicted that the alumina calcining kilns and boilers of the power plant on the compound, plus the bauxite stockpile at the Schwallenburg mine and the haul roads from the mine to the processing plant, would be the major sources of Particulate Matter (TSP and PM\(_{10}\)). The kilns and the oil-fired boilers of the power station were identified as sources of carbon monoxide and the oxides of nitrogen and sulphur.\(^\text{17}\).

The data in WINDALCO’s annual reports for 2016–2019 indicate that the predominant winds came from the Northeast through to the Southwest, with the winds coming from the Southeast through to Southwest generally being mild (<1.25 m/sec). The wind rose\(^\text{18}\) given in the modelling report for 2009–2013, which was used in the dispersion model, indicates winds between North-north-east to South-south-east which concurs with the stronger winds experienced during 2016–2019. The JBI’s 2016–2019 annual reports do not include wind directions for the Ewarton Plant.

The modelling report, included in the documents submitted with the licence application, gives maps which show the locations of the highest predicted concentrations. For partic-

\(^{16}\) “Special purposes” are not defined in the guidelines, but could include Residue Disposal Areas, schools, community centres or towns, etc.

\(^{17}\) The oil-fired boilers produce steam for generating electricity and for heating within the Bayer plant.

\(^{18}\) A wind rose is a graphic tool used to show wind speed and direction at a particular location.
ulates, the highest concentration of 3223 µg/m$^3$ was predicted to be in the vicinity of the bauxite stockpile at Schwallenburg, while concentrations of the order of 100–500 µg/m$^3$ were seen close to the haul roads and to the Southwest (downwind) of the processing plant (Figure 2). The model output does not indicate whether the particulates in the vicinity of the processing plant are from the kilns or from bauxite stockpiles or haul roads. Calculated emissions, however, (Table 3) show that the particulates from the kilns (alumina) and boilers (oil combustion products) contribute slightly more than the bauxite dusts for both TSP and PM$_{10}$, and that PM$_{10}$ emissions are comparable to those of TSP, except along the haul roads.

Table 3: Estimates of Emissions from UC Rusal’s Ewarton Plant and Surroundings

<table>
<thead>
<tr>
<th>Pollutant (grams/second)$^{19}$</th>
<th>Kilns</th>
<th>Boilers</th>
<th>Bauxite stockpile: plant</th>
<th>Bauxite stockpile: Schwallenburg</th>
<th>Mud Stacking area</th>
<th>Haul roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSP</td>
<td>14.7</td>
<td>13.7</td>
<td>1.4</td>
<td>9.9</td>
<td>1.7</td>
<td>11.6</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>11.7</td>
<td>11.7</td>
<td>1.3</td>
<td>9.9</td>
<td>1.7</td>
<td>3.0</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>96.5</td>
<td>153</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO$_x$</td>
<td>14.1</td>
<td>63.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>15.1</td>
<td>6.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Dispersion Model predicts (Table 4) that both TSP and PM$_{10}$ maximum concentrations at ground level will exceed the ambient air quality standard by large amounts (24-hour averages of over 3000 µg/m$^3$ predicted for both particulate forms vs. the 24-hour average standard of 150 µg/m$^3$) and therefore suggests that both parameters should be monitored. Recall that neither of these parameters will give indications of impacts on human health.

For gases, the model predicts that SO$_2$ concentrations at ground level will exceed 75 percent of the air quality standard values and so recommends monitoring. NO$_x$ and CO, however, will not require monitoring.

Figure 2 shows the locations of the agreed on monitoring sites and the locations where the higher ground level concentrations are predicted to occur. The monitoring sites had been used for monitoring prior to this modelling exercise.

The selected monitoring sites, except for Orangefield, bear little relationship to the model’s predictions of the sites of maximum impact, given that most monitoring sites are not within the prevailing wind plume from the emission sources. The Orangefield site, while downwind of the plant, is closer to the plant than the predicted maximum sites. It is, however, reasonable to select this as a population exposure site. The Mud Stacking site, being within the boundaries of the industrial facility, does not meet the criteria for ambient monitoring sites but could well be of special interest to the company. The Hayfield and Pleasant Farm sites could be considered sites of special interest as they are within small communities and could be impacted during the direction-variable light winds.

$^{19}$ SO$_2$ – sulphur dioxide, NO$_x$ – gaseous oxides of nitrogen, CO – carbon monoxide.
Table 4: Dispersion Model Results for UC Rusal’s Ewarton Plant at the Pre-existing Environmental Monitoring Sites

<table>
<thead>
<tr>
<th>Pollutant (µg/m³)</th>
<th>Average period</th>
<th>Ja. NAAQS a</th>
<th>Max pred. concb</th>
<th>Orangefield</th>
<th>Mud stacking</th>
<th>Hayfield Closec</th>
<th>Hayfield Club</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>pred</td>
<td>obs</td>
<td>pred</td>
<td>obs</td>
<td>pred</td>
</tr>
<tr>
<td>TSP 24-hr</td>
<td>150</td>
<td>3330</td>
<td>56.3</td>
<td>126</td>
<td>40.6</td>
<td>276</td>
<td>22.9</td>
</tr>
<tr>
<td>annual 24-hr</td>
<td>60</td>
<td>347</td>
<td>8.7</td>
<td>49.7</td>
<td>3.3</td>
<td>90.8</td>
<td>2.1</td>
</tr>
<tr>
<td>PM10 24-hr</td>
<td>150</td>
<td>3250</td>
<td>20.6</td>
<td>80.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>annual 24-hr</td>
<td>50</td>
<td>89.8</td>
<td>1.7</td>
<td>24.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOx4 1-hr</td>
<td>400</td>
<td>213</td>
<td>61</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual 1-hr</td>
<td>100</td>
<td>13.6</td>
<td>6.3</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO 8-hr</td>
<td>40000</td>
<td>740</td>
<td>117</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO2 1-hr</td>
<td>700</td>
<td>9940</td>
<td>524</td>
<td>259</td>
<td>465</td>
<td>396</td>
<td></td>
</tr>
<tr>
<td>24-hr</td>
<td>280</td>
<td>2065</td>
<td>179</td>
<td>36</td>
<td>114</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>annual 24-hr</td>
<td>60</td>
<td>147</td>
<td>40.4</td>
<td>51</td>
<td>4.4</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Note: a Jamaican National Ambient Air Quality Standard; b pred – predicted, obs – observed, conc – concentration; c site also called Morri sons; d NOx – oxides of nitrogen.

But there are no compliance sites and no background sites. The dispersion model results seem to have little bearing on the location of agreed upon monitoring sites and data from them will give no guidance as to the plant’s compliance to the NAAQS. If the chosen monitoring sites were those that were in existence before the modelling exercise, why was the modelling required?

The report on the model’s results also presents data on predictions for four sites for which monitoring data were available from 2012 – Orangefield, Mud Stacking, Hayfield Close, and Hayfield Club (Figure 2), and then compares the predictions with the observed data. These data are presented in Table 4.

It is customary when using a model to validate its predictions by deploying monitors at sites to see if predictions adequately reflect measured concentrations. Such a validation has not been done for this air dispersion modelling. The exercise above does, however, give some idea of the validity of the modelling process, even though it has not been done for the sites predicted to have the maximum ground-level concentrations. Given the many assumptions and uncertainties associated with the model calculations, uncertainties of ± 100 percent in the calculated concentrations would not be unusual.

From these data some conclusions can be drawn:

- The concentrations predicted at the monitoring sites are significantly less than the maximum predicted concentrations (column 4), indicating that if the predicted concentrations are reasonable these sites cannot be considered compliance sites.
The observed concentrations for TSP often exceed the NAAQS values, suggesting that the compliance plan that would have been in force at the time of the 2012 monitoring needed to be refined. The other parameters are in compliance.

- The model is significantly under predicting TSP and PM_{10} at the monitoring sites, particularly the annual averages.
- The NO_{x} and SO_{2} predictions are in reasonable agreement with observations, keeping uncertainties in mind, which suggests that the model has worked reasonably well for these parameters.
- The model significantly over predicts CO concentrations.

These few examples give some evidence on the validity of the modelling. The results of the calculations for the oxides of sulphur and nitrogen are not unreasonable. The predicted and observed results for carbon monoxide differ by close to an order of magnitude, but this is not a concern as both results are significantly less that the ambient standard values. The model does not, however, make accurate predictions for both forms of Particulate Matter (TSP and PM_{10}). This is of particular concern as these are the parameters that most companies are required to monitor based on model results.

Why are companies required to do calculations using the dispersion model when the model does not seem to give satisfactory results for all parameters and the results seem to be ignored when selecting the monitoring sites? Why, if a model is to be required, is it not also required that the model be properly validated?

**Air Quality Monitoring Data**

The discharge licence for the Ewarton Plant (there is a separate licence for the mining area) requires SO_{2}, NO_{2}, TSP, and PM_{10} to be monitored – the gases (SO_{2} and NO_{2}) continuously, while the particulates (TSP and PM_{10}) for 24 hours every six days. The model indicated that NO_{2} need not be monitored. The operators of the Ewarton Plant are required to submit monthly reports on their operations, including the atmospheric monitoring.

The JBI’s 2016–2019 reports present data for five monitoring stations: Orangefield and Mud Stacking (TSP and gases), Hayfield Club and Pleasant Farm Club (PM_{10}), and Hayfield Close (TSP). The JBI’s quarterly and annual reports interpret these data.

The companies do face some difficulties. The PM_{10} equipment at the Pleasant Farm Club monitoring station was vandalized in June 2018, and there was no data collected there for the rest of the year and for all of 2019. The equipment for monitoring the gases was also non-functional over that time. The data reports indicate that there have also been other instances of vandalism that have kept equipment out of operation for a few days to weeks; presumably in those cases repairs were possible. The JBI indicated that UC Rusal has difficulties with purchases owing to the US embargo on Russian companies.

---

20 One order of magnitude means a multiple of ten.
Perhaps the companies did not regard the replacement or repair of equipment as urgent, given that data for other years show compliance with standards for both particulates and gases. If, however, environmental monitoring is required, companies must be prepared to comply and therefore have backup equipment ready, as is the norm for production.

The TSP concentrations at the Mud Stacking monitoring site exceeded the annual average standard of 60 µg/m³ in 2016, 2017, and 2019, and according to the JBI reports this also occurred in 2014 and 2015. The JBI report did not, however, indicate that any action was taken by the company. This site is within the boundaries of the processing plant and therefore presumably a site of special interest to the company, but it does indicate that the Mud Stacking area is a considerable source of TSP. Why did the company not take effective action and why did the JBI not require them to, or if action was taken, why did the JBI not describe it in their reporting?

The monitoring equipment for the gases operates continuously and reports data every hour, generating 24 datum points per day, per pollutant. The operators of the Ewarton Plant reported SO₂ and NOₓ for all of 2017 and about half of 2018 and CO over the same period, but not as consistently.

Verifying Data

To be able to make meaningful conclusions from data, some indication of the quality of the data must be available. In their monthly reports, UC Rusal includes information on instrument calibrations for the Ewarton Plant. The December 2019 report states that the instruments at Orangefield and Mud Stacking (TSP and SO₂/NOₓ/CO) were last calibrated in 2017 while the 2016 report states that the previous calibrations had been done in 2011. The 2019 report indicates that the PM₁₀ instrument at the Hayfield Club and the TSP instrument at Hayfield Close had not been calibrated since 2011. It is unusual for equipment to be calibrated so infrequently. The JBI indicated that equipment calibration is done by a third party, usually the equipment manufacturer, and that the authorities (NEPA/JBI/EHU-MOH) will undertake verification monitoring if capacity allows, but no such verification monitoring was done in the 2016–2019 period. NEPA claimed that “standard air quality validation best practices and rules of thumbs such as removal of negative and suspect datasets” and “conducting instrument audits” were the base of the quality assurance programme, but no objective evidence was given that this has been done. No quality control data were provided with the monitoring data and all indications are that no such data are available. The JBI did not address data quality in the reports reviewed.

In the air quality data sets received there were many negative values (Table 5), many zeros (does that mean a “concentration of zero” or “no data”?); the spreadsheets suggest both cases have occurred) and information that was not clear. The data have not been carefully reviewed

---

21 Personal e-mails from S. Barnett, General Manager, JBI, 2020 to the author
22 Discussions with NEPA personnel, 2020
and their quality has not been assessed. It is the responsibility of laboratories to provide clients with objective evidence of the fitness for purpose of their data and the regulators should be insisting on this.

The data for SO$_2$, NO$_2$ and CO for 2017 and January to June of 2018 are summarized in Table 5. In their reports for 2016–2019, the JBI stated that there were no gaseous data for the period.

In 2017, SO$_2$ concentrations at Orangefield peaked on May 11, between 11 am and 1 pm (375, 791 and 524 µg/m$^3$) with all other concentrations over the year being less than 400 µg/m$^3$. At the Mud Stacking site, a similar peak occurred on May 10 between 3 and 5 pm (741, 1035 and 418 µg/m$^3$); over the year there were only two other concentrations greater than 400 µg/m$^3$. The high CO concentration in 2017 at Orangefield occurred between 11 am and 1 pm on May 11 (19200, 35990 and 21200 µg/m$^3$); these were the only observations greater than 1860 µg/m$^3$ during the year. The 168 µg/m$^3$ datum seen at Orangefield, at 1 pm, again on May 11, was the only datum point above 30 µg/m$^3$ for the year. Apart from these extreme values occurring in early May 2017, which would suggest a short-term problem at the plant, all other data in 2017 through 2018 were well below the relevant air quality standard.

**Table 5**: Summary of Hourly Data (µg/m$^3$) for Gases at Orangefield and Mud Stacking Monitoring Stations

<table>
<thead>
<tr>
<th>Monitoring Site</th>
<th>Orangefield</th>
<th>Mud Stacking</th>
<th>Orangefield</th>
<th>Mud Stacking</th>
<th>Orangefield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollutant</td>
<td>SO$_2$</td>
<td>NO$_2$</td>
<td>CO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>23.5 11.2</td>
<td>-8.1 4.9</td>
<td>5.24 6.0</td>
<td>2.9 8.5</td>
<td>916 385</td>
</tr>
<tr>
<td>Median</td>
<td>17.8 0.8</td>
<td>2.1 1.6</td>
<td>4.32 5.3</td>
<td>2.4 8.1</td>
<td>869 481</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>39.8 28.5</td>
<td>69.8 13.2</td>
<td>4.57 4.6</td>
<td>5.7 8.3</td>
<td>805 346</td>
</tr>
<tr>
<td>Maximum</td>
<td>791 304</td>
<td>1036 240</td>
<td>168 34.4</td>
<td>275 92</td>
<td>35990 1385</td>
</tr>
<tr>
<td>Minimum</td>
<td>-3.1 -34</td>
<td>-265 -0.5</td>
<td>-0.9 -0.6</td>
<td>0 0.2</td>
<td></td>
</tr>
<tr>
<td>Number Obs</td>
<td>5619 3080</td>
<td>5250 5476</td>
<td>5618 3447</td>
<td>5246 4420</td>
<td>3554 3914</td>
</tr>
<tr>
<td>Negative Values</td>
<td>55 445</td>
<td>557 12</td>
<td>70 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Jamaica National Ambient Air Quality Standards**

<table>
<thead>
<tr>
<th></th>
<th>1-hr average</th>
<th>24-hr average</th>
<th>Annual average</th>
<th>8-hr average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-hr average</td>
<td>700</td>
<td>280</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>1-hr average</td>
<td>400</td>
<td>Annual average</td>
<td>100</td>
<td>10000</td>
</tr>
<tr>
<td>1-hr average</td>
<td>40000</td>
<td>10000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 3 and Figure 4 show typical monthly data for SO$_2$ and NO$_2$. The obvious peaks in concentration in the SO$_2$ data generally start at about 8–9 am and last for 3–4 hours and must relate to some industrial activity, presumably within the power plant or the calcining kilns. The “peaks” in the NO$_2$ data show no trends with time and so are probably reflecting real variability. The CO data are random. The step in the baseline for the SO$_2$ data on the 11th of the month would suggest a shift in the zero of the instrument which raises questions about its calibration. The SO$_2$ concentrations are almost always less than half of the 1-hour air quality standard of 700 µg/m$^3$, suggesting that community exposure at Orangefield is not excessive (the Mud Stacking site is within the boundaries of the plant) and less than 5 percent of the dispersion model’s maximum predicted concentration, but since these are not compliance sites nothing can be said about the effectiveness of any implemented pollutant removal processes. While interesting, one wonders why the CO and NO$_2$ data were collected as the air quality discharge licence did not require it and they clearly are not expected to cause any problems at these concentrations. The same might now be said of SO$_2$. Does the model give results fit for the purpose? It does not seem so (author’s emphasis).

Figure 3: An Example of SO$_2$ Data

Figure 4: An Example of NO$_2$ Data.
Case Study 2: Noranda’s Mining Activities in St Ann and Trelawny

Noranda’s mining operations are presently subject to the conditions of three mining leases, three Environmental Permits (EPs), and a licence to discharge to the atmosphere. There may be others. The mining lease areas are shown in Figure 5, which also names the rail heads (Tobolski and Water Valley) and the three environmental monitoring sites (Calderwood, Clydesdale, and Green Hill). Mining has been permitted to take place within the areas of SML 165 since October 2004, and SML 172 since May 2017; SML 173 still awaits a final mining permit, a completed EIA and associated public process and the EPs.

Bauxite is mined within various pits within the areas, transported by truck to the rail heads, and then moved by rail to the Discovery Bay facility for drying and exporting. The Discovery Bay facility is subject to separate permits and licences. The mining plan for these areas received from MGD identified the ore bodies or mining pits by number, but did not indicate the relationship between pit number and pit location, so it is not possible to see exactly where mining has taken place over the past few years.

Mining permits, as mentioned above, require atmospheric discharge licences and therefore the use of a dispersion model as detailed in the previous case study.

Figure 5: Map of Noranda’s SML 165 area
Assessing the Appropriateness of the Monitoring Stations

The most recent applications for air quality discharge licences from Jamalco and UC Rusal for the Ewarton Plant included reports on the results of the application of dispersion models to their emission data and wind patterns. No such report was received from NEPA with the information included in the Noranda application, although the application did include data on the estimated emissions and the estimated maximum ground-level concentrations and their predicted locations. The model used emission data from 2006 through 2010 and showed that only TSP would exceed 75 percent of the ambient air quality standards and therefore require monitoring. Since the predicted emissions exceeded 75 percent of the TSP standard, a compliance plan to show how emissions would be controlled to bring them into compliance with the NAAQS became required.

The prevailing wind during 2016–2019 in the SML 165 and 172 areas was from the East-north-east through Southeast with 94 percent of the data between 60 and 160 degrees and 75 percent between 90 and 145 degrees, according to Noranda’s monitoring site data; the JBI’s annual reports for 2016–2019 give wind data for Water Valley (wind directions as for the monitoring sites) and for Tobolski (winds include a South to Southwest component). The dispersion model predicted locations of maximum ground level TSP concentrations are shown in Figure 3; they are all well downwind of the mining and Tobolski and Water Valley rail head activities, and outside of the SML 165 mining lease area.

The dispersion model calculates ground-level concentrations at various geographically defined points (called receptors) which are usually set on a grid which extends to at least a kilometre from the facility boundary and with receptors spaced by at most 100 m apart (Section 5.3.5 of the Air Quality Guidelines Document). The Guidelines further explain that “receptors may be omitted from the property of the facility under review, provided it is inaccessible to the general public.” This usually means that receptors are placed at the fence line and beyond (author’s emphasis). In Noranda’s application for the air quality discharge licence the sites identified as being those where the maximum ground-level concentrations will occur are named as “fence line” and, for example, “NW of lease.” This would suggest that the model used the boundary of SML 165 as the fence line of the mining facility, rather than the boundaries of the two rail heads and the haul roads. There are, however, many roads and small communities within the mining lease area, and therefore the regulation guidelines would require the receptor grid to include the areas within the lease boundaries that are accessible to the general public (i.e., all of the lease area). It appears the model has not been applied according to the regulation’s guidelines, making the predictions of compliance monitoring sites and the identification of pollutants to be monitored of no value.

The monitoring sites used by Noranda over the 2016–2019 period, and probably since mining started in SML 165 (2004) are at Calderwood, Greenhill, and Clydesdale.

Repeated questions to the JBI and NEPA as to the suitability of these sites to monitor the activities in the SML 165 and 172 areas met with either no response (NEPA) or that they were the approved sites, their selection was driven by proximity to population centres,
Calderwood served as a haul road monitoring site, and that there was movement of site(s) over the mining period (JBI).

The data provided from monitoring sites, however, was limited to the three sites (fixed as indicated by the GPS data provided). Unfortunately, the mining plan as received means it is not possible to see when these sites may have been downwind of the mining operations, but from their locations it can be seen that they can only have been background sites for the activities at the two rail heads and within the western half of SML 165 and all of the SML 172 areas. In short, these sites do not comply with the guidelines to the Air Quality regulations. As described previously for the Ewarton Plant, there are no compliance and no downwind community exposure sites.

Once again, the selection of the monitoring sites does not comply with the recommendations of the Ambient Air Quality Guideline Document, which provides information for the implementation of the NRCA (Air Quality) Regulations.

Assessing Whether the Correct Parameters were Monitored

Based on the modelling, the licences to discharge to the atmosphere name the parameters that must be monitored. The licences for the SML 165 and 172 mining areas refer to the same discharge license: 2008-06017-AQ00002, which was in force from April 2015 to April 2020. The licence states: “The Licencee shall (author’s emphasis) conduct ambient monitoring in accordance with the guidelines as stipulated below” and then gives a table that identifies Total Suspended Particulate (TSP) matter and PM$_{10}$, both to be monitored for 24 hours every six days. The licence also states that “the licencee shall submit an air quality monitoring plan.” An ATI request to NEPA (4 June 2020) asking for copies of all air quality monitoring plans relevant to this licence for the years 2016–2019 had not been responded to at the time of writing.

An ATI request to NEPA for air quality data relevant to SML 165 and 172 for 2016 through 2019 returned only TSP data for Calderwood, Clydesdale, and Green Hill. No PM$_{10}$ data was received. When asked what was done about the absence of PM$_{10}$ data, the JBI responded, “It is common to focus on PM$_{10}$ in urban areas . . . and utilize the TSP in rural areas” and: “As the network goes through an approval process between government regulators, it is not considered deficient for Noranda to not have PM$_{10}$ monitoring in the mining areas.” In a follow-up e-mail, they added, “The licence AQ00020 (sic) gives the two (2) options and does not prescribe that both MUST be used.”

NEPA offered to check on why PM$_{10}$ was not monitored – they did not seem to have noticed this – but at the time of writing, no response had been received.

The question therefore becomes: How is it that the regulators (NEPA and JBI), the same ones who issued and reviewed the licence, did not consider Noranda deficient in not monitoring PM$_{10}$? Was the issued licence in error? If it was, why was this not corrected?

---

In the absence of any further information, it is mystifying as to how the data from these sites are considered fit for the purpose of assessing impact on human health and the environment, given the site locations and the failure to monitor PM$_{10}$. Why was PM$_{10}$ included in the permit? Why are there no compliance stations? Why haven’t the stations been moved, or new stations introduced, as the mining activities have moved within the lease areas? In each of the JBI’s 2019 quarterly reports to NEPA on the environmental monitoring of the industry they state that they continue to have dialogue with the companies as to the rationalization of the station locations, but no action seems to have resulted from this dialogue. Moreover, as indicated earlier, TSP and PM$_{10}$ can give very little information on the impact of the activities on human health.

Given the inappropriate application of the (unvalidated) model there is no basis for deciding that TSP and PM$_{10}$ should be monitored in the first place.

**Assessing the Quality of the Total Suspended Particulate (TSP) Data**

Companies are required to submit their monitoring data to the JBI each month, and the JBI, in turn, reports to NEPA on these data every quarter and annually.

Interpreting the 2016–2019 TSP data at these three sites presented some difficulties. The data are in Excel spreadsheets and the titles at the top of the columns indicate that they are the average micrograms per cubic meter (µg/m$^3$) for the 24 hours. Another column gives the operating (pumping) time for the instrument. While this is normally exactly 24 hours, in several cases it was different from 24 hours, sometimes significantly so. On one occasion, a note on the spreadsheet indicated that the instrument ran for three days and yet the time entered for run time was 24 hours.

This raises doubt as to whether the data in the “TSP 24-hour average” column have been averaged using 24 hours or the actual pumping time. The mass entered for the occasion when the instrument ran for three days was 117 µg/m$^3$, approximately 45 µg/m$^3$ larger than the next credible value. Were the correct times used in the averaging process?

Also, the datasets include data which were said to have been affected by external factors. In July 2017 and 2018, the external factor was reported to be Saharan dust, but on other occasions the external factors were not identified. These externally affected results should not be considered when looking for the impact of the mining activities, but in the interpretations given in the JBI’s annual reports, such data have been retained.

The graphs in the 2016 through 2019 JBI annual reports of the mining area TSP data (which all, in error, include one of the stations relevant to the Discovery Bay plant and PM$_{10}$ in the title) present the monthly averages for the three monitoring sites. Sampling for TSP is done every six days and so there are normally five results per month. Monthly averages are usually in the 20–30 µg/m$^3$ with maxima in the 40-50 µg/m$^3$ range, 24-hour averages are also in the 20–30 µg/m$^3$ range but the maxima are in the 70–80 µg/m$^3$, once the data identified as impacted by external factors (see above) are removed.
In interpreting TSP data, one is looking for potential environmental effects (human health effects are not indicated by TSP data; see above) and hence the maxima are the incidents of relevance. Averaging results can hide these maximum values and leave the false impression that the mining is not creating problems to the environment.

In addition, each datum is collected over 24 hours while the working day is normally around 10–12 hours. The major sources of TSP, according to the model, are the haul roads. Therefore, to get the true representation of the impact of dusting during the day, the reported data should probably be approximately doubled, leading to concentrations in the 40–60 µg/m³ range with maxima being in the 140–160 µg/m³ range and the likelihood that the daily standard of 150 µg/m³ could have occasionally been exceeded during working hours (the data suggest this could have occurred five times between 2016–2019). Dusting within the mining area during working hours can therefore be considerable, especially given that this conclusion has been drawn from data for sites upwind of the mining and transporting activities; TSP in downwind areas during the day could well be a significant problem. Simply comparing the obtained data to the NAAQS is somewhat simplistic and does not adequately address the objective of monitoring the industry in order to assess its impact on human health and the environment.

**CONCLUSION**

The legislation and associated regulations relevant to the impacts of the bauxite-alumina industry on Jamaica’s environment finally became what could be considered satisfactory in 2015, 65 or so years after the industry started on the island, although it seems that “grandfather” status still applies in some instances. This occurred despite the establishment of the JBI in 1976 with a mandate to advise the GOJ on, amongst other things, the technical aspects of the industry and to ensure the following of good environmental practices, including the rehabilitation of mined-out lands. The JBI did encourage the industry to follow internationally accepted practices, and they seemed receptive to this, but why did the regulators depend on encouragement rather than legislation for so long?

Jamaica took a significant step forward towards sustainable development and environmental protection with the enactment of the NRCA Act in 1991, but why did it take almost six years to get the regulations promulgated, and then a further nineteen years to get amendments made to the regulations to remove the permit exemptions for existing activities that encompassed all of the bauxite-alumina industry? The authorities found what could be termed innovative ways to get around the deficiencies in the legislation, and it seems that the companies were cooperative, but why were the regulators not effective in getting suitable legislation in place more quickly?

The recent preparation of a draft policy on mining is encouraging. The new National Minerals Policy emphasizes the need to conduct mining and the associated processing in keeping with best international practices in order to minimize impacts on ecosystems and
people. The recent report from the Intergovernmental Forum on Minerals, Metals and Sustainable Development identifies ways to get these ideas into practice. These are positive steps.

Despite the existence of reasonable legislation and the apparent interest within state agencies, the implementation of the legislation leaves a lot to be desired. This study found errors in permits and MOUs, lack of due diligence in ensuring the quality of monitoring data (for example, via instrument calibrations and/or verification exercises, auditing of compliance to permits and licences, quality control data from analytical laboratories) and superficial reporting on the environmental monitoring of the companies.

Why are the authorities, including the JBI, the technical advisor to the GOJ on matters relating to this industry, allowing themselves to be limited by Jamaica’s outdated air quality standards when specifying their requirements on an industry known to cause considerable dust nuisance in several areas around the country?

The many drafts of the National Minerals Policy call for the industry to conform to international best practices and the industry has generally shown its willingness to be guided by international best practices, as evidenced by their acceptance of the stop-gap manner that they were subjected to prior to 2015. But still, despite the international standards including PM$_{2.5}$ for many years now (EPA 2019), the industry is only required to monitor for TSP and, occasionally, PM$_{10}$. Without PM$_{2.5}$ data, one cannot assess the impact of particulates on human health, part of a stated objective of the environmental responsibility of the JBI. Why, given the technical knowledge available, weren’t companies asked to monitor PM$_{2.5}$ at least within the vicinities of nearby communities? The bauxite-to-alumina processing industry is well known to anyone who passes by or lives close to one of the processing plants to emit caustic aerosols (which cause nasal irritation and corrosion of roofs). Why are there no requirements to quantify these?

Considerable effort is put into preparing and assessing applications for permits and licences by all involved. But why are companies required to calculate emissions and apply dispersion models to those emissions when the results of the model and the suggestions given in the guide to the air quality regulations are effectively ignored? The monitoring sites selected for the Ewarton Plant do not include compliance sites and are barely relevant to the requirements of the air quality regulations. The predictions of compliance sites for the Noranda mining areas were wrong, as the model was not applied correctly. Also, the predictions as to which parameters should be monitored are not followed. There is no evidence that the predictions are fit for the purpose, as the models have not been validated. Why go to the expense of doing the calculations if the decisions are to be made by rule-of-thumb or guided by expediency?

The recommendation within the draft mining industry policy for the transition of the JBI into a National Minerals Institute which will focus on applied research into the minerals industries, including the bauxite-alumina industry, will allow for the environmental oversight of the industry to return to NEPA. There is little evidence to indicate that the partnership between the JBI and NEPA has worked to the benefit of the environment and
public health. This should prove to be a positive move, provided NEPA ensures their work is done diligently and the new policy is finalized in a reasonable time frame.

Finally, obtaining information for this study was slow and tedious. State agencies need to ensure that all information that can be made available to the general public is accessible through their websites. Such information and that supplied through the ATI Act procedures must be correct, complete, and understandable; for it to be anything less suggests an unwillingness to divulge information.

The bauxite-alumina industry is important to the nation but so is our environment and the health of our citizens. Let’s be proactive in getting closer to the path of sustainable development.

REFERENCES


NEPA-JBI MOU 2013. Agreement between Jamaica Bauxite Institute and Natural Resources Conservation Authority and The Chief Executive Officer of the National Environment and Planning Agency, April 2013. Received from NEPA.

3: A Healthy and Productive Environment:
The Public Health Impacts of the Bauxite-Alumina Industry in Jamaica

PATRECE CHARLES

“As soon as I had gotten out of the heavy air of Rome, and from the stink of the chimneys thereof, which being stirred, poured forth whatever pestilential vapors and soot they had enclosed in them, I felt an alteration to my disposition”
—Seneca

OVERVIEW

In the context of long-standing complaints raised by residents of communities in proximity to bauxite mining and processing in Jamaica, this paper seeks to explore what conclusions can be drawn regarding the public health impacts of the bauxite-alumina industry, focusing on the processing of alumina, using existing public health data and the reports and testimonies of residents.

This chapter will:
- describe the known public health impacts of specific air pollutants;
- summarize newspaper accounts by residents of their reported health effects due to dust pollution in the vicinity of the industry; and
- review the findings of three studies on the bauxite-alumina industry and its impact on public health of communities in Clarendon, which are in proximity to the Jamalco refinery at Hayes.

This review has its limitations. Accounts by residents, for example, have not been verified by a medical practitioner. The author has not been able to ascertain Particulate Matter
(PM)¹ readings within the area of discussion in order to correlate the association between the prevalence of respiratory illnesses caused from air pollutants, specifically PM₁₀ and PM₂.₅, emanating from bauxite mining and processing. Numerous attempts have been made by the author to acquire current public health data from NEPA, the JBI and the Ministry of Health and Wellness (MOHW) in time for the completion of this chapter, without success. Studies were only available for a single parish (Clarendon) and a single facility (Jamalco) and two of the studies reviewed are more than 12 years old. No data were found on the impact on public health of dust pollution or emissions generated by the use of haul roads. This chapter did not consider the impacts of mining alone in any detail.

¹ Particulate Matter (PM) refers to solid and liquid particles suspended in air, many of which are hazardous.
THE BAXITE-ALUMINA INDUSTRY AND AIR QUALITY

One of the main impacts of the bauxite-alumina industry on public health is its effects on air quality. PM$_{10}$ and PM$_{2.5}$ are the main particulate matters (PM) that have been observed within the vicinity of bauxite activity. Bauxite dust is classified as a “nuisance dust,” consisting of coarse particles that compromise environmental amenity, damage machinery, decrease visibility, or act as an irritant substance (Lee KY, 2017).

Mining operations mobilize large amounts of material, including small size particles that are easily dispersed by the wind. The largest sources of air pollution in mining operations are:

- Particulate Matter (PM) transported by the wind as a result of excavations, blasting, transportation of materials, and wind erosion (more frequent in open-pit mining);
- fugitive dust from tailings facilities, stockpiles, waste dumps, and haul roads;
- exhaust emissions from mobile sources (cars, trucks, heavy equipment); and
- gas emissions from the combustion of fuels in stationary and mobile sources, explosions, and mineral processing (Environmental Law Alliance Worldwide, 2010).

Mobile sources of air pollutants include heavy vehicles used in excavation operations, cars that transport personnel at the mining site, and trucks that transport mining materials. The level of polluting emissions from these sources depends on the fuel and conditions of the equipment. Even though individual emissions can be relatively small, collectively these emissions can be of real concern. In addition, mobile sources are a major source of Particulate Matter (PM), carbon monoxide (CO)$_2$, and Volatile Organic Compounds (VOCs) that contribute significantly to the formation of ground-level ozone$^3$ (Environmental Law Alliance Worldwide, 2010).

Particulate Matter (PM) is a common air pollutant, consisting of a mixture of solid and liquid particles suspended in the air. Indicators describing PM that are relevant to health refer to the mass concentration of particles with a diameter of less than 10 µm (PM$_{10}$) and of particles with a diameter of less than 2.5 µm (PM$_{2.5}$). PM$_{2.5}$, often called fine PM, also comprises ultrafine particles having a diameter of less than 0.1 µm. PM$_{2.5}$ constitutes 50 to 70 percent of PM$_{10}$. PM between 0.1 µm and 1 µm in diameter can remain in the atmosphere for days or weeks and thus be subject to long-range transboundary transport in the air. PM$_{10}$ and PM$_{2.5}$ include inhalable particles that are small enough to penetrate the thoracic$^4$ region of the respiratory system.

The health effects of inhalable PM are well documented. They are due to exposure over both the short term (hours, days) and long term (months, years).

Bauxite dust is inhalable (respirable) and defined as dust particles less than 10µm in diameter or Particulate Matter of PM$_{10}$ and PM$_{2.5}$. There is ‘no safe level’ for PM$_{10}$ and PM$_{2.5}$.

---

2 Carbon monoxide (CO) is a dangerous odourless, colourless gas produced by burning fossil fuels.
3 Ground level ozone is a colourless and highly irritating gas produced when nitrogen oxides (NO$_x$) and volatile organic compounds (VOCs) react in sunlight and stagnant air.
4 Thoracic refers to the upper chest and back.
as per the World Health Organization (WHO Regional Office for Europe, 2013) because these particles can deposit in the alveoli\(^5\) during respiration and cause increased hospital admissions due to respiratory and cardiovascular problems. Exposure was ubiquitous and involuntary, increasing the significance of this determinant of health (WHO Regional Office for Europe, 2013).

Bauxite dust can also cause harm to the lungs, nose, and throat. The eyes and exposed skin are at risk, as well as the gastrointestinal tract. In some, it can also cause allergic reactions such as asthma or eczema (WHO Regional Office for Europe, 2013).

There is evidence of the effects of short-term exposure to PM\(_{10}\) on respiratory health, but for mortality, and especially as a consequence of long-term exposure, PM\(_{2.5}\) is a stronger risk factor than the coarse part of PM\(_{10}\) (particles in the 2.5–10 µm range). Mortality was estimated to increase by 0.2 to 0.6 percent per 10 µg/m\(^3\) of PM\(_{10}\) (WHO Regional Office for Europe, 2013).

Exposure to both PM\(_{10}\) and PM\(_{2.5}\) can cause emphysema, pneumonia, tuberculosis, cancer, acute respiratory distress syndrome (ARDS), respiratory distress syndrome, pulmonary oedema, and asthma (Charles, 2007). Diseases which affect the alveoli and result in reduced oxygen being delivered to the tissues of our body, may result in damage to every major organ (Charles, 2007).

Air pollutants (sulphur dioxide\(^6\) and PM) cause corrosion to building materials, including “zinc” roofs, soiling of personal property (such as clothes hung out to dry), and can cause damage to crops. Dust reduces visibility, becoming a safety hazard, and covers leaves of crops and other vegetation (Environmental Law Alliance Worldwide, 2010).

In a report compiled by Environmental Consultant Davis and Associates to provide technical details and support information for a Regulatory Impact Analysis Statement (RIAS) for the Air Quality Regulations developed by the National Environment and Planning Agency (NEPA) in November 2002, it was noted that the deterioration of air quality, especially in the vicinities of industrial facilities, was evident from reduced visibility supported by frequent citizen complaints about dust emissions emanating from industrial facilities (cement, alumina and bauxite), (Claude Davis and Associates, 2020).

**COMMUNITY PERCEPTION OF THE BAUXITE-ALUMINA INDUSTRY**

The bauxite-alumina industry in Jamaica has spanned almost 70 years. Communities within the vicinity of bauxite mining and processing have had their fair share of exposure to air, noise, and water pollution, and have continuously complained to authorities since the early days. As in many other bauxite producing countries, such as Australia, Brazil, Suriname,  

---

\(^5\) Alveoli are tiny air sacs at the end of the bronchioles (air tubes in the lungs). The alveoli are where the lungs and the blood exchange oxygen and carbon dioxide during the process of breathing in and breathing out.

\(^6\) Sulphur dioxide (SO\(_2\)) is a toxic gas released naturally by volcanoes and by industrial activity, including the burning of fossil fuels.
and Malaysia, concerns have been expressed about the impact of the industry on the health of those who live close to processing plants, mines, or haul roads (Charles, 2007).

Excerpts from articles from local media are presented below as examples of community concerns. In some cases the entire article is reproduced:

**Dust, poor air quality and alleged illness**

**11 February 2007**

**Dust, stench and claim of impotence: Pollution killing us, say communities near bauxite plants – Firms insist waste not toxic**

Karyl Walker, *Jamaica Observer*

EXCERPT: The approximately USD400 million earned by the bauxite sector last year meant nothing to Sandra McLean and other residents of districts surrounding the Alumina Partners of Jamaica (ALPART) refinery in Nain, St Elizabeth. McLean and her neighbours reported that they had to contend with wheezing children, contaminated water, dead crops and damaged garments, which they blame on pollution from the plant. “You know how long mi have flu and it can’t better? McLean asked. “The white acid from the plant a kill we slowly. Mi niece dem suffering from asthma, all four to five time a year them go a hospital.”

McLean’s cry was echoed by persons living in New Building, Myersville, Stephens Run, Punch Bowl and other districts close to the refinery. “The pollution a kill we. The dust is a real problem for us who live near to the plant,” said Lenford Bailey, a New Building farmer. “When you get up in the morning and see the white stuff pan you step, you wouldn’t believe. The acid carry a stinking stench.”

In all four districts, the residents seemed more than willing to tell tales of their woes. Some of the men said they believed the bauxite dust was rendering them impotent. “Mi no have no use fi mi woman again and mi a hear say a no me one tan so,” one man, who declined to give his name, said to snickers from his neighbours.7

**21 May 2017**

**Unpaid dust nuisance money sparks protest at Jamalco Plant**

Kimmo Matthews, *Jamaica News*, published by Loop Jamaica

A group of residents of Cornpiece district in Clarendon staged a demonstration outside the gates of the Jamalco bauxite plant in the parish on Friday. Residents said they were seeking compensation from the company for dust nuisance which they have been experiencing.

The protesters claimed that the company had agreed on Friday as the date for distribution of the compensation money, but the payment was not forthcoming. The residents said they were instead told that a reverification exercise had to be conducted by the company before the

---

payments were made. The company, in response, said there was no agreement for the payment to be made on Friday and reverification had to be done before compensation payments are made. A senior representative indicated that following the first assessment, the company discovered some discrepancies, and decided to do a reverification. The company representative said the reverification must be done before the compensation payments are made.

Indications are that the company representative tried to arrange a meeting with the community residents on Friday afternoon but the residents opted not to engage in the proposed dialogue.  

---

**9 April 2018**

**Bauxite Woes: St Elizabeth residents complain of dust, poor air quality**

Garfield Myers, *Jamaica Observer*

EXCERPT: Councillor Layton Smith (PNP, Myersville Division) in St Elizabeth South Eastern was a relieved man last Thursday when Sophia Frazer-Binns, the Opposition People’s National Party (PNP) shadow spokesman on the environment, visited his division. As he explained to the Jamaica Observer Central, he has been under mounting pressure from local residents in recent times. This as a result of dust nuisance and alleged poor air quality emanating from the reopened JISCO/ALPART alumina plant at nearby Nain and the plant’s “red mud” lake. St Elizabeth residents from Myersville complained about the dust nuisance and alleged poor air quality emanating from the reopened JISCO ALPART alumina plant at nearby Nain and the plant’s “red mud” lake (containing waste from alumina processing) at Myersville.

---

**21 April 2019**

**Danger in the dust: Decades-old problem stokes anger among residents**

Garfield Myers, *Jamaica Observer*

EXCERPT: Fiona Facey, a young resident of Austin, close to the JISCO Alpart bauxite/alumina plant, smiled ruefully when asked whether she thought her community would be better off without bauxite/alumina production. “Look here,” she said, “nobody is calling for a shut down of the company (JISCO Alpart), we are happy that a lot of young people are up and working, providing for their families. But is one thing to provide for your family and then another thing, a few years down the line, you losing your family . . . everybody dead.”

Her comment, seemingly melodramatic even in its ambivalence, captured the mood of a turbulent public meeting at Austin Primary School last Wednesday to discuss ongoing concerns about dust and air pollution in the communities of the Myersville Division, close to the bauxite/alumina plant.

---

8 [http://www.loopjamaica.com/content/unpaid-dust-nuisance-money-sparks-protest-jamalco-plant](http://www.loopjamaica.com/content/unpaid-dust-nuisance-money-sparks-protest-jamalco-plant)

The meeting, with scores of people, mostly women, in attendance, was organized by the Opposition People’s National Party, caretaker for St Elizabeth South Eastern Dr Dwaine Spencer and councillor the Myersville Division, Layton Smith (PNP). It was attended by Opposition spokesman on mining Phillip Paulwell.

As a Cabinet minister in 2015/16, Paulwell played a mediatory role in the acquisition of Alpart by Chinese metals powerhouse Jiquan Iron and Steel (JISCO) from Russian aluminum giant UC Rusal. That acquisition led to the eventual reopening of Alpart refinery operations in 2017.10

14 January 2020
‘We can’t tek it nuh more’ St Elizabeth residents fed up with ‘poisonous’ dust from red mud lake
Garfield Myers, Jamaica Observer

EXCERPT: Over recent days, people living to the west of the bone-dry Jiuquan Iron and Steel Company (JISCO)/Alpart bauxite-alumina waste, red mud lake at Myersville have been driven to the edge of despair by clouds of contaminated dust, carried on the wind. Yesterday, when the Jamaica Observer visited Warminster, in the foothills of the Santa Cruz Mountains, overlooking the mud lake, the picture was evident of wave after wave of dust, lifting on the wind and sweeping towards the communities above. “We don’t know what to do,” one woman complained. Residents told of their water – harvested from rain and stored in large concrete tanks – being “spoilt” by the dust; of crops being ruined; and sinus-related illnesses affecting children and adults.11

13 February 2020
Residents complain of health hazard due to bauxite stockpile in French Park, Manchester
Radio Jamaica (RJR) News

EXCERPT: The Government’s attention is being called to another health hazard developing in French Park, Manchester where bauxite is being stockpiled. The bauxite is stockpiled by Jamalco on behalf of JISCO/Alpart, which has suspended alumina production due to modernisation work being done at its plant in Nain, St Elizabeth. Residents of French Park, most of whom were wearing masks, staged a protest Wednesday to complain that the bauxite, which is left uncovered, is being stored daily. They say this has resulted in a major dust problem, which has spread to at least six other communities, including, Providence, Berry Hill and Mount Pleasant. They showed Radio Jamaica’s correspondent layers of red dust clinging to surfaces, including trees, floors and furniture.12

11 http://www.jamaicaobserver.com/article/20200114/Article/200119887/1470
Dollars For Dust – JMD40 Million Compensation For JISCO/ALPART Nuisance

Albert Ferguson, *Gleaner*

Close to 1,200 residents in 10 St Elizabeth communities affected by a dust nuisance emanating from the JISCO/Alpart mud lake in the parish have been offered a JMD40-million compensation package after days of discussions, at times heated, with the bauxite company about their concerns.

Daryl Vaz, minister without portfolio in the Ministry of Economic Growth and Job Creation, said yesterday that the affected communities of Upper Warminster, Myersville, Alvalley, Lower Warminster, Upper Brinkley, Northampton, Lower Brinkley, Austin, Boulevard Housing Scheme and Genious are to receive the compensation from the management of JISCO. “JISCO has agreed to compensate for the dust events that took place in December and one which took place in early January, at total settlement for four days compensation,” Vaz told residents, following a visit to the affected area. “That compensation will be paid starting tomorrow (Friday). It will be paid in phases, which means that the 10 communities that I name will get four days’ compensation.” He added: “Some will get tomorrow. Some communities will get a part payment tomorrow [and] if that is the case; they will get the remaining compensation by the end of February. That is a commitment that has been made by JISCO.” Vaz went on to note that investigations would continue into dust nuisances that occurred after December and early January and that JISCO would finalise compensation in those cases as well.

The JISCO/Alpart refinery was shut down last year to facilitate a modernisation and expansion project expected to continue into 2022, but dried sections of the mud lake, accosted by strong winds, send massive dust clouds into the surrounding communities. It was reported that one school had to shut down for at least a day as a result of the dust nuisance.

Yesterday, some residents said they were dissatisfied with the level of compensation, arguing that while it provides money that they didn’t have, they were still experiencing the dust nuisance. “That little compensation money can’t go far. We are still hampered. We can’t even get a good shower,” said Marvinia McLeod, a resident of the area.

Paul Hanson, who also resides in the area, said his main concern was to see the dust nuisance fixed so that normal life could return to the community. “Dust has been affecting us for almost 30 years now, and all the previous owners of the bauxite plant have treated us very bad, and now the Chinese owners are about to do the same, “ said Hanson, exuding his pent-up frustration.

But despite the compensation, Vaz also pointed to the lack of rainfall since last year as one of the factors contributing to the dust nuisances. He said that the last time it rained in St Elizabeth was on December 10 when it temporarily halted the dust nuisance from the mud lake, which is located on 650 acres of land.13

Cockpit Country, Trelawny

Residents of the area known as Cockpit Country in west-central Jamaica also have expressed concerns, which are broader than pollution and public health.

16 September 2019

Bauxite mining dispute very painful

Editorial, Jamaica Observer

The long-running dispute over bauxite mining in and around the Cockpit Country is painful. While boundaries have been, or are being drawn under the Cockpit Country Protected Area project, it is a hard sell to tell local people who have always considered themselves part of the protected area that in fact they are not.

We are not surprised that locals in hilly, forested western St Ann are rejecting the notion that the Cockpit Country suddenly starts and/or stops. Note this comment attributed to an elderly man in yesterday’s Sunday Observer story: “The whole area is the Cockpit Country . . . Over deh so and over here so. All of it is the Cockpit . . .”

For those of us on the outside, there is relief that the authorities have made an effort to protect the core of the Cockpit Country – the source of much of Jamaica’s water as well as a last refuge for varied species of flora and fauna – and embracing heritage of immeasurable value. However, for those on the fringes of the Cockpits, now having to deal with the messy consequences of bauxite mining, it’s a far more personal matter.

We shouldn’t discount the negative psychological consequences of witnessing pristine hills and valleys being permanently transformed –RED perhaps we should say disfigured. Spare a thought for Ms Gretchen Linton, who lamented the loss for young people and children yet unborn. “The pickney dem weh a come up nah guh get fi see di Cockpit Country as we know it. If dem come and mine it, the younger ones coming up nah guh know this land,” she said.

Then there are the farmers in areas bordering on and embraced by the Cockpit Country. For generations they and their ancestors have been among the country’s leading producers of root crops such as yam, Irish potatoes, sweet potatoes, etc. From their perspective, what’s needed are support systems to maximise production and earnings. They do not need a change of life, which is what bauxite mining brings.

But, of course, the argument doesn’t end there. As Mr Lance Neita of Noranda Bauxite Company points out, Jamaica’s bauxite/alumina industry is a cornerstone of the Jamaican economy. We know, for example, that there will be considerable fallout for the national economy when the JISCO Alpart plant closes soon to facilitate modernisation.

We recall that the shutdown of the bauxite/alumina industry in 2009 played a major role in Jamaica’s return to the International Monetary Fund. Yet, all of that doesn’t ease the public dissatisfaction with Jamaica’s bauxite/alumina industry. People in communities which host bauxite/alumina operations consistently complain that they do not have nearly enough to show for the environmental degradation and pollution which go hand in hand
with such operations. Shamefully, in many such communities people are without piped water, for example.

A Capital Development Fund (CDF) set up by the Michael Manley-led Government in 1974 envisioned that levies charged to bauxite mining companies would finance development projects, especially in host communities. Instead, the CDF was largely drained to support the national budget.

Mr Neita tells us of several economic and socially uplifting projects his company has implemented towards a lasting legacy for host communities. We believe there needs to be much, much more on a far larger, grander scale for Jamaicans to feel even remotely rewarded.14

17 September 2019

Groups march to Gordon House regarding concerns about mining in Cockpit Country

Prince Moore, Radio Jamaica News Online

Pro and anti-mining groups marched to Gordon House Tuesday afternoon to register their concerns about bauxite mining in the Cockpit Country. There were claims and counter-claims from both sides about the impact on the economy and the environment. Both groups delivered letters to the Clerk of the House, calling for the Government to make a decision in their favour. The anti-mining protesters gathered at National Heroes Circle and then marched to Gordon House prior to the start of the sitting of the House of Representatives. The pro-mining group had already converged on Duke Street. Their placards and chants made it clear which side of the fence they stood on the issue, with chants of “Save Noranda jobs!” and “No mining!” ringing out above the beats of drums.

Entertainer Queen Ifrica was among those against mining in the Cockpit Country and argued that where mining has already taken place in Jamaica, “we see where the after-effects have made many families lose their family members to cancer and many other (diseases).” She also highlighted that about 40 per cent of Jamaica’s clean water comes from the Cockpit Country, alluding that it was therefore important not to affect this.

Jeffrey Shuttlworth, who led one of the church groups, is also against mining in the Cockpit Country.

He believes the Government should instead focus on eco-tourism to generate money from the Cockpit Country. “We believe if we look at alternative ways of income generation from the Cockpit, with the 1,500 endemic plant species, 28 endemic birds and other kinds of flora and fauna, the medicinal plants that are there, the many caves that are there, we see where many kinds of employment can be generated,” he suggested.

However, another group comprising workers of mining company Noranda said there is no mining in the protected areas of the Cockpit Country. They are concerned that if the

14 http://www.jamaicaobserver.com/editorial/bauxite_mining_dispute_very_painful_174906
Government heeds to the pressure of anti-mining groups, there could be fall out in the economy, beginning with the loss of their own jobs.

Mikael Phillips, Member of Parliament for Manchester North West, who met with the protestors outside Gordon House, has appealed to the Prime Minister to urgently address their concerns.\(^\text{15}\)

**THE BAUXITE-ALUMINA INDUSTRY AND PUBLIC HEALTH – REVIEW OF EXISTING STUDIES**

The environmental effects of air pollutants and their effects on the health of the public has not been widely reported or investigated in Jamaica. This chapter reviewed three studies informing the relationship between public health and the bauxite-alumina industry:

- A 2007 study conducted by Patrece Charles, the author of this chapter, entitled *The Reported Respiratory Illnesses in Communities within the Parish of Clarendon, and its Association with Environmental Conditions, Particularly Bauxite Activity* (Charles, 2007).
- A 2008 *Health Impact Assessment (HIA)* requested by the Ministry of Health (MOH) and conducted by UWI and Yale University for the Jamalco facility in Clarendon because of a planned expansion (Jamalco, 2008).
- A 2015 health survey commissioned by the Jamaica Environment Trust (JET) and carried out by Professor of Public Health, Dr Homero Silva, entitled *Strengthening the Capacity of Jamaican Communities to Protect their Environmental Rights: Health Survey of the Mining Communities of Ten Miles, Bull Bay, St Thomas, Hayes and New Town, Clarendon, and Control Communities of Albion, St Thomas and Lionel Town* (JET, 2015).

**The 2007 Charles Study and the 2008 UWI/Yale HIA**

Both the 2007 Charles study and 2008 UWI/Yale HIA investigated the impact of industrial related air pollutants on the public. They used similar, but not identical, approaches and methods. The UWI/Yale HIA included a study of the communities surrounding the Clarendon alumina refinery (within a 15-kilometer radius) as part of the development plans for expansion of the Jamalco operations and compared morbidity and mortality data in “exposed” and control communities (Jamalco, 2008). The 2007 Charles study investigated the prevalence of respiratory illnesses in communities located within a ten-mile proximity of the Jamalco bauxite plant in the parish of Clarendon.

The objectives of the 2007 Charles study were to:

- determine the pattern of selected reported respiratory illnesses in communities at specified intervals from a bauxite plant;

---

• identify the type of air pollutants within the selected study areas;
• identify the possible sources of the pollutants identified within the study areas; and
• determine the relationship between reported cases of respiratory illnesses and the possible sources of airborne pollutants.

The objectives of the 2008 UWI/Yale HIA were to:
• describe the demographic profile of the area around the refinery and that of a comparable control area;
• compare a household survey of symptoms and reported disease of the area around the refinery to the control area, with particular focus on health conditions that can be predicted from the refinery emissions; and
• compare the mortality and morbidity patterns of the area of interest around the refinery to that of the control area.

Approaches – Study Area

The 2007 Charles study conducted preliminary monitoring of air quality for two months within several communities surrounding the Jamalco bauxite facility to ascertain the areas that had both low and high levels of PM. A ten-mile radius around the Jamalco plant was selected based on preliminary tests of where the levels were at the highest, which the study referred to as the “exposed” group, (Zone 1). Where the levels were lowest was designated as the comparison or control group (Zone 2).

The UWI/Yale HIA considered an area within a 15-kilometre radius of the Jamalco plant, designated as the “exposed” area. An area of the parish of Clarendon was determined to be demographically similar to the “exposed” area, but not in proximity to the Jamalco refinery, and this was defined as the control area.

Both studies were concerned with similar communities in roughly the same area.

Approaches – Surveys, Focus Groups, Air Quality Testing

The UWI/Yale HIA included a community health survey of 2,350 interviews, a morbidity and mortality analysis, the convening of focus groups, and the analysis of public health data. The 2007 Charles study conducted a health evaluation to obtain information regarding individuals and their households, using an interviewer administered questionnaire and a Peak Expiratory Flow Rate Test (PEFR). A measurement of how fast a person can exhale. The 2007 Charles study was also conducted within similar communities exposed to bauxite mining and processing where 2,559 people were medically assessed due to their exposure to bauxite mining and processing.

Both studies investigated the prevalence of each of the reported respiratory symptoms, prevalent illnesses, and in the case of the UWI/Yale HIA, causes of death. Both studies used
multivariate logistic regression to determine if location (‘exposed’ community vs. control population) was a significant predictor of respiratory symptoms or illnesses.

2007 Charles Study – Summary

The 2007 Charles study investigated the relationship between the environment and health in communities exposed to industrial emissions, by examining ambient air quality within selected communities, to determine the levels and type of contaminants, and whether or not they were a by-product of bauxite processing. The study surveyed 2,559 people to examine the prevalence of respiratory illnesses within those communities that had unacceptable levels of PM compared to those communities with acceptable levels (control area) of PM within the ten-mile study area. The study also assessed the documented relationships between airborne contaminants and respiratory complaints within one to ten miles of the Jamalco bauxite facility in the parish of Clarendon.

The 2007 Charles study focused on outdoor air pollution. The outdoor sampling sites were based on results from previous monitoring. The results at the time of the study indicated that 50 percent of the adults surveyed were unemployed and were more likely to remain inside their homes or near to their home environment throughout the day. Giving this tendency, the 2007 Charles study may have underestimated, rather than overestimated, the impact of ambient air pollutants with limited indoor penetration, because fine Particulate Matter (PM) efficiently penetrates indoors (Charles, 2007).

2007 Charles Study – Results

Community perception: 36 percent of the adults surveyed reported that they perceived both the bauxite plant and the roads to be the major contributors to air pollution within a six-mile radius of the bauxite facility.

Levels of PM_{10} and PM_{2.5}: The average of the levels of PM_{10} exceeded the national acceptable average of 50µg/m³ at one to six miles from the bauxite processing plant. Exceedance of PM_{2.5} was observed within the one to three and one to ten-mile radii.” Further investigation revealed that mile ten was located within a rural area and the seasonal burning of sugar cane was the source of the PM_{2.5} at mile ten.

Pattern of respiratory illnesses: 37 percent of adults and 21 percent of children living within six miles of the facility suffered sinusitis. Asthma afflicted 23 percent of adults and 26 percent of children. Allergies were markedly more prevalent among those who lived closest to the plant than in control groups.

Sources of pollutants: Particulate Matter (both PM_{10} and PM_{2.5}) measured within the study

---

17 The PM_{2.5} standard was adopted from the United States Environment Protection agency (US EPA) standard, which determined that the annual fine particle standard (set in 1997) was not adequate to protect public health as required by law. In 2012, the US EPA strengthened the annual fine particle standard by revising the level from the current level of 15.0 µg/m³ to 12.0 µg/m³.
area had aluminum and sodium particles which were both associated with bauxite mining and processing.

**2008 UWI/Yale Health Impact Assessment – Summary**

The UWI/Yale Health Impact Assessment (HIA) occurred in the context of an expansion, termed a “capacity and efficiency upgrade,” to the Jamalco alumina refinery in Clarendon and a permit condition of Environmental Permit No. 2004-13017-EP00083, issued by the NRCA/NEPA, requiring the HIA. The assessment was a collaboration between the University of the West Indies (UWI) at Mona – Department of Community Health and Psychiatry, and the Yale University School of Medicine in the USA, and contained qualitative and quantitative aspects.

The qualitative study reviewed the demographic profile of communities in proximity to the refinery and conducted an assessment of morbidity (disease prevalence) and mortality (cause of death patterns) in communities within a 15-kilometre radius of the refinery and control communities outside of this zone.

The mortality assessment looked at death records for the parish of Clarendon from 2000 to 2004. The morbidity assessment collected data from randomly selected health records from hospitals, health centres and private clinics in both exposed and control communities. The HIA also conducted a household symptom survey via 2,350 interviews.

The quantitative Health Risk Assessment (HRA) dated 2013 was conducted by consulting firms, ENVIRON and Epsilon, and considered the potential cancer and non-cancer health risks to those living, working, and recreating within the same 15-kilometre radius presented by emissions to ambient air.

**2008 UWI/Yale Health Impact Assessment – Results**

*Community perception:* Self-reported health symptoms collected during the personal interview process suggested a belief that Plant-related health impacts were occurring.

*Health outcomes:* There was no statistically significant difference in objective measures of health outcomes between the exposed and control groups, so there was no scientific basis for the belief that the Jamalco facility was causing public health impacts in the areas studied.

*Expansion:* Emissions to ambient air from the proposed expansion would likely not have significant adverse impacts on human health.

**2015 JET Study**

JET commissioned a health survey of selected mining communities in 2015 as part of an on-going project funded by the Inter-American Foundation to empower mining communities to protect their rights to a healthy environment. The JET study was a cross-sectional
A HEALTHY AND PRODUCTIVE ENVIRONMENT

A Multidisciplinary Review of the Bauxite-Alumina Industry in Jamaica

The JET study did not carry out any monitoring or testing of air quality but did evaluate the adequacy of Jamaican air quality standards in comparison to WHO standards.

**2015 JET study – Results**

**Community perception:** 64.7 percent of the respondents from Hayes/New Town rated the air quality as unacceptable, compared to one percent in the control communities (Homero Silva, 2015).

**Health impacts:** The results indicated that with the exception of hives/rashes and BMI, mining and quarrying operations were having an adverse impact of varying degrees on the health of residents (Homero Silva, 2015).

**Adequacy of Standards:** The current Jamaican ambient air quality standards were inadequate to protect public health.

**The Response of the Industry**

In a November 2004 Washington Post article entitled *Ill Jamaicans Putting Blame On Bauxite-Alumina Industry,* author Carol Williams accused the Jamaican authorities of dismissing claims of ailments by residents of the bauxite-alumina sites stemming from exposure, mostly in the Southwestern hills around Mandeville, despite health studies elsewhere having linked bauxite to hypertension and alumina dust to asthma and sinusitis (Williams, 2004).

Williams’s article highlighted comments from Parris Lyew-Ayee, then Managing Director of the Jamaica Bauxite Institute (JBI), who was responsible for keeping Jamaica competitive in the world alumina market as well as protecting the environment. He disparaged Charles’s 2007 research as unreliable because it covered only a small area (within a ten-mile radius of the bauxite company, Jamalco, in the Parish of Clarendon). He dismissed claims of roof
damage from dust as the fault of inferior materials. As for crop failures and stunted fruit growth, he said plants sown by the industry on reclaimed land prosper and that the problems elsewhere are “... not from alumina dust – any dust can cause that.” Lyew-Ayee also denied any conflict of interest in his institute’s joint responsibilities for exploiting the resource and setting environmental standards (Williams, 2004).

More recently and in the context of the ongoing debate about bauxite mining in Cockpit Country, an 11 September 2019 article in the Jamaica Observer entitled “The bauxite mining debate continues” sought to outline the positive contribution made by the industry. The article carried no byline.

The article stated, “... the reputation of the bauxite-alumina industry in Jamaica for good corporate citizenship and sound economic, social, industrial, and agricultural contribution is being misrepresented by a wave of irresponsible social media messages, staged demonstrations, and media campaigns that have not taken into consideration the interest of hundreds of Jamaican workers and thousands of residents who benefit from the industry on a local and national scale.” Examples of the initiatives by Noranda included that local school and students were the recipients of scholarships to secondary schools through the Noranda Primary Exit Profile examination recognition programme for all schools in the mining and plant areas. The article also stated that greenhouse technology was provided to farmers in the mining areas, in order to improve farming techniques before and after mining, which was “... welcomed by farmers across the region because it does not rely on rain in drought-stricken areas. The farmers say that the initiative has transformed farming in the communities, and that they are now involved heavily in lettuce, cucumber, broccoli, sweet peppers, and tomatoes, with lucrative markets in Brown’s Town and in hotels.”

The article further contended that there was no bauxite mining taking place or planned for the protected areas of the Cockpit Country, and that this “... has been confirmed from the investigative reports of all regulatory agencies with regulatory and management responsibility for the Cockpit lands.”

Concerns expressed by some residents who were interviewed about the possibility of relocation were rejected as false. According to the article, “... farmers complained that Noranda was taking away their land for mining, but failed to assert that landowners under the present system remain as owners of the land during mining, are compensated for disturbance of surface rights, crops, yield, livestock, trees and buildings, and have their lands returned to them as rehabilitated and renewed for farming or occupational use.” The point the author wished to make was that the policy on resettlement focuses on landowners remaining in their communities, rather than moving them away.

The Observer article also highlighted the fact that the bauxite company does not own land, but leases such for mining, an act that can only occur after approval from NEPA. The article indicated that the named bauxite company, conducted environmental impact assessment studies mandated by the mining regulations prior to mining, and had community consulta-

---

tions with the residents, in which the mining areas, technical aspects, and land rehabilitation process information was shared.

Also in September 2019, an article by Balford Henry of the *Jamaica Observer*, entitled *Noranda workers counter criticisms of bauxite mining rights*, described a “face off” between factions on either side of the disputed issue of bauxite mining close to the Cockpit Country Protected Area (CCPA). More than 200 employees and community leaders from the Cockpit Country area travelled to the headquarters of Jamaica Environment Trust (JET), on Constant Spring Road, to counter what they said was a campaign against Noranda Bauxite Company’s mining operations just outside the protected area boundary. Spokespersons for the demonstrators, who packed into six 30-seat Toyota Coaster buses and a single 60-seater for the trip to Kingston, said that they went to JET because they wanted the environmental watchdog to hear the facts. They accused JET and other activist groups of spreading “propaganda and false news” by demanding that there be no bauxite mining in or around the protected area. “The environmentalist groups, the artistes and sections of the media are trying to lock us down,” said Alfred Henry, a mining superintendent at Noranda Bauxite. “This industry is very critical, and we cannot use politics and downplay the situation so that the investors move out,” he stated.

In the global context, there have been early studies that were not able to link bauxite mining to respiratory illnesses. A cross-sectional study of employees at a large bauxite mining operation in Western Australia in 1995/1996 investigated respiratory symptoms and lung function in relation to bauxite dust exposures (Donoghue AM, 2014). The study found that after adjustment for age and smoking, there were no significant relationships between any of the symptoms and quartiles of exposure to bauxite mining. There were also no statistically significant decrements in lung function (FEV₁, FVC, and FEV₁/FVC) within any of the quartiles of exposure to bauxite (Donoghue AM, 2014).

**CONCLUSION**

It is clear that those who live near the bauxite-alumina industry in Jamaica believe their health is being adversely affected by the operation of these facilities and they have been making complaints about these impacts for more than 50 years. Yet, we were only provided with one GOJ-conducted comprehensive health impact assessment (between 2007 and 2013) during the life of the industry, whose response remains that these complaints are exaggerated or untrue and are merely efforts to acquire compensation.

It is also worth noting that the HIA and HRA were conducted after the environmental

---


22 Forced Vital Capacity (FVC) – the total amount of air exhaled during the Forced Expiratory Volume (FEV). These are basic lung function tests.
permit for the Jamalco upgrade had been granted by NRCA/NEPA. The HRA was not completed until 2013, by which time presumably the upgrade was well underway, if not completed. Recent discussions by the author (March 2020) with residents of Halse Hall, Clarendon indicated that they were currently experiencing the same effects that were experienced by residents in 2007 and 2008. Residents also reported itchy eyes; coughing and asthma-type symptoms; and dust accumulation on furniture, on clothes when hung outside to dry, on plants, and on the roof tops of houses. In addition, residents complained about occasional “soot” from the refinery and the uncomfortable chemical smell. There has been insufficient research to conclusively link the occurrence of respiratory illnesses to the current levels of PM emanating from bauxite mining and refining in nearby Jamaican communities.

In 2007, the Charles study recommended that an objective epidemiological study should be conducted to determine any deviations in the norm of the health status of communities impacted by industrial activities, specifically the bauxite-alumina industry, but to the best of our knowledge, this has not been done.

It is still true, however, that the adverse health effects of PM$_{10}$ and PM$_{2.5}$ are well documented. There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur. Even at relatively low concentrations, the burden of air pollution on health is significant, and effective management of air quality aiming to achieve WHO air quality guidelines levels is necessary to reduce health risks to a minimum. Monitoring of PM$_{10}$ and/or PM$_{2.5}$ needs to be improved in many countries to assess population exposure and to assist local authorities in establishing plans for improving air quality. In fact, currently in Jamaica, the industry is not required to test for PM$_{2.5}$ at all, although the relatively more serious impact of fine particles has been known since the 1980s.

It is also true that the industry pays for what is euphemistically called “dust nuisance” to those who live within a specified distance of the processing facility. There have been contestations about who gets this money, as some residents complain that the area which benefits from dust nuisance is an arbitrary one. The industry position seems to be that the complaints about poor air quality are merely an attempt to extract higher levels of compensation. It is up to the GOJ, through its regulators, to listen to the lived experience of the mining communities and commission suitable research to establish whether there have been health impacts. Specifically, a public health tracking system to determine the prevalence of respiratory illnesses related to the bauxite-alumina industry, including mining and transport, is urgently needed.
REFERENCES


Homero Silva, L. H. (2015). *Strengthening the Capacity of Jamaican Communities to Protect their Environmental Rights. Health Survey of the Mining Communities of Ten Miles, Bull Bay, St Thomas & Hayes & New Town, Clarendon Control Communities of Albion, St Thomas & Lionel Town, Cl.* Kingston.


UWI, Yale University, Jamalco Health Impact Assessment, 2008.
“New terrain, far from fambly an fren”:
The Social Impact of the Bauxite-Alumina Industry in Jamaica

HORACE LEVY AND PETA-ANNE BAKER

“Nobody don’t plant any more. All we do here is steal each other’s animals, steal electricity or gas oil, and wait for dust money.”

—ALVIN GALLIMORE, Journalist and Cable Operator, Resident, Lime Tree Garden, St Ann

OVERVIEW

This chapter discusses the impact of bauxite mining and processing on Jamaican community and society. Bauxite mining and processing takes place on the island, not in remote and mostly flat areas, but in well populated hilly terrain among a people who are not slow to defend their perceived rights. The social dimension, defined as a set of social relations and outcomes, is woven inextricably into what is essentially an economic enterprise between bauxite mining companies and Jamaican communities. These social relations and outcomes are the central concern of this chapter. They cannot be examined, however, without some introduction of related economic factors.

There are two interpretations of social dimension. One focuses on immediate benefits, such as grants by a company to a school for toilets, to a community for a playing field, or to workers for a health fair. The other interpretation focuses on longer term development structures like, for a farming community, the means enabling continued farming or an alternative comparable livelihood. These two aspects of the social dimension overlap and complement rather than contradict each other. Their relative weights will determine to a great extent the assessment to be made of the impact of the bauxite-alumina industry on social relations and Jamaican society.
After setting out method and approach, this chapter comprises an examination of the impact of resettlement on the lives and livelihoods of small farmers; and the impact of mining on the land, production and community, together with the response from mining companies, and other social consequences. The concluding section is devoted to Community Councils and to a case study of small farmers in St Elizabeth.

**METHOD AND APPROACH**

Our study was guided by two research questions: What were (and are) the lived experiences and perceptions of people living in communities affected by the bauxite-alumina industry in their own words? What effects did resettlement have on small farming families, on small farming itself, and on the farmers’ communities?
Qualitative Method

Employment of the qualitative method, which required interviews, encountered challenges, due in large part to the COVID-19 pandemic. COVID-imposed travel and physical distance protocols constrained in-person interviews of groups and even of individuals. Telephone and Zoom virtual exchanges became the sole substitute. Representatives of two bauxite companies, UC Rusal’s WINDALCO Plant at Ewarton, and Noranda Jamaica Bauxite Partnership in St Ann did not grant interviews. The Jamaica Bauxite Institute (JBI) – after we had already interviewed one of its field staff – made it clear that it was “unable to facilitate us at this time” and did not extend any option for a virtual meeting. In fact, as this research was starting, the JBI closed its doors to follow a Government-ordered national lockdown in pursuit of corona virus containment. Later re-opened, the JBI still did not allow access to requested files and records.

Interview contacts were provided by JBI staff chairpersons of the 15 active Community Councils, and by the Jamaica Environment Trust (JET), who put us in touch with a few community members in the Noranda mining area of St Ann. Selection thereafter followed a rolling procedure, the first contacts providing other contacts, and so on. For these, we usually asked for people, preferably in farming, with independent minds or views different from those of the first contact. Other persons knowledgeable about the relevant parishes, especially one parish manager of the Social Development Commission (SDC), were also very useful contacts and able to put us on to still others so as to enable, for the different mining areas, comprehensive sets of opinions.

With only a few exceptions, for their protection from any victimisation, interviewees are not named (See Table 6).

We focused on the recent period (from 2004, when Noranda entered into an agreement with the GOJ to take over almost 50% ownership of the company formerly in the hands of Kaiser) but to a lesser extent, incorporated earlier experiences. Our study concentrated on the impact of mining on community people and communities, rather than on workers at the processing facilities, who appear among respondents in very small numbers.

The “other” (non-farming) category included people passed to us by other contacts in the following occupations or professions. Three of those listed below (two former school principals and the herbalist) are also included in the number above for “farming,” which corrects a discrepancy in numbers. Several in this list turned out to be key informants (See Table 7).

Among those in farming, in a rare (for the COVID-19 period) face-to-face focus group discussion, were seven members of a Community Development Committee (CDC) represented on a Community Council in St Ann. Several interviews were held with some of these

---

1 Noranda Jamaica Bauxite Partnership is jointly owned by the Government of Jamaica (51 percent) and by Noranda Bauxite Ltd. (49 percent), a subsidiary of the US company, Noranda Aluminum Holding Corporation.

2 CDCs are networks of community-based organisations, such as neighbourhood watches, youth groups, and women’s groups, which meet to discuss development issues, and advocate for positive changes within the community.
individuals, including knowledgeable journalist Alvin Gallimore of Lime Tree Garden. Two interviews and other questioning were carried out with a JBI staffer, a member of its Bauxite Community Development Programme (BCDP) with a wealth of on-the-ground experience and data.

**Quantitative approach**

We sought to review relevant data already collected in national censuses, and academic and the JBI papers. However, the agricultural and population censuses did not offer data
targeted on specific sets of communities in the mining areas, and efforts to get them from the Statistical Institute of Jamaica (STATIN) were met with promises, but in the end, no data were received, so our quantitative review was limited.

COMMUNITY RESETTLEMENT

The discussion regarding resettlement combines data from the JBI and research conducted by the University of the West Indies in the 1980s, with the testimonials of residents of mining areas about resettlement experiences in both earlier and more recent years, from 2004 to the current period in 2020.

Farmer Relocation a Necessity for Companies

To the companies, relocation of farmers was unavoidable in Jamaica: the open cast mining of bauxite was taking place in a populated countryside. The sought-after bauxite-bearing red dirt was not in the alluvial plains occupied for centuries by large sugarcane estates. Bauxite ores were relatively close to the surface of the interior hilly land, much of it held by large farmers and used for animal pasture but often also, with absentee landholders, unused; and on the steeper hillsides or valley bottoms where freed slaves had been pushed after their Emancipation in 1838 to become, through their descendants, today’s small farmers. This historical inequity was never corrected, and the significant value of their crops was also ignored, in the words of Donovan Stanberry, former Permanent Secretary in the Ministry of Agriculture (Stanberry, 2020). It was these peasant farmers with average holdings of under one hectare that the bauxite companies (except Reynolds, most of whose acquisitions were properties in St Ann over 500 acres) were having to resettle.

When small farmer resistance to parting with their land prevented a company from acquiring it by purchase, resettlement not just of individuals, but of entire communities, became the next step. Willing community resettlement, timesaving in negotiations, was preferable to individual acquisitions. When hold-outs made demands the companies regarded as unreasonable, compulsory resettlement was treated as a last resort to be generally avoided as bad for public and community relations.

The JBI was established in 1976 by the GOJ to carry out dispute mediation between companies, workers and communities, along with other negotiation and regulatory responsibilities. According to (Anderson et al, 1978), the JBI shared the GOJ’s position – that the bauxite company should have the land, but with the least possible disruption of community

---

life: there should therefore be “planned re-settlement of communities designed to ensure continuity in social relationships” (Anderson et al., 1978).

Against this background, JBI staffers proposed a “model resettlement programme” as well as a set of criteria for a resettlement site and even the idea of an invitation to prospective settlers to assess the site for themselves (Anderson et al., 1978). This meant challenging choices. The JBI offered to present the proposal jointly with a company to prospective settlers but this offer does not appear to have been generally accepted. In most instances, the company made the final decisions.

**For the Resettled: Starting life over with better houses but on new terrain far from old friends**

Turning then to consider instances of resettlement, Schwallenburgh people recall being first approached by ALCAN in the mid-1950s but resettlement was not concluded until 1981 (Cowell, 1987). Other companies were doing resettlements in the 1970s. Writing about one of these companies, two JBI researchers expressed the view that “ALCOA . . . because its mining area is densely populated has had the most persistent problems” and that the model they were advancing was “particularly relevant to the ALCOA/Mocho situation at this time” (Anderson et al., 1978)

The resettlement process had different effects and we offer two case studies illustrating better and worse approaches.

**Schwallenburgh, St Ann – A Better Approach**

By Noel Cowell’s account, Village was a small, self-contained, very cohesive community in Eastern St Ann of 15 inter-related families who for years resisted acquisition by ALCAN. This was tolerated by the company for some time because it was not ready to mine there. When nine families gave in, they had learned from the experience of those whose land had already been acquired and this benefited their collective bargaining. The arrival and mediation of the JBI also brought benefit to the residents, as the JBI insisted on resettlement leaving the community intact. The Village community was settled at Schwallenburgh, in concrete and steel houses on land, and many were employed with the company. Peasant agriculture nonetheless suffered, and this result is discussed more fully later in this chapter.

Schwallenburgh is one example of several that a JBI handout has celebrated with pictures of successful resettlement programmes (another is Russell Place near Williamsfield, Manchester). Others listed by the JBI in Manchester, Clarendon and St Catherine are Hope Village (ALCAN), Lyndale (Kaiser), Denbigh (Jamalco), and Montpelier (ALPART). In these subdivisions, the companies relocated the families and provided them with houses.

---

Mocho, Clarendon – Much More Contested

In the case of Mocho in Clarendon, two families (at least), not conjointly but individually, disputed notice dates, criticized and rejected relocation sites, and held out against acquisition by ALCOA. Every aspect of the process was disputed. The resistance, while weakened by internal disputes in one hold-out family, was based on various grounds such as the quality of the relocation site offered at Rhymesbury. Preferring individual to group negotiations and removal, ALCOA was perhaps too easily drawn into using compulsion over compromise. With reports on JBC radio and cartoons like the one below from Workers Time, a left-leaning publication with local circulation, hold-outs could be assured of much public sympathy, even if compelled in the end to accept the company’s offers and acknowledge overriding national interest. After much confrontation and legal action, resettlement eventually occurred.

Lime Tree Garden, St Ann

Resettlement by Kaiser of the small farmers of Lime Tree Garden in St Ann, another area of interest for this chapter, is detailed by Cowell based on his field research there in 1981–82.

"Resettlement was born from the staunch refusal of small settlers to sell their land. Their logic was unassailable. Many refused to consider the value of their land in terms of money. They had inherited the land, worked it for their entire lives and schooled their children. It had provided for their needs and continued to do so. Furthermore, experience had taught them that it was by no means certain they would acquire a suitable piece of land elsewhere after sale."

Thus, 60 Lime Tree Garden households were moved en bloc to Retreat, which was only seven miles away by road and one mile from Brown’s Town, following two of the criteria proposed by the JBI, namely, retaining some proximity to family and friends as well as to the facilities offered by a town.

Other criteria, such as the lack of water (and electricity, not common in villages then)

---


6 July–October 1977. 2(7–10)

7 Cowell traces the history of Lime Tree Garden from the late nineteenth century up to the arrival of the bauxite companies and the corrupt behaviour of the agents employed by Kaiser to persuade farmers to part with their land. His conclusion is cited in the text above.
were ignored. Only the formation of a citizens’ association and years of struggle got Kaiser to provide a water tank three years later. Some of the relocated families received land with fruit-bearing trees, but others were resettled on very poor land, bare of vegetation. Other Lime Tree Garden residents, acting individually and resettled earlier, found themselves relocated to Trelawny’s distant Fontabelle and Windsor, with very different physical topography and crops.

**Resettlement from St Ann/Trelawny Border to Eastern St Ann**

People from Retirement or other St Ann/Trelawny border areas were relocated in the 1970s by Kaiser to Lillyfield, near Bamboo, and to Griersfield, near Moneague, both in Eastern St Ann. One member of a resettled household, then quite young, now the retired former principal of a prominent high school in the parish remembered this as “well far from family and friend.” The relocated areas are also described by the relocated, depending on the case, as “bush,” or as “… so steep as to be useless,” or as having “… no-good soil,” although in Griersfield, in fact, farming on the inferior soil has “… continued up to the present,” according to a pastor/farmer there.

In Lillyfield “… neither road nor school nor clinic” was said to have been provided by company nor, for the first batch, housing. To attend the nearest school in Bamboo, children had to “… walk five miles each way, to and from.” In some locations, younger ones were “… glad for indoor toilet, more rooms” and semi-urban life. But most of the older generation made it very clear that they were being “… forced to start dem life over,” which for them meant “… misery and fight.” A JBI staffer reported hearing “… quarrels erupting in family homes” between generations in disagreement over relocation.

Since it began mining in St Ann in 2004, Noranda, Kaiser’s successor, required new waves of relocations of the communities on the St Ann/Trelawny border to other areas within the parish. Many of those who chose to stay behind tended to see only the negative side of the mining. One man told of “… entering the first of three hospitals with sinusitis, dust-contracted, weighing 155 lbs, and emerging seven months later weighing 93 lbs.” Others reported what their resettled relatives were telling them of their new lives: “… welcome freedom from the dust and noise,” “… equal or even more acres” in the new place and, sometimes provided by the company, “… nicer house with inside buttery (kitchen).”

Reactions are similarly mixed regarding Noranda’s present-day drilling around farmland in the vicinity of Watt Town in St Ann and its buying up of land from the small farmers there. Some are gladly taking up the cash offers, which others claim are below current market prices (certainly in contrast with the prices paid by the companies in the early days – six times market rates) (Cowell, 1982). The smaller number who decline the offers argue that “… the sell-outs think $1.2 million for 10 acres (the story going around] is big money.” When they move to Brown’s Town, their critics predict, they will discover that “… this ‘likkle’ money come up very short.”
Resettlements in St Elizabeth

It was the same story in St Elizabeth in the 1970s. Relocated people spoke of being given “... big promise of every facility” – roads, school, clinic; but “... in the end hardly anything.” The new locations meant, in their words, being “... cut off from long-time friend and big family,” which was an “... unwelcome something for get-together country people.” “Fitting in” with the people of their new community and with different agricultural conditions was “... the other everyday trouble” often remarked on. Yet another was the slowness of the land titling process, especially for those who previously occupied land without a formal title (IISD, 2020).

Rural Population Decline

One significant reality connected with both the land shift from farming to mining and the relocations was the loss of population in small farmer villages. According to journalist, cable broadcaster (Channel Five) and area resident Alvin Gallimore, Lime Tree Garden, formerly a fairly large district of 3,000 to 4,000, is today a struggling village of 500 to 600. This complements the data from Cowell’s field study of 1981–82 recounted above.8 The well-reputed

---

8 While a notable population decline is certain, determining precise numbers of a small district is difficult. Going on the basis of the nine districts (each with 30 to 50 households, according to Cowell) that he includes under their...
primary school, of which Gallimore was board chairman for many years, drawing students even from urban Brown’s Town, has shrunk, he reports, from 480 students in the 1970s to 170 currently. The pastor of a nearby church told him that for Harvest Sunday he had to go to Brown’s Town to buy yam, which formerly everybody grew and would bring to that Sunday’s service. Rural population decline is borne out by growth of nearby Brown’s Town, discussed below.

**CONCLUSION**

Starting in the 1970s, 50 years of resettlement has exhibited the following features:

a) Land acquisition by companies was initially from individuals by purchase at the very high prices offered by the companies and were often used for migration (Beckford, 1987). Resistance by more settled and older peasants forced the companies to resort to resettlement of entire communities, which allowed land-holders to negotiate for better relocation sites and other more favourable terms than what they could achieve as single individuals.

b) Generally, resettled people, “transplants,” in Cowell’s terminology (the left behind he calls “residuals”), found the experience extremely disruptive and painful. While a few were able to continue farming, most found themselves in semi-urban situations and/or in lower level bauxite jobs, resulting in reduced small farming production in the mining areas. The failure of company and government to handle this situation adequately is shown in the second priority recommendation (of three) made recently by the Inter-governmental Forum on Mining Assessment that the “benefits of mining contribute to long-term social and economic development . . . , particularly in those communities located near mining . . .” (IAI et al., 2018)

c) Interviewees reported that many small farming communities in mining areas shrank considerably in size and lost their sense of community. This supports the contention of the George Beckford-led UWI research study of the 1980s that bauxite mining hastened rural-to-urban drift and dealt a blow to peasant farming and peasant social life in Jamaica.

---

**INTERVIEWEES REPORTED THAT MANY SMALL FARMING COMMUNITIES IN MINING AREAS SHRANK CONSIDERABLY IN SIZE AND LOST THEIR SENSE OF COMMUNITY**

---

9 Report cited, p. 38, which also, p. v, identifies “a lack of consideration for post-mining transition and how affected communities will transition – economically, socially and environmentally – once a mine has closed.”
IMPACT OF MINING ON LAND, PRODUCTION AND COMMUNITY, AND COMPANY RESPONSE

Mined-out Land Less Productive

Mining bauxite in Jamaica has meant open-cast stripping of the surface soil from mostly hillside land cultivated by small farmers, who occupied the land either by ownership or by lease from bigger land owners. During the period while mining and reclamation were proceeding, that land was, of course, removed from farming. Thereafter, it could and usually was made available to farmers for their use. The critical question is whether reclamation did in fact make the mined-out land as productive as before. Did practice accomplish what legislation required? What was the judgment of farmers in this regard?

Predictably, opinions about the success of reclamation have differed and some of the variation can be explained by the differences of practice and inspection according to company, contracted agency, land features, and period. The farming areas of consideration in this chapter are those held by Kaiser, later Noranda, in the political constituencies of Southwest and Northwest St Ann, on the west side of the parish; the ALPART/JISCO land in Southeast St Elizabeth, to the west side of Nain in the vicinity of Myersville, Warminster, and Russells, and in South Manchester around Newport, the source of its ore; and the Jamalco South Manchester land in Harmons and St Jago, as well as in the North Clarendon Mocho mountains.

People from Western St Ann spoke of the top soil put back as “...too shallow to sustain vegetable crops,” while for people in Southeast St Elizabeth, where soil covering appeared to have had somewhat better depth, crop yield, and quality, still did not match growth on “original soil.” South Manchester’s sweet potatoes, “...the best in the world,” were said to have taken a blow. Thin soil, also, is unable to “...resist heavy rainfall,” leaving pasture growth vulnerable, although in one area, according to people there, ackee was said to grow well. Often, farmers said, there was a failure to properly spread topsoil. Instead, “...you can see the soil pack up in bush to one side.” In North Clarendon, in the words of one resident, “...after two to three years you might be able to rear a few goats and cows on the grass, but fruit trees are all gone – their roots need deeper soil.”

Government inspectors came in for criticism for their failure to supervise closely and demand correction of shoddy performance. Even the six-inch (15 centimetres) regulation requirement was condemned as insufficient, much less the “uneven three inches” that many said was the frequent practice. A now retired former, nearly 20-year member of a reclamation crew, claimed it was better in his first days under Kaiser.

This generally negative view of mined-out land is consistent with the finding of the 1981 survey conducted by Roy Russell as part of the UWI 1987 research study. This identified 82 percent perceiving mined-out land to be worse than pre-mined, only 1.4 percent to be better, and 11 percent having no opinion. Over 80 percent of those declaring it worse had more than 21 years of farming experience (ISER, 1982).
Other Impacts – Removal of Forests, Dusting

In addition to the direct impact of mining and likely also to affect the take-up of mined-out land, has been the 1) impact on climate that residents attribute to the removal of forests to make way for mining, and 2) damage by mined dust to agricultural produce – fruit trees and vegetable crops grown on small plots, and in household gardens\(^\text{10}\) in surrounding districts. North Clarendon people are emphatic about the loss of rainfall making the land arid and difficult for farmers. Parish Development Committee Chairman Anthony Freckleton asserts the same about South Manchester. In regard to dust, it comes not only from the mining and, in St Elizabeth, the dried-up mud lake, but also, for populations nearby, from the transport of ore by truck, train, or ship loading (e.g. at Port Rhoades) as well as from alumina transport and plant emissions.

The dust came in two colours, red and white. The red comes from the ore. The white, with its caustic soda content, comes from plant emission and effluent. The red dust is stirred up and spread by mining operations and trucking near populated districts near mining sites and trucking roads. It blankets fruit trees and vegetable crops, and interviewees contended the dust can destroy their produce. Citrus production in South-west and Northwest St Ann, South Manchester, and North Clarendon, for example, where community members said citrus production had previously been substantial, was virtually wiped out during the period of mining. This was corroborated by spokespersons for the Citrus Protection Agency and the Jamaica Citrus Growers Association.\(^\text{11}\)

The white dust derives from alumina processing. It contains caustic soda, which burns sweet peppers, tomatoes, and other produce, according to farmers. This is the situation faced by people living in the vicinity of the ALPART/JISCO plant while it is under operation in Southeast St Elizabeth. Damage from the two dusts is continuously commented on by everyone interviewed. This includes both the “transplants” before resettlement and the “residu-als” after (both, Cowell’s terms).

---

\(^{10}\) Across the parish 60.4 percent of households, _St Ann Parish Profile_. (2012). P. 43. Social Development Commission.

\(^{11}\) Dr Percy Miller, President of the Citrus Growers Association, and Mr Alfred Barrett of the Citrus Protection Agency, who speak of the CGAs once having branches in those areas, each branch (to qualify as such) supplying at least 4,000 boxes of citrus per annum.
The persistence and seriousness of the dust problem may be gauged by the number of records that result from a search in the Jamaica Gleaner’s archives for “bauxite dust”: 721 records between 1960 and 2020, a substantial number even allowing for several entries for the same dust event.

Farmland Decline

According to the Agricultural Census 2007 (STATIN), “active farmland” declined across the country by 22.2 percent between 1996 and 2007. The 30 percent decline in St Ann and the 22.5 percent decline in St Elizabeth (11.4 and 9.2 percent of the national total, respectively) therefore contributed significantly to the national decline, amounting to about 20 percent of the total.

The national decline in active farmland is generally attributed to the rural-to-urban trend occurring globally, due to the pull of urban social amenities and employment opportunities.

Table 8: Population Change in Selected Towns, Jamaica

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Black River</td>
<td>3,610</td>
<td>4,095</td>
<td>13.4</td>
<td>5,352</td>
<td>48.2</td>
</tr>
<tr>
<td>Brown’s Town</td>
<td>6,874</td>
<td>8,054</td>
<td>17.0</td>
<td>9,051</td>
<td>31.7</td>
</tr>
<tr>
<td>Mandeville</td>
<td>40,680</td>
<td>47,467</td>
<td>16.6</td>
<td>49,695</td>
<td>22.2</td>
</tr>
<tr>
<td>Jamaica</td>
<td>2,380,666</td>
<td>2,607,632</td>
<td>9.5</td>
<td>2,697,983</td>
<td>13.3</td>
</tr>
</tbody>
</table>


While the three parishes as a whole grew less than the whole country, their chief population centres (Black River, Brown’s Town and Mandeville) grew at a much higher rate than Jamaica as a whole.

We were unable to locate numbers for small farmers who were either relocated or had ceased farming. The JBI was unwilling or unable to provide any population figures on relocation – neither those who were resettled, nor those who remained behind. Though not affected by immediate life disruption, the latter also had to re-shape their lives in depleted communities and on mined-out land. Data for these limited areas are not offered in the censuses.12

Table 9 shows the take-up of agricultural land for active farming. We estimate average size of holdings of active farmland to be 0.79 ha for Manchester, 1.3 ha for St Ann and 0.87 ha for St Elizabeth, or even less. This applies especially in St Ann, because so much of the land was held by large landowners, leaving little for small farmers.

12 Approximate numbers could be compiled, laboriously, from electoral registration districts, which do not coincide exactly with the districts and areas under examination here, but time did not allow us to undertake this task.
Table 9: Agricultural Land vs Active Farmland in Jamaica, Manchester, St Ann and St Elizabeth

<table>
<thead>
<tr>
<th></th>
<th>Jamaica</th>
<th>Manchester</th>
<th>St Ann</th>
<th>St Elizabeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Land (ha)</td>
<td>325,810</td>
<td>24,521</td>
<td>37,099</td>
<td>30,022</td>
</tr>
<tr>
<td>Active Farmland (ha)</td>
<td>202,727</td>
<td>18,193</td>
<td>27,513</td>
<td>22,482</td>
</tr>
</tbody>
</table>

Source: Census 2007

Interviewees agreed that the number of small farmers, and farming generally, declined significantly in the mining areas of the three parishes examined, due to voluntary or involuntary relocation to other parts of the island, either individually or as a community; and/or migration; and/or lack of access to fertile land.

Compensation and Benefits from the Companies

Bauxite companies have traditionally offered some monetary compensation for crop losses. In St Elizabeth, the impact of dust on farming currently draws compensation only for above ground crops. This leaves out peanuts (underground, but damaged by burnt above-ground plant growth), the principal crop in some areas of the parish. The general complaint from interviewees was, however, that the compensation of JMD7,000, JMD7,500 or JMD8,000 per incident “don’t meet up to” the losses incurred from the dust from mining, trucking, and train haulage. This is especially the case in respect to train-blown and facility-emitted white dust (caustic soda). Respondents alleged that this covered and polluted water in people’s tanks, their sole source of water in dry seasons. It also damaged “zinc” roofing of homes, as well as cars, and clothes drying outdoors.

A more direct attempt to make up for farm losses was the JBI building greenhouses in Manchester and St Ann with significant funding from the Jamaica Social Investment Fund (JSIF). The greenhouses are built in clusters – up to 11 or sometimes 20 – with a water storage system provided by the mining company for larger clusters, by lining and filling a nearby mined-out hole (Neita, 2019). Eight communities with 160 farmers benefitted from the JBI and JSIF, with World Bank funding, amounting to $245 million (JBI, 2017). Manchester Community Council members have reported, however, the non-functioning of some greenhouses – 24 out of 24 in one location for 18 months; in a second case, three out of three for four years (with the construction of seven more, however, to be completed in six months); and single ones elsewhere. The problem is damage to roofs by high winds, with operators lacking the resources to make repairs, and action by company or the JBI slow in arriving.

Mining companies have also taken a host of other steps to address community needs.

---

Ha means hectares. 1 hectare = 2.47 acres.

At the time of writing the Jamaican dollar was trading at 1 USD to approximately 145 JMD.


The JBI’s denial of access to the minutes and records of the councils has made a comprehensive report impossible.
Those taken by Noranda in St Ann offer a typical example. This is described by members of both its Mining Community Council and Plant Community Councils as “generous assistance” and “very satisfying.” The Mining Council represented a dozen villages from Higgins Land and Shelly Piece, through Greenhill and Clivesdale North to Watt Town; and the Plant Council, in Discovery Bay – some ten districts. The Councils were reported to be active, to have met every month (pre-COVID), and enjoyed the attendance of a company representative who was their chairman.

Many kinds of help were listed, starting with replacement of “pit latrines with four flush toilets in each of two primary schools,” tuition grants of 10-15 percent to many primary school students, and outright scholarships. Members of the Plant Community Council secured grants for a variety of projects, such as chicken and goat rearing, and small businesses. Plant Community Council members in Discovery Bay received HEART NTA technical skills training opportunities. Many sports have also been extensively assisted by Noranda, and Noranda has been commended for this by nine parish sport (and other) organizations, as well as the then Minister of Culture, Gender, Entertainment and Sport, Olivia Grange (Gleaner, 5/12/2019). 17 Many still remember the “pushcart derby” that Kaiser, Noranda’s predecessor, sponsored.

Similar assistance was noted by more than one of several councils connected with Jamalco mining, processing, and transport. In Mile Gully, in addition to back-to-school help, book vouchers, tuition fee contributions (JMD4,000 and JMD5,000 to each primary or secondary student) and university scholarships (two in 2019, each of JMD228,000), there is a “JMD1 million for a bee-keeping project” for 13 people. Highly rated by recipients, this is expected to “enable start-up for other projects”. Health fairs and other medical treatment, through visits by teams from overseas, are also provided. 18

It should be noted that while the companies disclose the size of such benefits, they are silent – and two of them declined to be interviewed – on their contribution to the greenhouses constructed by the JBI, or to the ponds, some of which they built.

Persistent effort was made to review the minutes and records of the Community Councils, in order to get more details on the initiatives undertaken by companies and community concerns, but these requests were denied by the JBI, in spite of initial willingness on the part of one of its staff (a member of the BCDP) who had in his possession the minutes and his notes on meetings going back to 1996. JET advised us that an ATI request for these records was responded to with a referral to the Councils themselves, but they are not public authorities within the purview of the ATI Act. Denial of access to these important historical records made a comprehensive report impossible.

The benefits provided by the companies are, of course, welcomed by community members, some of whom also expressed feeling the negative impacts of bauxite mining. When the question arises, of which carries the greater weight when making a choice between mining and no mining, most come down on the side of immediate benefits. At the same time, the comment attached by one articulate Community Council chairwoman is worth noting because it reflects a widespread view: “We just have to put up with the suffering. We have nothing else to turn to. But it is not the option we would prefer.”

SOCIAL CONSEQUENCES

The removal of farmland from farming and consequent loss of livelihoods indicated previously could be expected to have major social as well as economic effects. Thus, complaints of increased poverty and other social ills – for example, gambling and petty theft – were strong.
in St Ann, less so in Southeast St Elizabeth and South Manchester. Further examination of poverty rates and incidences of gambling and petty crime during mining periods should be carried out, along with investigation into differing parish circumstances, such as alternative employment opportunities (e.g. nearby tourism in St Ann), the amount and history of mining (more extensive and older in Southwest St Ann and South Manchester compared to St Elizabeth) and local resilience and spirit (higher in St Elizabeth – see below).

In the St Ann districts adjoining the Trelawny border, now part of Special Mining Lease 173, older residents testify that some un- and much under-employment is the enduring situation, resulting in a general increase in poverty. They point to the importance of the chief dump for Northwest St Ann located between Tobolski and Brown’s Town as evidence of this increase. People and dogs, they assert, can be observed since 2017 “looking out for” and “chasing the dump trucks to rummage” for items. Since a large proportion of the waste (in pre-COVID days) came from hotels and tourist-occupied villas, known for discarding goods with only minor damage, not only the hogs and cows let loose to feed on the dump, but also humans salvaged goods of value.

Also reported in St Ann was the increase in the theft of animals and produce, although as an island-wide phenomenon, it is questionable how much of this can be blamed on bauxite mining. Because of their mostly small size, the thefts were not generally reported to the police and therefore not reflected in police statistics. Petty theft is widely recognized, and interviewees were unsurprised by this in the context of decline of livelihoods. In the words of one respondent, 30 years ago Lime Tree Garden had “three thieves” (clearly known and dealt with). Today, “a phone call brings a pick-up to collect a stolen animal,” carcass or alive. Many “live” by stealing, another testifies. Some farmers confessed to having given up entirely on goat rearing because of ongoing larceny.

Residents in Southwest St Ann also spoke about thieving and its relation to the loss of a sense of community. They said those seeking collective action in defence of community interests were usually unable to gather even minimal support. According to many respondents, younger people and young parents have an “every man for himself” attitude that resists the efforts of others toward collective action.

Some interviewees in St Elizabeth alleged that the distinctly inferior produce of shallow soil and regular blankets of red and white dust resulted in a perceived absence of opportunity, especially in young people, which went beyond lack of access to employment. In their analysis, these negative realities appeared to have a “socializing effect” on both males and females, which on examination, turned out to be more “a poverty of energy and spirit” than of material goods.

In rural Southwest St Ann, by contrast, with small farming in decline, it was reported older teens are quick to head to the coast in the hope of a job in a hotel or call centre (Business Process Outsourcing or BPO unit). This was given as an example of the break-up of the farming family, formerly integral to peasant farming communities. As several people emphasized, farming used to be “a family matter,” with young children and teens shelling
peas and feeding farm animals or helping to fork up a piece of ground. “This is now a thing of the past,” they lamented.

Interviewees from Manchester and St Elizabeth also described negative impacts on the peasant family and the peasant farming way of life, which they allege is due to bauxite mining. One effect of the bauxite mining alleged by the chairpersons of two Community Councils has been the waiting for, and heightened dependency on, company hand-outs and company initiatives.

COMMUNITY COUNCILS AND SMALL FARMERS

The first Community Council emerged in 1990, born at the ALPART Sports Club in St Elizabeth following a protest by 2,000 people at the plant gate the previous day over the dust from the 400-acre dried mud lake. The council was the first of its kind and grew to represent 45 communities. It was followed, two years later, by another in South Manchester for 33 communities, again the work of community members. These were major achievements with huge potential. Community members were showing their will to shape the future, to benefit themselves and their communities, not just the national budget.

The JBI then joined with community interests to promote another 15 councils of the 17 that came to exist in other bauxite areas. JBI’s tool in this process was its Bauxite Community Development Programme (BCDP), which maintains that 15 are still active and, prior to COVID-19, still holding monthly meetings. This is certainly true of the nine with which this study made contact.

The council members had a very different prime purpose, however, from JBI and the companies. For the community members who formed the first councils and made up most of its membership, they were the first hopeful response to the impact of bauxite mining and processing on their communities. They would become a channel for ideas and complaints to be heard, to ensure that livelihoods would be improved and developed. The councils came to offer not only a reason-it-out alternative to instant plant or mine closure, but also fostered, according to a veteran former chairman, a flourishing democratic process in the communities themselves.

The companies accepted the first and later councils. Their aim was to use the councils to head off strikes or demonstrations by workers or communities that risked losing company income. The JBI, as representative of the state in its contractual relations with the companies, had the same objective. In addition, however, to JBI’s stated remit of monitoring, researching, and advising the GOJ, it also had the responsibility of playing a mediating role between company and community or plant workers, which often meant holding compromise positions. These included looking out for the wellbeing of the community and the plant workforce, as demonstrated by the greenhouses built, the supply of seedlings in the JBI nursery at its headquarters, and the over 350 projects that it claims to have completed.

In the twenty-first century, with demonstrations and work stoppages on the decline, the
diverse objectives of the company, the JBI and the community found common ground. Interviews revealed, however, a real difference between the approaches of the parties. When a council was chaired by a community person, even one who had a contract with a company, there was no hesitation in talking about the drawbacks of mining and processing, alongside the benefits. In cases where the chairman was a company representative, as in most councils, the focus was principally on the compensating benefits provided by the company, which was regarded as “generous.” The contrast between the two kinds of leadership was striking.

What did the councils with their claimed potential achieve and to what extent was achievement influenced by how their members and their chairmen performed? A criticism made by community members was that many council members often represented their personal interests, not those of the community that elected them, and perhaps for that reason, were not reporting back to them.

This notwithstanding, the creation of the councils was a major achievement and there were many gains. For example, the 2009 emergence of the ALPART Community Council produced the non-profit Essex Valley Community and Associates (EVCA), a development organization with business, economic, and social impact. The Essex Valley Community and Associates enabled plant workers to get the many contracts funded by the company, some JMD200 million worth of projects over the years, including construction or repair of
community centres, police stations, and school classrooms. It has also regularly contributed to student tuition and back-to-school needs.

St Elizabeth community members also can claim outstanding achievement, outside the ambit of the bauxite-alumina industry. Farmers, tradesmen, and some businesspeople declared the low value of the bauxite-alumina industry to the parish when compared to farming. In their view, where mining and processing have not interfered, it is small farming that is most lucrative, bringing higher incomes and quality of life. These small farmers are the ones in the farming belt to the south, around Junction, Top Hill, and Ballards Valley, as well as those in the south of the Essex Valley around Comma Pen, and New Forest. The impact of the ALPART facility processing plant (now JISCO and closed) reached this far south only through the train to the port.19

St Elizabeth respondents said that tradesmen, such as welders, masons, and carpenters, can earn more working for other types of business, compared to the bauxite company. Farmers outside the mined-out land use technology their parents did not have – the low-tech mist-blowers, plastic water tanks, weed whackers, drip irrigation tubing, plus traditional dry grass mulching – and made a prosperous living from a few acres, as their large homes with two or more vehicles in each driveway testify. As one store owner added, small businesses have prospered accordingly. The great demand, presently, is for land, even if the only available is small plots – although with the changing climate, there are also calls for irrigation systems. Farmers and tradesmen adamantly prefer their lines of work to work in the bauxite refinery.

Many in Southeast St Elizabeth see the way forward in small farming, while also welcoming government help, as in the currently underway Essex Valley project. They are enthusiastic, not only about the resulting prosperity, but also by the independence and continuity of community life that small farming brings. “Houses in Comma Pen are not grilled,” one respondent proudly declared to the interviewer. Most have switched, he added, by their own choice “...from marijuana growing to scallion and other vegetables, for which they have ready urban markets.”

The agricultural parish of St Elizabeth has had most of its land untouched by mining. After mining a limited area, ALPART turned to the South Manchester plateau for its ore and JISCO has continued there.

The spirit and intention of the Community Councils was to defend two main community interests – the restoration of mined-out areas to their original productivity, and the control or elimination of dust pollution to protect public health and livelihoods. While there have been efforts to mitigate dust pollution and some compensation was (and still is) offered – the so-called “dust nuisance” payment – interviewees felt that the Councils have so far failed to protect broader community interests.

Those for whom bauxite mining and processing is the better option are critical of successive governments for their failure to channel part of the huge national income generated back

---

19 Also, in the south and only touched by the rail-line from ALPART/JISCO were the farmers in the Essex Valley in the Common Pen and New Forest area, recipients of irrigation help from the Government.
into the mining communities. Nonetheless, they are persuaded by the benefits offered by the industry in employment, national foreign exchange earnings, sports, training, scholarships, greenhouses, and other benefits. They do not grasp the contribution of small farming to a national agriculture sector with its capacity to reduce Jamaica’s total dependence on foreign inputs and foreign markets, or the importance of a food culture. They do not place importance on the loss of small farming communities, and the high value these communities hold for land and heritage, strong community life, and a self-reliant independent spirit.

CONCLUSION

In our view, every government engaging foreign transnationals to develop in its territory a major industry, such as bauxite mining and processing, has a basic duty to assess the social impact of the industry on its country. Such an assessment would track effects on small farmers, the size and productivity of their plots, the number of farmers, any exodus to urban centres, any alternative livelihoods taken up, any differences in these from mining

---

20 For a thorough account of the views of the Caribbean world-renowned economist, St Lucian W. Arthur Lewis, 1979 Nobel prize winner, not just on industrialization but on the centrality of agriculture and small farming, see Figueroa, Mark (2009), Rethinking Caribbean Agriculture. Re-Evaluating W. Arthur Lewis’s Misunderstood Perspective. Business, Finance and Economics in Emerging Economies, 4(2). While urging 20–50 acre farms (that were former sugar lands now thrown up and lying idle, e.g. Monymusk) to make use of economies of scale and mechanization, Lewis had a high respect for small farmers, their independent self-reliant spirit and achievements (pp. 20, 25–27).
community to community and from company to company, and any accompanying changes in community structure and lifestyles. Numerous and repeated complaints, over decades, from farmers and residents about the bauxite-alumina industry’s impact on their lives and livelihoods have underlined the need and urgency for such assessments.

We were unable to find any evidence of work of this nature being done and it appeared that resistance to this type of vital inquiry has come from the very agencies with responsibility for the public interest. We refer in particular to the JBI, which was established over 40 years ago to be the GOJ’s mediator, expert advisor, monitor and guide, such that the bauxite-alumina industry would benefit not only the nation’s finances, but also the well-being of the communities most affected.

The JBI’s published research shows how well this mandate has been executed on behalf of the industry and the nation’s finances, and to some extent for the public interest, as this chapter noted with its acknowledgement of JBI-built greenhouses, for example. On the other hand, we were not provided with any evidence of tracking small farmers, farm sizes or productivity, farmer numbers, and population movements, or any study of indicators of the vibrancy of rural life. We were not even able to discover how many people have been displaced by the industry.
Requests for interviews were made of two of the existing bauxite companies, UC Rusal’s WINDALCO Plant (Ewarton) and Noranda (St Ann). Noranda declined outright and UC Rusal kept delaying a meeting which, in the end, did not take place. In contrast to cooperation extended by some of its staff members, the JBI’s management refused to make resources gathered with public funding for public services available to us, and this limited the comprehensiveness of our research. We also found STATIN unwilling or unable to provide the kind of data required by a social impact study.

These failings do not cloud or dim our findings – that the bauxite-alumina industry did not receive sufficiently strong oversight and guidance from the very institutions established for that specific purpose, and as a result, small farmers contend that the industry has inflicted long-lasting damage on their livelihoods, their culture and their potential for enriching the agriculture of Jamaica and the nation’s prospects for self-reliance.

REFERENCES


Impact of Bauxite-Alumina in Rural Jamaica. (1987). Social and Economic Studies, 36(1) This is a collection of papers led and directed by George Beckford, University of the West Indies.


ISER (1982) A survey of Farmers in Five Selected Bauxite Mining Areas. UWI.


5: Degradation of Ecological Heritage

The Impact of Bauxite Mining on Karst Ecosystems in Jamaica

SUSAN KOENIG

To understand karst formation requires seeing it as a system. The features of a karst landscape depend on the interaction between the components of this system: water, air, soil, rock, life, energy, and time. The integrity of karst systems depends on the preservation of this interaction . . . If the balance is upset by sudden changes in one or more components, the whole system may be disrupted.


OVERVIEW

Open-pit extractive mining can have substantial short-term impacts and insidious long-term effects on the environment. The most visible impacts during mining include the removal of agricultural vegetation or native forests, the elimination of mineral-bearing soils, and the physical reshaping of the landform. These changes, in turn, will influence the processes which drive the geo-biological formation of new soils, regulate microclimates (e.g. air temperature, relative humidity), and govern the movement of water within and beyond the mining area (e.g. how rainfall is locally intercepted and channelled to the surface; subsurface penetration, water storage, catchment outflow). Functional processes such as these, in

1 Karst is the term applied to a terrain which is created by the chemical solution (in contrast to mechanical erosion) of a bedrock under conditions of high rainfall. This process most frequently, but not exclusively, occurs in carbonate rocks such as limestone and dolomite. In karst, there will be distinctive landforms and water drainage patterns of: (a) closed depressions on the land surface (like dimples on a golf ball); (b) disrupted (i.e., sinking/disappearing) surface drainage; and (c) caves and underground conduits through which water moves. The term is derived from the word Kras, the name of a limestone plateau in Slovenia, bordering Italy.
Dunns Hole, Trelawny
turn, govern the successful development of new vegetative land cover, which in turn directly influences the processes. This dynamic cycling of functional processes ultimately provides ecosystem services of value to humans (e.g. food, water, climate regulation). Mining can arrest any of these services; the extent to which they can or are being brought back into a functional, self-sustaining condition in Jamaica has never been rigorously assessed in the ~70 years of bauxite mining on the island.

The original approach of this research was to: (a) review existing literature to identify post-mining rehabilitation practices from the inception of the industry in Jamaica; (b) obtain printed maps or electronic files of spatially-explicit, geo-referenced boundaries of all bauxite ore bodies which have been mined-out in the parish of St Ann; (c) obtain records on the reclamation status and rehabilitation land cover status for every mined-out ore body in St Ann; and (d) undertake field assessments to evaluate the current land cover status of rehabilitated ore bodies, which would have been randomly-selected in time-series subsets (i.e. 5, 10, 20, etc. years since they were certified as rehabilitated by the Commissioner of Mines of the Mines and Geology Division (MGD)). Within the matrix of a “Disturbance Index for Karst Environments” (van Beynen & Townsend, 2005), the mined-out areas would have been evaluated as to whether the characteristics and processes which are unique to and critical for karst ecosystems were functioning at levels prior to mining. This information would have been further conceptualized to define parameters for a process-based model of Jamaica’s karst, for improving management and conservation in mined and un-mined areas.

Unfortunately, while MGD was able to provide data files on the rehabilitation status (including land cover designation) of mined-out ore bodies under current Special Mining Leases (SMLs), the Division was unable to provide boundary data for mined-out ore bodies. A request for boundary data to the JBI remained unanswered at the time of this report. This precluded computer-based spatial analyses and verification field surveys. This research, therefore, was restricted to a web-based literature review in order to determine to what extent the characteristics and system properties of karst are being applied by authorities so as to minimize and/or eliminate environmental degradation caused by bauxite mining in Jamaica.

Because much of the historic and current mining in Jamaica occurs in areas where the native forest covering the ore had already been converted, particularly to agricultural-pastoral activities, assessing the impacts of deforestation on forest-dependent biodiversity was mostly beyond the scope of this review.

**BACKGROUND: THE DEVELOPMENT OF BAXITE MINING IN JAMAICA**

While the presence of aluminum in the “red ferruginous earth” of Jamaica was recognized as early as 1869 (Sawkins et al., 1869), no attention was paid locally to the mineral composition until 1939. In that year, during the course of systematic investigations of soils by the Agricultural Chemistry Division in the Department of Agriculture (Kingston), it was
discovered that the *terra rossa* soils contained sufficiently high alumina content to enable their classification as “bauxite” (Howard & Proctor, 1957). The analyses were undertaken in part to improve the fertility of this soil type, which under native forest cover and regular decomposition of plant and animal material recycles soil nutrients, but when converted and left exposed by conditions such as overgrazing and inappropriate farming-tillage practices rapidly loses nutrients (particularly phosphorus), with a consequent reduction in crop yields (Swabey, 1939; Howard & Proctor, 1957; Harris 2016). Of note, the first field experiments to improve the fertility of bauxitic soils in Jamaica were applied at Grove Place, in the parish of Manchester and at Bull Savanna in St Elizabeth (Howard & Proctor, 1957; Figure 9).

Figure 9: Aluminum Bearing Soils

In 1942, the Department of Agriculture again was asked to analyse soil samples, this time from Sir Alfred DaCosta’s property near Lydford, St Ann, over concerns of low corn yields (Young, 1965). The Senior Agricultural Chemist, Mr R.F. Innes, confirmed high alumina and low silica percentages, such that he advised further evaluations for possible commercial exploitation. Following laboratory analyses in New York, London, and Ottawa, and additional field sampling, deposits of economic importance were confirmed near DaCosta’s Lydford property as well as in the parishes of Manchester and St Elizabeth. (Hose, 1950).

---

2 The terms *terra rossa* and red dirt are used interchangeably for the surface layer that geologically is a clayey soil with iron and aluminum oxides. The generic term “bauxite” is used when the aluminum content is sufficiently high to warrant commercial exploitation; i.e., bauxite, itself, is not a mineral but instead is both a rock and soil type (of finely-grained rock particles), which are composed of aluminum-bearing minerals. These minerals – composites of aluminum, oxygen, and hydrogen – are processed to extract the fundamental metal element aluminum.

3 Locations where the earliest concerns for poor agriculture performance on aluminum-bearing soils led to the development of bauxite mining in Jamaica. Base map of the distribution and concentration of aluminum from Lalor (1996). Concentration values >19 percent represent commercially viable bauxite.
Prior to World War II, the ownership of any bauxite ore body in Jamaica belonged to the owner of the land, in accordance with the Common Law of England. This was in contrast to gold and silver, which were vested in the Crown. However, with rising concerns over German U-boats sinking of bauxite cargo ships from the Guianas, on 27 November 1942, all bauxite in Jamaica was declared the property of the Crown under the Emergency (Defense) Acts 1939–1940, further known as the Jamaica Defense (Amendment No 21) Regulations 1942. Although large reserves (estimated 200 million long tons) were quickly confirmed, mining did not proceed because overseas plants at that time did not have the ability to process Jamaica-type bauxite, which, because of its very fine grain, does not behave like other bauxites from elsewhere in the world (Hose, 1950; Strahl, 1971; Chin, 1971; Madourie, 2013; Roach et al., 2016). It is notable that Jamaican farmers had already recognized the “peculiar physical properties relative to erosion, water absorption, slickness to traction, and texture . . . [so] that special techniques are necessary for even marginal crop production and the botanists have learned of often unusual and endemic plants occurring on these soils” (Howard & Proctor, 1957, p. i).

By 1944, the emergency defence regulations had been withdrawn and the ownership of bauxite reverted to its pre-war “landowner owns” status. Recognizing the future importance of bauxite deposits in Jamaica, the GOJ rapidly set out to develop laws and regulations not only to govern exploration and mining but also to ensure that ore bodies were vested in the Crown. The Minerals (Vesting) Act, The Mining Act, and The Mining Regulations were all passed in 1947, and the Aluminum Company of Canada (ALCAN) and Reynolds Jamaica Mines began purchasing the largest bauxite-bearing properties in Manchester and St Ann (Rousseau, 1987; Coke et al., 1987). By 1957, ALCAN, Reynolds and the third entrant Kaiser Bauxite Company, obtained access to some 136,472 acres (55,228 hectares) or 5.7 percent of Jamaica’s land area (Young, 1965; Salmon, 1987; Figure 10).

By the late 1940s, with mining companies eager to benefit from working within the framework of the European Recovery Program (aka the Marshall Plan) and its United States-based administering organization, the Economic Cooperation Administration (ECA), ALCAN (through its American subsidiary) signalled interest in securing loans from the ECA. Their proposal included building an alumina refinery in Jamaica and the promise of sharing the company’s technology to process Jamaican ores. ALCAN also signalled that it could repay the loan in aluminum or bauxite. Thus, while ALCAN retained control of value-added revenue through vertical integration, the USA benefitted from having another source of alumina to build its “strategic material” stockpile while protecting its own national reserves (Ingulstad, 2013). Jamaica received the construction of refineries to process bauxite into alumina, which even then was an industrial process recognized globally for producing toxic waste (Evans 2016).

---

4 In 1943, during the first large-scale processing experiment of Jamaican bauxite in ALCOA’s East St Louis (Illinois) alumina plant, it took only half an hour before the plant gummed-up completely. The waste material, known as “red mud,” settled in the filters, where it should not, and it would not settle in the industrial thickeners (Ingulstad, 2013).
By 1963, principal bauxite deposits had been identified across Jamaica. Subsequent maps, such as those prepared by the Jamaica Bauxite Institute (JBI), present bauxite as a contiguous distribution across the land surface, but this misrepresents the true spatial pattern, where ore bodies occur in discrete pockets and valleys of the underlying karst white limestone. The Special Mining Leases (SMLs) on the JBI map encompass a surface area of approximately 1,020 km², or 9 percent of the island. Missing from the JBI map are SMLs # 169, 170, and 173 (encompassing ~ 308 km²) and areas which were mined between 1947 and 1990. Given that the first three entrants, ALCAN, Reynolds, and Kaiser obtained access to some 136,472 acres (~ 552 km²; Salmon, 1987), at least 17 percent of Jamaica’s land surface area has been under the control of bauxite mining. Figure (a) from Young 1965; (b) from Drakopoulos 2018.

Figure 10: Principal Bauxite Deposits
Based on kiln-drying reducing free moisture content on average from 22% to 13%, 626 million metric tonnes (by weight) of “dry” bauxite equates to 682 million metric tonnes of bauxite when it was removed from the ground. Assuming that haul trucks are not overloaded, this can be visualized as the equivalent of 68.2 million trucks leaving the mining pits and driving along the haul-road network.

At a 22% free moisture content, those 682 million metric tonnes also can be viewed as 532 million metric tonnes of solid material and 150 million metric tonnes of water. Given that one tonne of water represents 1,000 litres of water, bauxite mining has potentially removed the capacity of the Jamaican karstscape to physically hold 150,000,000,000 litres of water at any moment in time. This is equivalent to 60,045 Olympic-sized swimming pools.

Understanding Water Storage Capacity: What is Really Needed?

Refining this gross simplification of changes to water storage capacity (and also water residence time) in a karstcape following the removal of bauxite ore requires data on the distribution of water within the bauxite, both by location (horizontally and vertically) and by time. Distribution, in turn, will be influenced by myriad of factors, including:

- patterns of rainfall (e.g., seasonality, duration and intensity of rain events);
- vegetation cover (incl. precipitation interception and dew point condensation characteristics, evapotranspiration rates, and sapflow velocity);
- vegetation root architecture;
- geo-physical properties of the bauxite (e.g., bulk density / infiltration capacity, hydraulic conductivity);
- the volume of ore bodies (surface area x depth); and
- drainage characteristics of the underlying limestone substrate (e.g, slow diffuse vertical percolation, faster conduit flows).

Data for these parameters are required in order to model and understand the localized and cumulative landscape-level impacts of removing bauxitic soils from watersheds.

Sources: Young, 1965; Lee, 1971; JIS 2010; https://jbi.org.jm/project/export/).

Modeling examples: Jackson et al., 2000; Chandler, 2006; Hartmann et al., 2013; Caton et al, 2016; McFarlane et al., 2018; de Souza et al., 2019.
In 1952, the first shipload of kiln-dried bauxite ore was exported from Jamaica to the US and in 1953, the first shipment of Jamaican-processed alumina was exported to ALCAN’s smelter in Norway for final processing into aluminum (Young, 1965). From its first export in 1952 through 2018, approximately 626 million metric tonnes (by dry-weight) of bauxite-bearing earth have been extracted from Jamaica (Young, 1965; Ministry Paper, 1977; https://jbi.org.jm/project/export/; Box 1).

The history of how and when bauxite mining developed – the dismissal of “red dirt” as worthless (indeed, of even negative value) where agricultural productivity was poor, and the technical requirements for processing Jamaica’s unique bauxite ore during a period of wartime colonial exploitation – establishes the framework for understanding how mining was given the upper hand in exploiting Jamaica’s natural heritage. Then, with individual mining leases issued for periods of up to 40 years, practices became locked in the past, as knowledge advanced and social and environmental values changed (e.g. as occurred in 1991 with the passing of the Natural Resources Conservation Authority (NRCA) Act, and in 2011 when Jamaica amended its Constitution to include environmental rights in the Charter of Fundamental Rights and Freedoms; see also, Crawford et al, 2020). Thus, what has been described as a legacy issue (Persaud, 2018) is, in fact, a retaining of the upper hand by mining interests over all other environmental concerns and values.

SURFACE MINING: CHANGES IN LANDFORM

The process of extracting Jamaican bauxite has hardly changed since mining commenced in the 1940s. First, the positions of ore bodies are mapped. Historically, that would have been done by hand-drawing on topographic maps, with each potential ore body outlined along contour lines. Ore bodies are then numbered so that each can be tracked “through being mined out, being rehabilitated, and being certified if satisfactorily rehabilitated” (A. O’Gilvie for Commissioner of Mines, personal communication. June 22, 2020; Figure 11). Archiving

---

6 The free-moisture content of Jamaica’s bauxite in situ ranges from 19–25 percent (Tretzel, 1971). To meet shipping requirements (US Congress 1982), ore is dried to 10-15 percent free moisture (Young, 1965; Lee, 1971) which, in turn, creates problems with regards to controlling fugitive dust of the very fine-grained Jamaican bauxite (US Congress 1982).

7 As agricultural interests dismissed the “poor fertility” of red dirt, the ecological relationship of deep bauxite deposits supporting the largest trees and the role of forests in soil and watershed protection were both understood and of such importance that The Forest Law was enacted in 1937, with explicit reference ”for the preservation of the soil on the ridges and slopes and in the valleys of hilly tracts” (The Forest Law, 1937; Swabey, 1939, 1942).

8 Topographic maps at a highly detailed resolution scale of 1:5,000 were available in the 1950s; the Preliminary Edition maps of the entire island, at a scale of 1:12,500, were produced in 1968 /69. <https://nla.gov.jm/content/nla-price-list-maps-topographic-maps>

9 Mined-out ore bodies are presented to the Commissioner of Mines (Mines and Geology Division) during certification exercises. For the certification process to work, the locations of ore bodies must be known before mining commences and each ore body must be uniquely numbered. On maps (b) and (c) enclosed, black-lined polygons indicate either an un-mined ore body or an ore body which has already been mined and previously certified as rehabilitated. The hatch-lined polygons are for those ore bodies which were presented to the Commissioner in the southern Schwallenburgh district of Special Mining Lease (SML) 162, near Faith’s Pen (St Ann) on 8 December 1999 and certified on 7 January 2000. For expanded details of the certification map, see Appendix 1. (d): GIS computer software facilitates this mapping process while enabling additional monitoring
Figure 11: Example of Mapping of the Rehabilitation Process
this mapped, spatially explicit information is paramount, at a minimum for ensuring that any new mining leases adjacent to an existing or completed lease aren’t assigned an already mined-out ore body. Most critically, accurate mapping is required for ensuring company compliance with The Mining Regulations, 1947.

At least as early as 1971, computerization of ore body data was being discussed (Roberts, 1971\(^{10}\)). This corresponded with the founding of the Environmental Systems Research Institute (ESRI) in 1969 and the creation of spatially-explicit Geographic Information System (GIS) software (https://en.wikipedia.org/wiki/ArcView_3.x). Certainly since 2000, ESRI and Maptek\(^{11}\) were pioneering GIS/mine modelling integration for use in Jamaica (Price, 2004a, 2004b; Figure 12\(^{12}\); Appendix 1). In addition to enhancing MGD’s capacity to certify rehabilitated ore bodies, GIS computerization would have enhanced the ability of the Jamaica Bauxite Institute (created in 1975 by order of Cabinet) to achieve one of its core functions, which is to assess and allocate Jamaica’s estimated 1.3 billion tons of bauxite reserves (Rosseau, 1987; see, e.g. Jamaica Bauxite Institute (JBI) Annual Report 2012–13, pg. 18\(^{13}\) and “Cartographic Services of the JBI” on its website: https://jbi.org.jm/services/).

After preliminary mapping, field surveys using techniques such as auger borings (drill

---

10 Bauxite companies were interested in computerization of ore reserves to speed up, simplify, and provide better blending schedules (Roberts, 1971), so there was strong financial incentive to adopt computerized technologies.

11 For further details about Maptek’s Vulcan 3D mining and geological modelling software (which was used by Kaiser in Jamaica; Price, 2004), visit: <https://www.maptek.com/products/vulcan/index.html>

12 GIS Software can be used to visualize spatial relationships and estimate the volume of bauxite ore bodies, so as to facilitate the formation of mining schedules. In this example, 10-foot Thickness Contours were created from depth data, which would have been collected in the field. Coupled to the polygon boundary of a discrete ore body (i.e. the surface area, as bounded in red, which corresponds to the natural shape of the landform), the volume of bauxite is calculated by software algorithms. In this example, these ore bodies were calculated to contain nearly 389,000 dry metric tons (DMTs). Source: Price, 2004. Although Price presented ore bodies (numbered 430, 457, 458, and 460) as occurring in Block 11, readers should understand that, as the author noted, the data set used for the GIS tutorial were generalized from real data provided by companies mining in Jamaica. That is, Price used real data to create an example which captures the essence of Jamaican ore bodies while protecting the real data from public distribution. As part of the independent verification process of the current research effort, it was confirmed using ‘rehabilitation status’ data provided by MGD that, while the ore body identification numbers presented by Price were assigned to two different Special Mining Leases, none of their surface areas conformed to the sizes presented by Price (as estimated from the scale bar included in the figure). The tutorial dataset created by Price is no longer available (N. Simpson-Lake (ESRI/SpatialVision), personal communication 19 August 2020).

13 The JBI’s Annual Reports are not archived on the JBI’s website; however, some can be found on the Jamaica Information Service’s (JIS) website: https://jis.gov.jm/media/JBI-Annual-Report-2012-13.pdf
cores) and ground-penetrating radar are conducted to create vertical profiles of the ore bodies, to identify any unusual characteristics of the bauxite ore, to calculate average thickness and tonnage of the ore body, and to facilitate “blending” from multiple ore bodies to ensure the grade of bauxite is relatively constant for subsequent processing (Tretzel, 1971; Roberts, 1971; Price, 2004).

Both the field surveys and subsequent mining reveal the many complex variations of ore body size and shape which result from the pockets, sinkholes, and troughs of the underlying karst surface of the White Limestone Formation in which Jamaica’s bauxite deposits occur (Lyew-Ayee & Stewart, 1982; Miller, 2004; Madourie, 2013; Box 2). These troughs

\[ \text{Figure 12: Example of How GIS Software Is Used to Map Ore Body Characteristics} \]

14 Unlike, for example, in Western Australia where regulations require that drill cores must be stored and made available for public inspection (Mining Regulations 1981, Section 96D. (3), Western Australia), Jamaica has no requirements for archiving samples, which would be useful for validating models of impacts to the karstscapes.

15 While in Jamaica and, similarly, in Guyana and most of Europe, bauxite deposits are formed in association with carbonate (limestone and dolomite) substrates, bauxite also forms through weathering of other rock types, particularly silicate rocks such as granite, shale, and basalt. These types of silicate bauxites, referred to as “lateritic” (from the Latin later meaning ‘brick’, to acknowledge brick-making in southern India) occur in Australia, India, Ethiopia, and the Amazonia region of South America. Comparisons between Jamaica’s bauxite and lateritic bauxites, therefore, are not straightforward owing to differing underlying geologies. The two critical conditions for bauxite formation, whether carbonate or lateritic, are high rainfall and good movement of water. This enables weathering of the parent rock, removal of water-soluble minerals, and leaving behind the insoluble iron and aluminum mineral compounds.
and sinkholes are highly irregular, often very deep and steep-sided, so that at one point a
discrete deposit may have a depth of only 5–6 m, while less than 30 m away, it may be 15–20 m
(Hose, 1950; Price, 2004); limestone pinnacles hidden deep within the deposits are frequently
encountered (Roberts, 1971). Jamaica’s highly variable bauxite deposits range in depth from
5 to 150 feet (~1.5–46 m) (Porter et al., 1982). The relevance of this variation is discussed below,
under Surface Mining: Changes to Functionality.

BOX 2. KARST LIMESTONE AND BAXITE

Limestone — sedimentary rocks built up millions of years ago by corals, shells and other marine organ-
isms — will undergo the chemical process of karstification under conditions of extensive rain falling on a
blanketing layer of forest cover. Limestone, which consists primarily of a mineral called calcite, has low
solubility in pure water. However, as rain falls through the atmosphere it absorbs carbon dioxide, lowering
its pH (increasing acidity). As it flows through humic acid (Humic substances are organic components of humus.)
from leaf litter and soils (with their associated bacterial respiration processes), acidity continues to increase, which in turn increases the water’s capacity to
dissolve the limestone. Two processes can then occur: (1) very small pores of the limestone surface are
sealed off by the precipitates left when rain evaporates after dissolving small quantities of limestone (i.e.
“case-hardening”, the same process as when cement dries and matures); while (2) joints, fissures, and
larger cracks take in rainwater, enabling vertical movement of water through the limestone until a barrier
is encountered (e.g. an impermeable bedrock, the water table). Over time, these cracks widen into voids,
passages and caves, as water moves through the subterranean aquifer.

In addition to the porosity of limestone, which is a result of its paleogeographic history, other factors
shaping the development of a karstscap[e include the purity, mechanical strength and thickness of the
limestone, faulting in the bedding plane, the geological environment peripheral to the limestone (which
may influence acidification of water or be a source of abrasive sediments in flowing water), as well as
tectonic uplift.

The consequences of the above interactions — water, air, life, soil, rock, energy, and time — are dis-
tinctive aboveground karst landforms, with features such as oval (doline karst) or star-shaped polygonal
depressions (cockpit karst), sheer cliffs (mogote and, especially tower karst), and a subterranean drainage
network of caves and vertically-shafted sinkholes.

As carbonate rocks such as limestone are chemically weathered, another feature is that insoluble
residues can accumulate as the underlying limestone is dissolved. When hydrous aluminum oxides are
present, such deposits are described as “bauxite,” so named for the village of Les Baux in southern France.
In Jamaica, the aboveground doline- and cockpit karst depressions on the North and West sides of the
island’s Central Inlier have accumulated deep pockets of bauxite ore deposits, some >= 30 meters thick,
while on the south side of the island deposits are more blanket-type. The source of Jamaican bauxite —
whether it is derived from the dissolution of limestone or originates from major volcanic ash deposits
during the Miocene (23–5 MYA) — remains unsettled, although the extraordinary levels of cadmium give
strong weight to the volcanic ash explanation.

---

16 Humic substances are organic components of humus.
The physical structure of a native forest is directly influenced by the topography of the limestone and bauxite deposits. The largest trees, anchored with deep roots, grow on the bottomlands (valley floors), while trees of shorter stature and smaller diameters occur on exposed-limestone hillside slopes. Medium-size trees are found on hilltops or ridges, where accumulation of leaf-litter affords some degree of surface moisture retention, but which is offset by exposure to desiccating (drying) winds. Bottomland and hilltop tree species display strong preferences for their topographic positions, revealing their evolutionary adaptations for best survival under their widely disparate microhabitat conditions.

The distribution of bauxite deposits also directly influences human settlement and activity, notably via the conversion of forest to agriculture in the pockets of accumulated bauxitic soils. The type of agriculture most-suited for a location will, in turn, be driven by above-ground precipitation and drainage patterns of the limestone and bauxite substrate. Historically, limestone hillsides occurring in bauxite-bearing areas were typically left with forest cover, but selective harvesting would have occurred for building (including for lime production) and agricultural uses (e.g. fence posts, support stakes for yam plants).


Once the sequence of mining is determined from field surveys and laboratory analyses, a network of spur and haul roads is mapped and constructed to connect pits to the mine terminus, with road widths calculated to ensure unobstructed two-way passage of trucks (Tretzel, 1971; Roberts, 1971; Figure 13'). Owing to the naturally complex patterning of how...

---

17 In the area of 18° 17’ 20” N, 77° 02’ 48” W. Because of the unique deposition patterns of Jamaica’s bauxite – in enclosed depressions of doline karst and in valleys of undulating kegel (cone) karst (Miller 2004) – networks of haul roads have to be constructed. This involves blasting or bulldozing through portions of obstructing forest-covered limestone hillsides (Swabey 1939, Howard and Proctor 1957, Howard 1991). When haul roads are not rehabilitated with forest cover, plant and animal communities on hillsides are left isolated in small, discrete, patches of forest. Left in isolation, small populations experience reduced gene flow and inbreeding depression, which can impact
Jamaica’s bauxite ore bodies occur, mapping is judged by the industry to be critical for ensuring operational efficiency.

Before mining commences, surface vegetation is stripped away and the topsoil and remaining overburden are mechanically removed to expose the bauxite ore. The Mining Regulations, 1947 (last updated 2006) stipulate that “topsoil to a depth of not less than fifteen centimetres” must be removed and stacked aside for subsequent return to the pit after mining operations finish. Guidelines created by the National Restoration Committee (NRC) reproduction and survival. Reduced genetic diversity also lowers resilience to changing environmental conditions. Without vegetation corridors to connect isolated hills, recolonization is hindered following any localized extinction event. The functionality of an extinct species will be lost from each little patch of remnant forest.

In mining, the term overburden (also called waste or spoil) refers to all the material which lies on top of the ore component deemed to be economically valuable. Overburden, thus, can include terrestrial plant communities, decomposing leaf-litter/humus, topsoil (the upper-most layer of soil, usually the top 5–10 inches (13–15 cm), where organic matter and microorganisms are accumulated) and underlying soils, which are referred to as “subsoil” in order to distinguish them from “topsoil” (i.e., “subsoil” does not mean below the soil horizons; it is all soils below the topsoil layer). In the case of Jamaica, the subsoil will be divided into two categories: (1) bauxitic soils which are too ‘contaminated’ with organic matter to enable efficient processing into alumina (these are removed as overburden); and (2) ‘uncontaminated’ bauxitic soil which is mined as ‘bauxite.’ Owing to patterns of geologic weathering, visually demarcating the true depth of topsoil and the uppermost subsoil horizon of Jamaican bauxites is difficult; consequently, the likelihood of mechanical mixing of topsoil and subsoil during overburden removal is high (Harris and Omoregie, 2008). Younge and Moomaw (1960) coined the term “stripsoil”: while not pedagogically correct, it does, in fact, present an appropriate description.
recommend that stripping should not be less than 30 centimetres (12 in) (Appendix 2), but, of course legal enforcement will be to the regulations, not to guidelines. Once all overburden is removed, the ore is mechanically extracted down to the limestone substrate.

After all commercially-extractable bauxite is removed, the resulting steep-sided depressions are required under The Mining Regulations, 1947 to be reclaimed “in such a manner as to effect a smooth grading and prevent the creation of unsightly mound and dumps in the area.” (Section 53 (i)(c)(i)). Reclamation is done using backhoes to scrape-down the peripheral limestone hillside(s) to generate fill material for the void created by mining. This process not only creates steeper-sided depressions (Lyew-Ayee & Stewart, 1982) but also increases the surface area of the original ore body as it decreases the volume of the usually-forested limestone hillside (Figure 14; L. Nelson in NRC Meeting Minutes April 21, 2010). The percentage-change caused by excavation from its original in situ surface area and volume is defined

---

19 (a) By scraping down peripheral limestone hillside, rock rubble is produced to level the bottom of the pit. Because of the large spaces (conduits) between rocks and pebbles, rainfall at this stage would drain vertically and rapidly. Repeated movement of heavy equipment will compact the upper surface to a fine-grained marl. (b) Stockpiled overburden is returned, also by heavy mechanical equipment, to cover the contoured surface area. (c) Where slopes exceed 15°, contour barriers or terracing with rock is required. Note also in (c) that compaction of the substrate created an impenetrable barrier to the vertical drainage of rainfall, with a resultant visible “ponding” of water. (d) There are no explicit guidelines for the reclamation and rehabilitation of haul roads.

---

Figure 14: The Stages of Reclaiming the Void Created by Extractive Mining
as the “swell.” Under current Special Mining Leases (SMLs), the **surface area** reclaimed after mining increases on average by 60 percent. However, in nearly 30 percent of reported reclaimed pits, the swell was > 100 percent (i.e., at least twice the surface area of the pit had to be disturbed to reclaim it) (MGD certification data, 2020). Even though volumetric data are calculated prior to mining (see Figure 12) the swell factors associated with changes in **volume** of reclaimed pits have not been made available. For information on how the methodologies deployed during reclamation affect the swell factor, see Heit, 2011.

Reclaimed pits remain distinctly identifiable by the patterning of vertical faces which are created at this stage of mining (Figure 14 and Figure 15). While current reclamation guidelines specify that “vertical faces shall not exceed 3 metres (10 ft),” an exemption may be granted by the Commissioner of Mines “where there are specific challenges” (Appendix 2). Once the contours of the re-shaped pit are set, the stockpiled overburden, ostensibly described as ‘topsoil,’ is returned by heavy mechanized equipment, which results in a visibly compacted substrate (Morgan, 1974). Because of the increase in surface area from pre-mined to post-mined, the depth of soil will always be thinner than its original state unless another source stock is used. Critically, while the Regulations specify that prior to mining, topsoil “to a depth not less than fifteen centimetres” must be removed, the Regulations do not explicitly state depth requirements for soil reconstruction during rehabilitation. They state only that the holder of the mining lease shall “replace the topsoil which was removed.” (The Mining Regulations, S.53.–(1)(c)(ii), 1947).

While there are no published figures for natural rates of soil formation in Jamaica, it is thought unlikely to exceed 1 mm per annum (McGregor, 1995). Thus, if 30 centimetres of topsoil were removed and spread to a depth of only 15 centimetres because of the area “swell” during reclamation, it would take at least 150 years for the soil to return to its pre-mined depth if, indeed, pre-mined natural soil-generating processes resume. This predicted timespan also assumes that no excessive soil erosion occurs.

As per The Mining Regulations, 1947, “the holder of the mining lease shall restore every hectare of land disturbed for the mining in such area, as nearly as may be practicable, to the level of agricultural or pastoral productivity or of utilization for afforestation purposes or such other as may be approved by the Commissioner (of Mines)” or the Town and

---

20 See the white arrows. This enables rapid identification of mined-out ore bodies while viewing satellite imagery or during field inspections. Note also how haul roads gouge through and further fragment forest patches on limestone hills. The Google Earth image dates to 2001. The photograph, taken on 17 October 2006, shows that no regeneration of pioneering woody vegetation has occurred. Photographer location (yellow star): 18° 19’ 15.6” N, 77° 22’ 45.4” W.  

21 "Afforestation” appears to have always been interpreted to mean commercial plantations of Caribbean pine (*Pinus caribbaea*) or hardwoods for lumber production (Howard 1991) and not, as for example in Western Australia, where progressive rehabilitation is aimed to establishing ecologically-functional, self-sustaining forests of native species, (Bell, 2001; Norman et al., 2007).  

22 Under the Mining Act Regulations (1947), the Commissioner may waive requirements for reclamation and rehabilitation if it would “not be practicable as part of the operation of mining . . . be unreasonable or likely to raise costs out of proportion to the value of the ore body . . . or render uneconomical on otherwise economical mining operation” (Section 53 (2) (a–d).
Country Planning Authority” (Section 53 (i)). Since 2003, Napier (Elephant) Grass (*Pennisetum purpureum*) has been the primary post-mining treatment utilized (Lyew-Ayee, 2006; Drakapoulos, 2018). The land use is designated as “grass” or “pasture” and the primary objective is purportedly to prevent soil loss (https://jbi.org.jm/lands/reclamation-rehabilitation/).

Not only do The Mining Regulations fail to explicitly address rehabilitation of haul roads, they could be interpreted that roads are to remain un-reclaimed so as to “provide reasonable access to the area” (Section 53 (i) (e)). There are no indications that the chunks of forest-covered limestone hillside destroyed during haul road construction and pit reclamation have ever been accounted for under the “every hectare of land disturbed for mining” rehabilitation requirements. This is despite an agreed upon policy of “no net forest loss” with mining (C. Thompson *in* NRC Meeting Minutes, February 13, 2014; see Figure 13). Replacing the limestone substrate of the hillside is, of course, impossible, so that forest area is irreversibly reduced in size.

**Figure 15:** Vertical Scars on Hillsides from Mining and Reclamation
RESTORATION VS. REHABILITATION

**Restoration** is the return of an object to its original condition. Because surface mining physically removes a geo-structural and, therefore, functional component of any landscape, restoration, by definition, is impossible: surface mining irreversibly changes landform and functionality. The correct terms for what occurs post-mining are “reclamation” (physical reshaping of a mined-out pit) and “rehabilitation” (achieving a pre-defined condition).

HOW MUCH OF JAMAICA’S LANDFORM HAS BEEN IRREVERSIBLY CHANGED BY SURFACE MINING OF BAXITE?

Despite the critical requirement for mapping of bauxite ore bodies so as to validate company reporting\(^{23}\) and to ensure compliance with regulations, the MGD was unable to provide any geo-referenced spatial data under an ATI request for GIS ESRI shapefiles of the boundaries of all mined-out bauxite ore bodies for the period 13 October 1947 to 29 February 2020 (A. O’Gilvie for Commissioner of Mines, personal communication, March 30, 2020). This, despite the fact that the file extension *.shp (pronounced as a “shapefile” and which denotes a geospatial vector data format developed and regulated by ESRI, for use in any GIS software platform) appears on maps used for MGD rehabilitation “Certification Results” exercises at least as early as 2000 (Appendix 1).

A request sent via e-mail on June 8th, 2020 to JBI for these GIS data remains unanswered as at August 21st, 2020.

Until maps and/or GIS files of: (a) all bauxite ore bodies mined since 1947; and (b) all haul roads created to transport the ore for processing are made available to the public, it is impossible to calculate and/or independently verify claims presented by JBI as to how much of Jamaica’s land surface (and, therefore, karst functionality) has been impacted by mining.

In the absence of data, the default assumption should be that the entire area of all SMLs (or comparable documents which granted permission to mine) issued since 1947 (i.e., >17 percent of Jamaica’s land surface) has been/will be impacted and degraded (Figure 16\(^{24}\)).

---

\(^{23}\) For example, Noranda Jamaica Bauxite Partners reported that, up to July 2015, 1,601 ore bodies had been certified as rehabilitated and that between September and October 2015, field surveys were made on 1,552 of these areas, which covered a total of 2,749 hectares (L. Allen in NRC Meeting Minutes, March 15, 2016). However, records of rehabilitation certificates provided by MGD show that only 1,441 certificates were signed by the Commissioner from October 1974 (the oldest record in the “Noranda” data file) through December 2015. Thus, before even attempting to validate the area claimed to have been rehabilitated, discrepancies between the number of certificates purportedly issued need to be resolved.

\(^{24}\) Despite repeated requests, MGD was unable to provide any maps or licenses of areas which were mined prior to these current SMLs. Thus, the full spatial extent of historic and active mining remains uncalculated in this current assessment. It is however notable that areas which are known from the literature to have been mined (e.g. Sir Alfred DaCosta’s Lydford property, Nine Mile where Bob Marley was born and laid to rest), and Maggotty, where the derelict Revere facility is located, could be subjected to another round of mining.
DEGRADATION OF ECOLOGICAL HERITAGE: THE IMPACT OF BAUXITE MINING ON KARST ECOSYSTEMS IN JAMAICA

Additionally, without any maps or electronic files, the public (or, indeed, the National Environment and Planning Agency (NEPA), the environmental regulator in Jamaica) cannot independently verify what percentage of “every hectare disturbed by mining” has been rehabilitated in accordance with The Mining Regulations, 1947. As presented by Drakopoulos (2018), at a minimum, nearly ¼ of mined-out ore bodies have not been reclaimed, much less rehabilitated, since bauxite mining began in Jamaica (Figure 17). Without maps, it is impossible to know the landscape-level spatial configuration of un-reclaimed mined-out ore bodies (not to mention haulage roads), to quantify the effects of permanent isolation of forest fragments on hillsides.

It is notable that in October 2009, a National Restoration Committee (NRC) comprising representatives from the GOJ, industry, and academic institutions (see Appendix 3, including attendance records by entity), chaired by the Commissioner of Mines, was created with the recognition “that over time, there have been variations in the levels of compliance” with Mining Regulations and Guidelines. It appears to have taken more than 70 years since the Mining Act and Mining Regulations were created for the GOJ to take compliance seriously,

---

25 In an e-mail dated 24 June 2020, Mr Anthony McKenzie, Director, Environmental Management and Conservation, NEPA, confirmed that the Agency does not have any GIS polygons of mined-out ore bodies.

26 (A) Post Reclamation Land Use, as presented by Drakopoulos (2018), for mined-out ore bodies. Transport haul roads, which cause extensive physical alteration to the landscape, are not included in the calculations for this figure. Although MGD provided data on the rehabilitation status and land use certification of mined-out ore bodies, it wasn’t possible to independently replicate this figure because there were mixed-used categories which could not be teased apart and assigned to a single category on Drakopoulos’s list. For example, for a single ore body, how would a certified land use of “Pasture, Natural Vegetation, Road,” “Resettlement (orchard)” or “Pasture & Playfield” be tallied? (B) However, from MGD’s data set, the “No data (before 1998 or not yet certified)” category could be separated as “pit reclamation or rehabilitation in progress” and “no data recorded (i.e., not reclaimed).” As presented by Drakopoulos, 90 percent of the “no data” is, indeed, “no data” and only 10 percent is “work in progress.” That is, there are substantial gaps in MGD’s certification database which: (a) preclude quantifying the true quality of rehabilitation efforts by the industry; and (b) hint at the considerable extent of unreclaimed pits mined from 1947 to 1991 (i.e. prior to currently-active SMLs).
while allowing the industry to drive the guidelines by which rehabilitated pits would be certified (Appendix 2). Unfortunately, as will be discussed below, the NRC failed to address fundamental problems associated with the return of only six inches (15 centimetres) of soil – problems which certainly have been known since experimental field trials by ALCAN Jamaica, Ltd. in the late 1960s/early 1970s (Morgan, 1974) and recognized by farmers who attempt to grow agricultural produce on reclaimed pits (Coke et al., 1987; see also Howard, 1991).

Although the importance of reforesting mined-out lands was outlined in the first meeting of the NRC on 21 October 2009, and repeated discussions (or, lack thereof when Forestry Department representatives did not attend27) were had on an action item for the Designation of Areas to be Reforested, the NRC has yet to present a comprehensive list of trees suitable for reforestation nor has it designated areas to be reforested.

Although in theory the NRC is considered to still exist, it has not met since 30 June 2016. Therefore, the Forestry Department’s policy to “strengthen the capacity of the National Restoration Committee to address requirements for restoration (sic) into forest cover” and to have Forest Reserves and specially-identified Forest Management areas declared as “no go areas” for the purpose of mining (Forestry Department 2016, pg. 41) has yet to be communicated during a meeting of the NRC.

**SURFACE MINING: CHANGES IN FUNCTION**

**Soil Moisture (aka How Plants Grow)**

During exploration and mining, company representatives describe a major nuisance of bauxite ore as follows:

27 From the minutes of the NRC’s last meeting on 30 June 2016: “Contact is to be made with Ms. Headley to ensure that a representative of the Forestry Department attends the meeting.”
The physical characteristics of Jamaican bauxite create many problems for conventional drilling equipment. In one place the consistency may be tantalizingly soft yet deeper down or a few hundred feet laterally it may behave as though it were a leather hardpan. In situ bauxite is rarely dry enough to be drilled with an auger type bit without the freshly cut material clogging the lowest flights . . . after only an inch or two. (Lee, 1971).

The ore while damp to the touch (19–24% mechanically held water) becomes extremely sticky and slippery under rainy conditions . . . It is not unusual to have wet ore built up in buckets of the excavators requiring frequent stoppages for cleaning (Roberts, 1971).

This “nuisance” water-holding capacity results from the particle size, particle shape, and particle density of the bauxite. The size of the void (i.e., the pore) between the solid grains determines how easily a liquid such as water can move through the pores, either downwards by gravity or upwards via capillary action or, indeed, be held in-place by the laws of physics (Box 3).

**BOX 3. WATER MOVEMENT IN TROPICAL BAXITE SOILS: DOWNWARDS DURING THE RAINY SEASON AND UPWARDS DURING THE DRY SEASON**

Perhaps the singularly most important structural characteristic of bauxite with regards to the survival and growth of trees is the extremely fine, yet variable sizes of particles. Grains vary from less than 1 micron (i.e. one thousandth of a millimetre) to 40 microns (Stahl, 1971; Madourie, 2013). How the grains align determines the space between them (porosity); that space, in turn, determines not only how much air or water can occur within the soil (porosity volume) but also the ease with which water can move through the pore spaces (hydraulic conductivity).

**Transmission Pores:**
- When pore size exceeds > 75 microns, water drains freely downwards by the force of gravity – water is not stored. Such macro-pores will be created when, for example, tiny fragments of limestone get mixed-in with bauxitic soils.

**Storage Pores:**
- Meso-pores (30–75 microns) have the ability to store water; if a tree root reaches into a mesopore, the root can draw up the water via capillary action, but a water molecule, itself, cannot overcome the force of gravity “keeping it down”.
- Micro-pores (5–30 microns; e.g. the porosity of “coarse” bauxite): at this size, not only do adhesion forces between the water molecules and the grains of bauxite particles hold the water in place, but also the downward force of gravity is overcome by capillary (upwards) action – the same “wicking” process that enables a paper towel to absorb water from a countertop.
- Ultramicro-pores (0.1–30 microns; e.g. “fine” bauxite): these pores not only are large enough to hold molecules of water, but the voluminous space is also inhabited by microbial bacteria and fungi which can keep the pore open.

Box 3 continued
Residual Pores:

- Crypto-pores (< 0.1 microns): these pores are too small for most microorganisms but they can still hold water.

During the rainy season, precipitation intercepted by plants balances the water losses they experience during photosynthesis and transpiration (or what humans and other biodiversity value: the production of oxygen and sequestering of carbon dioxide). During a dry season, moisture held deep in bauxite is accessible via a network of deep, fine roots and/or is moved upwards towards shallower roots via capillary action; this enables year-round forest growth (Grant & Koch 2007, Davidson et al., 2011). Without capillary water, roots cannot survive drought.

Foresters and botanists have long-recognized how this “nuisance” water-holding capacity drives the topographic variation seen in the species composition and physical structure of Jamaica’s karst limestone forests (Swabey, 1939; Asprey & Robbins 1953; Howard & Proctor 1957; Kelly et al., 1988). This topographic pattern, indeed, is a hallmark feature of tropical karst forests around the world (e.g. Furley & Newey, 1979; Crowther, 1982; Wendt, 1993; Brewer et al., 2003; Guo et al, 2017; see also Box 2), notably that:

- the largest trees (by circumference and by height) are found in bottomland depressions and valleys, where deep clays (i.e., ‘bauxite’ if it were mined) and organically derived soils accumulate;
• trees become smaller in stature as one ascends the slope to the hilltop/ridgeline; and  
• species composition varies topographically, with those species functionally-adapted (e.g. thicker, waxier leaves; smaller compound leaves for minimizing moisture loss during transpiration) for the drier conditions found on slopes and hilltops; adaptations are in response to thin-to-absent soils, the high porosity of limestone, and exposure to desiccating winds.

Experimental studies in the Brazilian Amazon reveal just how important the ability to extract water held in deep soils is for the survival and growth of trees in tropical rainforest ecosystems which experience seasonal rainfall28. During the rainy season, water loss experienced by a plant undergoing the processes of photosynthesis and transpiration are balanced by intercepted rainfall. During the dry season, these functional losses are countered by uptake of soil moisture. Through a deep network of fine roots, tropical trees can extract water to depths of at least 11–18 meters (Nepstad et al., 1994; Nepstad et al., 2007; Brando et al., 2008; Davidson et al., 2011). In other research in French Guiana, where the technique of isotopic labeling29 of oxygen and deuterium in water was deployed, Stahl et al. (2013) discovered that during the dry season, trees were extracting water from at least a depth of 1.2 meters30 (which was the maximum depth of their experimental injection point, for subsequent uptake assessment). Most importantly, it was confirmed that trees were able to maintain their baseline functional processes, such that transpiration losses were fully balanced by deep-soil water gains during periods of drought (Wagner et al., 2012).

Similarly, in Australia, it has been extensively documented that deep friable (crumbly) bauxitic soils provide a year-round water supply for jarrah (eucalyptus) forest growth, even during annual five- to six-month drought cycles (Grant & Koch, 2007). Indeed, as part of the long-term research of jarrah forest in mined-out, rehabilitated areas, it has been shown that trees are largely reliant on water stored in soil and not on their roots penetrating to the underlying water table (McFarlane et al., 2018).

As a further note on root architecture, typically up to 90 percent of root biomass is found in the upper one meter of top- and subsoil; most nutrient cycling of organic material occurs in the top 10–15 centimetres. Thus, even though deep root biomass represents only a small part of total root biomass, deep roots (which may be barely visible to the naked eye) repre-

---

28 It is erroneous to assume that tropical rainforests are continuously wet. As in Jamaica, tropical forests experience seasonal patterns of rainfall, with distinct wet and dry seasons (Naughton, 1982). Thus, it is the pattern of rainfall which drives ecological processes: a rain event during a dry season functions differently from a rain event during the wet season.

29 Isotopic labelling is a technique used to track the passage of an isotope (the occurrence within a single chemical element whereby two or more forms occur; each form has the same number of protons but different numbers of neutrons in their nuclei) through myriad types of pathways, such as the flow of underground water in a karst aquifer (e.g., Ellins 1992) or tracing of groundwater contamination around alumina processing factories (WRA, 2006).

30 Stahl et al., 2013 also accounted for predawn leaf water potential where, as temperature drops, atmospheric dew condenses on leaves and drips to the ground. As an example, in Jamaica’s Cockpit Country, it has been estimated that forested cockpit bottomlands receive as much as 14 percent more water than surrounding hilltops as a result of this process (Aub, 1969).
sent a “keystone”\textsuperscript{31} function, whereby they contribute significantly more to the growth and survival of a tree than one would predict based on biomass alone.

**How much has the removal of bauxite altered the capacity of Jamaica’s karstscapes to produce forests of the stature which inspired the Taino to call the island Xaymaca – The Land of Wood and Water?**

Other than studies of nutrient cycles which examined the upper 10–15 centimetres of topsoil (e.g. Tanner et al., 1998; McDonald & Healy, 2000) and although Jamaica’s Forestry Department collects measurements of “Effective Soil Depth” during Biophysical Inventories (Tecsult International, 2000), no published information was found on the deep root architecture of Jamaican trees. In the absence of local data, one must assume that the roots of Jamaican trees on karst limestone function as tree roots do on karst in Central and South America (especially those species whose distributional range encompasses Jamaica and the mainland) with regards to their ability to extract deeply-held soil moisture.

The elimination of the structural/functional component of bauxite ore, which had the capacity to hold 19–25 percent water, consequently, means that:

- Jamaican forests will never again achieve their pre-Columbian stature wherever mining has occurred, regardless of whether the pit was reclaimed and rehabilitated\textsuperscript{32};
- even if post-mining rehabilitation to functioning forests of native tree species were to become an objective (it is not under current guidelines [Appendix 2]) the best that could be achieved is the smaller-stature forests of peripheral limestone hills\textsuperscript{33};
- with smaller trees, the capacity to capture and sequester carbon, both above-ground and below-ground in roots and in the soils, is forever reduced on Jamaica; and
- until maps and/or GIS polygons of mined-out ore bodies are made available, the full spatial extent of how much capacity for carbon sequestration has been lost due to mining cannot be determined.\textsuperscript{34}

\textsuperscript{31} The concept of a keystone species was created in that late 1960s by the zoologist Robert Paine. He used the term to describe a species which has a disproportionately large effect on its environment relative to its abundance.

\textsuperscript{32} Theoretically, an irrigation system could be engineered to water a forest during dry seasons. The practicality and cost of maintaining something like this forever, for one, let alone every mined-out ore body, is almost inconceivable. Further, such a solution would not mitigate the fact that deeply-rooted trees are better at withstanding hurricane-force winds (Uriarte, et al., 2019), so in the absence of the deep, anchoring bauxite ore, trees will still be more likely to topple during hurricanes regardless of how large they grow from irrigation-watering. Thus, these two ecological functions of the deep bauxite ore – hydrodynamics and root anchoring – must be recognized as non-substitutable ecosystem services.

\textsuperscript{33} Rehabilitating forest on limestone would have equivalencies to rehabilitating vegetation on a limestone quarry. Thus far, Jamaica only demonstrates the ability to establish an invasive alien tree species of Calliandra on quarry sites (Lewis et al., 2017; see also multiple NRC Meeting Minutes referring to a quarry in Flankers, St James; it should also be noted that the United Nations Development Programme (UNDP) expressed concerns about the use of an invasive species in what was a UNDP-funded project (NRC Meeting Minutes, 18 November 2010); a monoculture isn’t remotely comparable to the species diversity and community structure found on limestone hillside with native forest (Harris & Proctor 1957; Kelly et al., 1988).

\textsuperscript{34} Although mining is repeatedly identified as a significant source of deforestation in Jamaica (e.g. in State of the
Soil Neglect in Post-Mining Reclamation in Jamaica

_The earthworms are seen on the road instead of in the soil._

—DR VINCENT WRIGHT, Northern Caribbean University, Mandeville in NRC Meeting Minutes, 3 March 2011

Regardless of whether attempting rehabilitation of native forest (L. Nelson _in_ NRC Meeting Minutes, 15 October 2015), the production of biofuels (L. Simpson _in_ NRC Meeting Minutes, 13 February 2014) or for commercial forestry of hardwoods and agricultural fruit trees (Howard, 1991), where trees have been planted on reclaimed bauxite lands in Jamaica, a pattern is reported:

- If planting is not timed to the rainy season or irrigation is not provided, seedlings die.
- When water is provided, seedling survival improves but growth is stunted.

The source of the problem is repeatedly identified as one of post-mined soils being too shallow for trees (Coke et al., 1987). This comes as no surprise given that even the production of yam (_Dioscorea_ spp.) and sweet potato (_Ipomoea batatas_) requires a minimum of 30 centimetres of reclaimed soil (with application of fertilizer); maize (_Zea mays_; also requiring fertilizer) requires at least 60 centimetres of reclaimed soil to avoid problems with blight; and only grass (e.g. Surinam grass [ _Brachiaria decumbens_ ]) will establish on 15 centimetres of reconstructed soil (Morgan, 1974). Interviews with farmers support Morgan’s experimental results that 15 centimetres of reconstructed soil can produce grass to maintain a few tethered cows, but root crops, legumes and cash crops require soil greater than 30 centimetres in depth (Stirling 1999; see also Berkaak 1983).

Since there can be no assurance that the reclaimed land will be used for growing grass in perpetuity, spreading soil to a depth of 30 centimetres, which may produce acceptable yields for other crops, is recommended.


Here it cannot be emphasized enough: Morgan (1974) stated that 60 centimetres would be functionally better, but the recommendation for 30 centimetres was made in consideration of the costs of reclamation and possible loss of processable bauxite. Morgan did not include fruit trees in his experiments.

Given that the majority of nutrient recycling occurs in the upper 15 centimetres of topsoil, one must ask why the obsessive focus on quantity under The Mining Regulations has proved...

---

35 There is a Catch-22 in that, if timed to the rainy season, movement/erosion will occur if the soils are not stabilized. This is why comprehensive planning for soil management is critical in post-mining rehabilitation (World Aluminum, 2018).
so inadequate for rehabilitating “to the level of agricultural or pastoral productivity . . . or afforestation” after mining? The answer tracks not only to the inadequate depth of soil which is returned but also to the quality of the material stockpiled and returned during reclamation. Added to this is the fact that reconstructed material is returned to a compacted limestone substrate rather than to a 19–25 percent moisture-holding bauxite foundation.

The process of mechanically removing topsoil invariably results in the inclusion of subsoil and other components of overburden, so that when the stored topsoil is eventually returned to a reclaimed pit, it is mixed with larger fragments of limestone pebbles and rocks (Harris & Omorogie, 2008). The consequence is a reconstructed material which is physically bulkier, has larger pore-spaces and, therefore, is unable to retain water as well as un-mined topsoil (Greenberg and Wilding, 2007). Even after 20 years, the topsoil of pits rehabilitated with African star grass (*Cynodon plectostachyus*) and patches of Guinea grass (*Megathyrsus maximum*) remained so morphologically and functionally distinguishable from un-mined soils (see also Doolittle, 1994) that Greenberg & Wilding (2007) proposed a new symbol for soil classification in Jamaica which denoted “Human Transported Material.” This parallels a descriptor of “stripsoil” from the 1950s and 60s (Younge & Moomaw, 1960). Not much has changed in 70 years.

The problem of reduced water-holding capacity in post-mined, reconstructed soils is not unique to Jamaica. Indeed, even native drought-adapted species in Australia display signs of water-stress when planted on reclaimed bauxite lands (Bateman et al., 2016; see also Lad & Samant, 2015).

Beyond changes to water-holding capacity, soil degrades while stockpiled owing to changes to/losses of organic inputs from plants, soil microorganisms, and soil fauna (Macdonald et al., 2015). In a project funded by Jamalco/ALCOA Inc. to assess microbial communities, soil function, and soil fertility in reclaimed pits with a chrono-sequence of: (a) within-year rehabilitation (2007), (b) 10 years post-rehabilitation (1997), and (c) 20 years post rehabilitation (1987), levels of carbon and nitrogen as well as diversity and abundance of bacteria – all indicators of soil quality – were reduced compared to un-mined soils (Lewis et al., 2010, 201236). Critically, the authors found that these differences persisted at the 10-year and 20-year post-rehabilitated sites. Indeed, the oldest site was the least improved of all sites examined. They particularly noted the absence of nutrient-rich plant material (i.e., an indicator of low plant productivity) for the depauperate37 soil microbial communities and the dominance

---

36 This ALCOA/Jamalco-funded research was conducted in the Mocho Area of SML-130. The authors presented spatially explicit maps showing the polygon boundaries of mined-out/rehabilitated ore bodies and the unique alpha-numeric ID coding for each ore deposit. This ID coding and year of certification were cross validated in a certification dataset provided by MGD in July 2020. Thus, GIS data are confirmed to exist dating back to 1987 (the oldest site sampled) and should be made available for public review.

37 Depauperate means lacking in numbers or diversity. There are different measures to compare the diversity in natural ecosystems, including soil-dwelling organisms. *Species richness* counts the number of different species, *species evenness* counts the number of individuals within each species to determine whether all species are equally abundant or if a few species dominate while others are rare; and *taxonomic diversity* measures how closely-related species are to each other.
of bacterial rather than fungal biomass, an indicator that vegetative successional processes were not occurring (Harris, 2009).

In the absence of demonstrating an ability to rehabilitate soils to a level of pre-mined microbial quality, how much rehabilitated land truly has met the requirements of The Mining Regulations, 1947 to “restore . . . to the level of agricultural or pastoral productivity”? (Section 54. (i))

In light of the fact that not only a minimum of 30 centimetres, and preferably 60 centimetres of reclaimed topsoil is needed for agricultural productivity (not including fruit trees) (Morgan, 1974), but also that soil health remains degraded even after 20 years post-reclamation (Lewis et al., 2010, 2012), it is no surprise that rehabilitation efforts in Jamaica have shifted to constructing greenhouses in reclaimed pits (NRC Meeting Minutes, 2010–16). Any efforts to re-establish processes for soil development and soil fertility have mostly been jetisoned (if they ever existed). Given that strong winds damage greenhouses (F. Ross in NRC Meeting Minutes, March 15, 2016), it is questionable whether greenhouses are sustainable in a hurricane zone such as Jamaica.

Beyond questions of sustainability, additional environmental problems arise from greenhouses in that, because plants are protected from direct rainfall, external water storage is required for irrigation. The industry has adopted the method of creating artificial ponds by placing impermeable liners at the bottoms of reclaimed pits (NRC Meeting Minutes, 12 June 2014). However, this also creates the conditions for ponds to become breeding reservoirs for disease-transmitting mosquitoes and invasive alien cane toads (*Rhinella marina*), a species which has strong neuro- and cardio-toxins which are lethal when ingested by small vertebrates (e.g. dogs, endemic Jamaican Boas (Wilson et al, 2010)) and also can prove fatal to humans (Gowda et al., 2003). Cane toads, which were introduced into Jamaica in 1844 to control another introduced invasive species (rats), ranks in the top 10 of the world’s 100 most invasive species (Invasive Species Specialist Group of the IUCN: http://www.iucngisd.org/gisd/species.php?sc=113). Endorsing any mining-related actions which facilitate its spread is in direct contravention to Jamaica’s responsibilities to the 1992 Convention on Biological Diversity (which entered into force in Jamaica on 6 April 1995) (see Crowther, et al., 2020).

The accepted practice of using Napier grass during rehabilitation efforts in Jamaica makes salient the poor water-holding capacity of the reclaimed, reconstructed soils. Tolerant of drought conditions and able to grow on marginal, well-drained soils, the species has been “found to be useful in the bauxite and mining sector” (A. McKenzie, personal communication, June 12, 2020). Its primary function is purportedly to stabilize the movement of reclaimed topsoil (https://jbi.org.jm/lands/reclamation-rehabilitation/), but no published data could be found to verify this claim for Jamaican mining.

Any classification of Napier grass as “pasture” (e.g. see Drakapoulos, 2018) is incorrect and misleading. While young growth (e.g. 60–100 centimetres, age ~ 6–10 weeks) can be harvested and fed to cattle as fodder, mature plant growth is nutritionally inadequate for maintaining animals (Muia, 2000). Functionally, Napier is not a grass for pasture-grazing
livestock. As such, Napier grass does not represent compliance under The Mining Regulations, 1947 for “pastoral productivity.”

While it has been suggested that Napier grass is a “pioneer species” (A. McKenzie [NEPA], personal communication, 12 June 2020) and, therefore, useful in establishing processes of natural regeneration of forest, it is, in fact, globally-recognized as an invasive species. This is due to its ability to restrict colonization by other species and the difficulties in eradicating it once established. In Jamaica, NEPA (2014) designates Napier grass as a “Category 2 – Highly Invasive” species.

NEPA’s designation of Napier grass as an invasive alien species, one which prevents colonization by other species, is correct:

> Pasture was the most common land use for certification, the most common observed land use and evidently the one that is least subject to change.

—Mr Locksley Allen, Noranda Jamaica Bauxite Partners reporting on field surveys of the 1,552 ore bodies certified as “restored” up to July 2015 in NRC Meeting Minutes, 15 March 2016.

Promoting the usage of invasive alien plants, with no succession planning to ensure there will be turnover to native species, is counter to Jamaica’s responsibilities to the international Convention on Biological Diversity and directly contradicts the goals of the country’s National Strategy and Action Plan on Biological Diversity (ESL/NEPA, 2016). Further, in the most-recent State of the Environment Report 2013-Jamaica, NEPA included mention of non-native trees and grasses in its delineation of bauxite mining as one of the five main threats to Jamaica’s forests and watersheds (NEPA, 2015, see pp. 63–64).

How much of Jamaica’s land has been consigned, potentially in perpetuity, to a land use of marginal or deleterious grass, and with remnant patches of hillside forest left isolated by an absence of forest corridors?

Until maps and GIS files become available, and with every mined-out ore body identified by its uniquely assigned alpha-numeric coding, it is impossible to answer this question. Additionally, assessments of whether natural forest regeneration is occurring in any Napier-planted areas cannot be undertaken without the mapped locations of rehabilitated pits (see also commentary associated with Figure 11e, of ongoing problems with land cover classifications of satellite imagery which is used for remote monitoring).

How this near-total absence of any effort to rehabilitate ecological processes, or to bring back any kind of functional forest, has affected native and endemic species remains incalculable (Box 4).

38 https://www.cabi.org/isc/datasheet/39771
39 Plants listed as Category 2 are identified as aggressive invaders that displace native species and/or persist in dense populations for long periods, disrupting habitats. They are considered a high priority for control efforts.
The general climatic pattern of Jamaica is that of a tropical island in the trade wind belt, with oceanic moisture arriving via the Northeast trades and trough-cycles. Rainfall patterns, themselves, are closely tied to the island’s topography: as mountainous regions force warm moist air to rise, air temperature decreases, and the moisture condenses as clouds and rain. The windward side of the Blue Mountains at Millbank can receive more than 550 centimetres of rain per year while areas in a leeward rain shadow, such as Kingston, receive less than 90 centimetres.

The amount of rainfall and its seasonal patterns, in turn, defines the type of vegetation land cover — from montane elfin cloud forest to wet evergreen (i.e., leaves are retained year-round) to seasonally deciduous (i.e., leaves are shed during the dry season). The vegetation, in turn, plays an active role in the water cycle, both when rain intercepted by leaves subsequently evaporates in the sunshine and when leaves exhale moisture through the photosynthetic process of transpiration. Moisture from tree crowns returns to the atmosphere while moisture from understory vegetation remains trapped below the canopy, keeping the understory air moist and cool.

With high humidity in the understory, plant and animal life evolve to survive and thrive in air which can have a relative humidity saturation exceeding 80 percent for most of the day and night. The downside, however, is that desiccation and death will occur for highly-adapted species when the humid microclimate becomes drier due to changes in forest structure, deforestation, or increased exposure to wind — all factors which occur in a mined- and post-mined landscape.

One of Jamaica’s most iconic national symbols, the Jamaican Giant (Homerus) Swallowtail, is an indicator of the life-sustaining water cycle of native forests. Requiring 100 percent relative humidity for all stages of its life cycle, this magnificent butterfly — the largest in the Western Hemisphere and second-largest in the world — historically ranged across the island’s elevated central plateau in areas of highest rainfall, from western Cockpit Country to Mount Diablo, as well as in the eastern Blue Mountains.

While historic conversion of forest to agriculture would have reduced the quality of the butterfly’s habitat around Mount Diablo, sightings of giant swallowtails were still reported in the 1950s. Since bauxite mining commenced in 1952 at Lydford, there have been no reports of giant swallowtails for Mount Diablo. Whether habitat degradation had already consigned the butterfly to localized extinction will never be known. But if the severe forest fragmentation and associated microclimate desiccation which occur along all the edges of reclaimed pits continue unabated, giant swallowtails can never be returned to their historic range.

Box 4 continued

---

40 It has been speculated that more than one species of very large swallowtails occurred in Jamaica and that the Jamaican Giant (Homerus) Swallowtail is the last of several giant swallowtails. Thus, the Mount Diablo butterflies may have been endemic not only to Jamaica, but unique to Mount Diablo.
BOX 4. RAINFALL, MICROCLIMATE & EXTINCTION: A WARNING FOR THE FUTURE? (cont’d)

SOIL MANAGEMENT PLANNING

Because soil serves as the foundation for terrestrial ecosystems – whether agrarian or forest – a soil management plan is a critical element in reclaiming surface-mined lands (Sheoran et al., 2010; World Aluminum, 2018). Unfortunately for Jamaica, efforts can barely even be described as salvage much less the reconstruction of a suitable rooting zone (Macdonald et al., 2015). At an absolute minimum, rehabilitation needs to be directed towards ensuring that the processes which:

- enable soil development;
- create the conditions for vegetation establishment;
- ensure vegetative survival and growth during natural drought cycles; and
- are functioning before any mined-out ore body is certified as rehabilitated to the status comparable of an un-mined area.

This likely will require reconstructing deep overburden soil profiles which can store rainfall throughout the whole year (Grant & Koch 2007). In fact, this would almost certainly require that an ore body is not mined-out to the underlying limestone, as is currently practised.

The Microbe Project funded by Jamalco/ALCOA (Lewis et al., 2010, 2012) identified appropriate performance indicators for determining whether a rehabilitation effort is establishing the processes for development of soils. These include:

- moisture-retaining characteristics during wet seasons and dry seasons;
- chemical composition, especially carbon as an indicator of organic inputs;
- diversity and abundance of microbiota (bacteria and fungi); and
- microbial biomass carbon (e.g. carbohydrates, amino acids; indicating how microbes are utilizing the soil substrate).

Progressive rehabilitation (World Aluminum, 2018) will lead to further indicators of improved soil fertility, including:

- Bacteria-Fungi ratios, where increasing fungi indicate soil matrix stability and vegetation succession.
- Diversity and abundance of soil–dwelling fauna (e.g, earthworms that stay in the soil, not on the road).
- Recruitment of native plant species where agricultural usage is not the required end use.

Re-establishing moisture-holding capacity of the subsoil is critical, **both for sustainable productivity of agriculture** as well as for **any tree-based end use**. With climate change models predicting longer drought cycles in the Caribbean, the moisture-holding function of bauxite-left-in-the-ground assumes an even greater value for farming communities going into the future.
To achieve environmentally sustainable, healthy soils, Jamaica must shift from its obsession with the inadequate quantity metric of 15 centimetres to one of quality if it ever hopes to improve the “reclamation of devastated areas” (Morgan, 1947) in Jamaica. As it stands, current and future generations are now irreversibly denied the opportunity to rehabilitate the structurally-grand forests of pre-Columbian Jamaica and are being locked into a soil substrate which will only support pasture grasses and no other agricultural production (especially no fruit trees or ground provisions such as yam) without significant new interventions.

OTHER INCALCULABLE EFFECTS ON THE KARST WATER CYCLE

As previously highlighted, the inclusion of small fragments of limestone in reconstructed topsoil results in a decreased capacity to hold water: when pore sizes in the soil matrix exceed 75 microns, water (either from irrigation or rainfall) will drain rapidly downwards to reach the next horizon. Where mining has not occurred, that horizon would be bauxite of up to 40–45 m deep and with pore spaces < 2 microns (Stahl, 1971; Madourie, 2013). Functionally, downward water movement through bauxite remains diffuse and is slowed by the structuring of the solid particles (Box 3). Exactly how slowly is not understood for Jamaican bauxite deposits. As far as is known, only one field study has been made to trace the movement of rainfall through the above-ground limestone hillsides and bauxite-filled doline and cockpit karst depressions in North-central Jamaica (Day, 1976, 1979). During six monitored rainfall periods of 21 karst depressions, in no case was it possible for the investigator to detect dye-traced water after it penetrated the surface of the bauxitic material. Owing to the complexity of karst hydrodynamics, rainfall inputs for each depression would need to be measured at the surface for comparison to discharge rates of any given aquifer.

Water percolating through the bauxite eventually reaches the next horizon, the underlying limestone, with its myriad fissures, cracks, and conduits. If there is any slope associated with the underlying geology, horizontal movement of water can be exceptionally rapid through the subterranean network of conduits and caves (see Box 2). In this component of the karst, considerable research effort in Jamaica has revealed that water can move up to three kilometres per day, covering a straight-line-of-sight distance of more than 20 kilometres from where a tracer is placed into the flowing aquifer to a surface discharge point (i.e. the actual

---

41 Readers are reminded that the regulations state that not less than 15 cm of topsoil must be removed prior to mining but the depth of soil returned post-reclamation is not specified.
42 By comparison, the diameter of human hair ranges from 17-181 microns.
43 A doline is a simple closed depression having a shape like a dish, funnel, or caldron. Surface drainage occurs internally in the depression via a sinkhole shaft so that the terms doline and sinkhole often are used interchangeably. Dolines can range in diameter from a few to many hundreds of meters.
44 Cockpit karst is a topographic landform where enclosed depressions form in association with steep-sided conical hills. The depressions appear irregularly-star-shaped, but akin to an upside-down egg carton.
45 Land cover adds further complexity to mediating the amount of rainwater which reaches the surface. Even tree cover is not a homogenous variable, as canopy formation, leaf size and shape, and bark textures influence water interception and retention pattern; in tropical forests, the addition of tank bromeliads creates even further complexity to the water storage cycle.
46 An aquifer is a body of permeable rock that can contain or transmit groundwater. See Taylor and Greene, 2008 for extensive references for the complexity of karst aquifers.
twists and turns of the subterranean route remain unknown; Brown & Ford 1973; Smart & Smith, 1976; Ellins, 1992; Fincham, 1997; WRA, 2018; Figure 18\(^\text{47}\) and Figure 19\(^\text{48}\)

---

\(\text{47} \) Tracers were placed in flowing water in caves, sinkholes, or above-ground rivers and eventually detected at surface river risings. Flow direction indicates connectivity: the actual flow routes (which will vary seasonally) remain unknown.

\(\text{48} \) Underground hydrology is guided by the formation of conduits through the limestone substrate. Thus, one proxy for hydrology is the distribution pattern of caves (Holness, 2017). How conduits form, in turn, is influenced by paleo-geology, as evidenced by the differences of cave formation amongst cockpit karst (e.g. SML-172, SML-173), degraded cockpit karst (SML-165), and doline karst (SML-162). Base map from Miller (2004), based on Sweeting (1958).
Where mining has occurred and the buffering function of thick bauxite deposits has been eliminated from the karstscapes, rainfall will always enter the subterranean limestone conduits more rapidly compared to un-mined areas. The consequence will be a flash movement of a “packet” of water through the aquifer (i.e., a high-energy pulse event) rather than a steadier, lower-energy discharge rate that will flow for a longer period of time when it stops raining. The total volume of water discharged may be identical in an un-mined vs. mined karstscapes: the difference is how long that volume remains available for usage by all communities – natural and human – both locally where the rain fell and at the wider scale of the watershed.

How much has bauxite mining irreversibly altered the water cycle and its dynamics in Jamaican karst?

In order to estimate the localized and cumulative impacts of bauxite mining, a model would require spatially explicit (i.e., GIS operable) information on:

a) location, depth, and volume of every bauxite deposit extracted from the landscape;
b) the in-situ moisture gradient (vertically and horizontally; see Box 3) of every ore body prior to mining;
c) the network of existing haul roads, which even if only surfaced with marl and not tarmac, present a compacted, less permeable substrate compared to undisturbed limestone;
d) the land cover prior to mining;
e) daily rainfall data; and
f) daily surface river discharge rates.

Without these data, the full localized and cumulative impacts of bauxite mining on Jamaica’s water resources cannot be calculated. Any claims that no short-term impacts and long-term effects have occurred must be supported with all of these data layers.

But we do environmental monitoring of water quality, as well as air quality . . . besides, what does air quality (dust) have to do with Jamaica’s karst water cycle? JBI, WRA, & NEPA.

Although the absence of surface water is one of the defining characteristics of karstscapes (Zans, 1951; Sweeting, 1958; White, 1988; US Army Corps of Engineer, 2001, and more too numerous to list), a fundamental failure to appreciate how intercepted rainfall is stored in catchments – both in nature and by humans – has led to a complete failure to identify, much less monitor correctly, the impacts of mining-derived dust. While some dust is generated during the excavation and loading of trucks, anywhere from 78–97 percent of dust is generated along unpaved haulage roads (Reed & Organiscak, 2007; Figure 2049). Depending on

49 More than 75 percent of dust generated during mining and transport to factories occurs along unpaved haulage roads. These roads not only are used by bauxite trucks but by private vehicles and commuters to larger urban centres (i.e. communities not only are exposed to dust during travel but their travel also contributes to dusting of forest vegetation).
truck speed, ambient weather conditions, and the physical properties of the road surface, fugitive dust of the size to cause respiratory problems in humans (i.e. PM$_{2.5}$), may travel at least 30 metres beyond its source-point and will remain on a surface until washed-off, blown further afield, or settles in a water catchment.

In nature, epiphytic$^{50}$ tank bromeliads$^{51}$ intercept rain and condense dew on their waxy leaf surfaces and then retain this water in the cup-shaped base of the plant (Figure 21$^{52}$). This water, in turn, provides a nursery for all organisms with an aquatic stage in their lifecycle (Laessle, 1961; Janetzky et al., 1995). The nursery, in turn, provides a food resource for larger predators (Diesel, 1989, 1992; Dezerald et al., 2013) while also being a source of drinking water for vertebrate fauna (S. Koenig, personal observation). In karstscapes, tank bromeliads are a key component of the ecological food web (Ladino et al., 2019) – they literally are the equivalent of the watering hole in the African savannah.

When fugitive dust settles in tank bromeliads, water chemistry can be altered. Because of the chemical limits for biological growth and development, the tolerance ranges of aquatic

---

$^{50}$ Refers to plants that grow on other plants for support but not food.

$^{51}$ Colloquially known as “wild pine”, bromeliads are, indeed, members of the pineapple family (Bromeliaceae).

$^{52}$ A hillside water catchment (lower left), located within 100 meters of active bauxite mining and an unpaved marl haulage road. Note also the distinctive vertical scarring on the limestone hillsides and forest fragmentation associated with road construction and pit reclamation. Tucked within the limestone forests are terrestrial and arboreal tank bromeliads, which store water at the axil-base of their leaves.
biota\textsuperscript{3} can quickly be exceeded (Diesel, 1997). As sediments build-up over time, water volume capacity decreases and, eventually, the tank ceases to function unless it is manually cleaned.

Humans in karstscapes deploy similarly useful rain-interception-and-water-storage abilities, ranging from a simple piece of metal with guttering leading to a barrel to constructing a concrete slab on a hillside connected to a storage tank (Figure 21). There are at least 98 hillside water catchments within current Special Mining Leases (SMLs) and an additional 29 within a one-kilometre radius of the leases (Figure 22\textsuperscript{4}). Together, these serve 90 major communities and countless smaller villages. As best as can be determined, not a single public water catchment has been monitored for mining-derived fugitive dust. However, if water quality or storage capacity is compromised, it is the responsibility of Municipal Corporations, not the bauxite companies, to clear the problem.

\textsuperscript{3} Used in the context of tank bromeliads, the term \textit{aquatic biota} refers not only to organisms which spend their entire lifecycle submerged in water but also to those species for which part of their lifecycle includes a water-dependent, swimming stage (e.g. the aquatic larvae of a mosquito, in contrast to the terrestrial adult stage which flies above and around bodies of water (aka breeding reservoirs).

\textsuperscript{4} In 2010, 37 of 52 air quality monitoring stations owned by bauxite companies reported data to NEPA. Only 12 stations were positioned to monitor air quality where mining may have been occurring. In the absence of GIS shapefiles of bauxite ore bodies and their mining status, it is impossible to know if monitoring stations were correctly positioned to record meaningful data. In an e-mail dated 24 June 2020, Mr Anthony McKenzie, Director, Environmental Management and Conservation, NEPA, confirmed that the Agency does not have any GIS polygons of mined-out ore bodies.
Even if all air quality monitoring stations owned by bauxite companies were functioning properly, they are primarily positioned to detect alumina processing emissions and dust from post-processing bauxite residue deposit areas (BRDAs; Persaud, 2018; Figure 22). Where mining occurs, monitoring stations are placed “where people may be affected. In most situations, the stations are located near to population.”

Aside from the fact the vast majority of dust is generated on unpaved haul roads, so greatest exposure will occur when residents are traveling along roads for personal and business purposes, air quality monitoring stations are not deployed with this consideration in mind.

As far as could be determined during this review, assessing the impact of dust on terrestrial flora and fauna has never been taken into consideration in determining the placement of air quality monitoring stations; this has prevented any systematic monitoring of the impacts of dust on biodiversity where mining and haulage occur. The only assessments of environmental contamination caused by bauxite dust appear to be restricted to marine ecosystems at loading terminal ports (e.g. Perry and Taylor, 2004).

**How much has mining and fugitive dust impacted the natural environment and communities within mining areas?**

For tank bromeliad communities, two questions remain unanswerable:

1. How much limestone forest has been destroyed through the creation of haul roads? This must be determined to account for losses of terrestrial and arboreal tank bromeliads

---

56 Arboreal means living in trees.
(see Kelly, 1985). Only GIS data will provide that spatially based answer to the loss of forest.

2. How many tank bromeliad communities have ceased functioning because of accumulated fugitive dust? In the absence of baseline pre-mining assessments and monitoring during mining operations, this remains unknowable.

For human communities, the tank bromeliads may, in fact, represent the “canary in the coal mine.”57 By evaluating the condition of bromeliad communities (including the accumulation of limestone- and bauxite-derived sediments) located within, say, 30 m of haul roads, these plants could function as bio-indicators of air quality.

**BEYOND THE MINES: CONTAMINATION OF KARST GROUNDWATER & ABOVEGROUND RIVERS**

As noted in the background history of the industry, commercial mining initially was limited, because overseas alumina factories were unable to process the very fine-grained Jamaican ore: the plant literally clogged-up within 30 minutes (Hose, 1950; Ingulstad, 2013). Instead of modifying existing overseas facilities, bauxite companies chose to build new alumina processing factories in Jamaica (Figure 2358).

In order to reach the end-product metal of aluminum (Al), bauxite ore is manipulated to extract alumina (aluminum oxide [Al₂O₃]) via the Bayer Process, whereby concentrated sodium hydroxide is used at high temperature and pressure to separate aluminum oxides from iron oxides and other “contaminants” such as silica or quartz. The result is alumina and a toxic slurry of bauxite waste residue (aka “red mud”), which is:

- highly alkaline (pH in the range of 10.5-12.5; contrast to neutral pH = 7 or acid pH < 7);
- highly-saline (elevated levels of sodium (Na), even beyond that of seawater);
- has high sodicity (arising from the use of caustic soda (NaOH); and
- has higher concentrations of certain heavy metals.

Up to the mid-2010s, Persaud (2018) estimated that approximately 350 million tonnes of bauxite residue would have been produced in Jamaica. She also noted, “... though it is quite easy to find information and data on historic milestones in production, there is little

---

57 The idea of taking a live, caged canary (any bird would have worked) into an underground coal mine developed in the early 1900s to combat what is a lethal problem for miners – the build-up of toxic, deadly gases, especially carbon monoxide, in the enclosed mining shafts. When the canary showed signs of breathing distress or died, the miners still had time to leave the area before they, too, succumbed to the bad air. The canary literally served as an early-warning sentinel of harmful environmental conditions. If the aquatic biota which we normally find in tank bromeliads start to die after mining commences in an area, this will be an early indication that something has changed for the worse in the environment.

58 Alumina processing factories located at Ewarton, Hayes, Kirkvine, and Nain (and, historically, Maggotty) cause significant contamination of underground aquifers (NEPA SoE 2013). Although Karanjac (2005) only mapped caustic soda contamination for Ewarton, and for flows North of Nain, water quality reports through 1999 showed contamination in the flows south of Nain, at company- and GOJ-owned wells at Duff House/New Forest 2 (see 23b).
Figure 23a: Groundwater Flow Direction Base Map from WRA’s GWIS Online Database

Figure 23b: GOJ-Owned Wells in Proximity to Alumina Processing Plants
documented to outline the bauxite residue (red mud) disposal practices from the Bayer Process from the 1950s to the 1980s in Jamaica.” (Persuad, 2018, p. 403). Broadly outlined, in the earliest period the toxic slurry was discharged directly into mined-out pits near the factories. Given that we know that rainwater percolates immediately through limestone, we can infer that any contaminated liquid will do the same. At some point, a shift was made, and the liquid waste was deposited into man-made settling ponds and lakes which originally had “unsealed” clay substrates. As the clay was permeable, contamination of groundwater still resulted (Karanjac, 2005). Eventually, substrates were sealed in attempts to eliminate the problem of vertical seepage under the ponds and lakes, but during high rainfall events (such as occurs with tropical storms, hurricanes, and the occasional “freak” weather event (O’Hara, 1990)), overtopping as well as breakaways of embankments will occur (e.g. see RPS Group & ALCAN, 2006; WRA Annual Report, 2010/11). If the slurry of bauxite residue was not fully neutralized before being discharged into the storage pond or lake, overtopping of an embankment contaminates adjacent surface water bodies (especially rivers [Andrews et al., 2001; Hyslop & Nesbeth, 2012]), peripheral soils, and, eventually, the aquifer via vertical drainage through the underlying limestone (Karanjac, 2005).

Owing to an extensive literature on the global history and problems of neutralizing and managing the toxic “red mud” liquor generated during alumina processing, readers are referred to Evans, 2016 and Rai et al., 2017. Remediation and re-vegetation in Jamaica are discussed further below.

Since the mid-1980s, “dry stacking” by the Robinsky sloped thickened tailing disposal system has been used in Jamaica (Evans, 2016). This involves evaporating the bauxite residue slurry to a density of at least 48 percent solids (compared to 18–20 percent solids with lake storage), depositing it on a land surface, and then allowing it to further evaporate/consolidate before a successive layer is deposited. A slope eventually forms, allowing rainwater to run off – but to where? – and minimizing liquid stored in the disposal area.

While this change to “dry stacking” may be an improvement on previous bauxite residue disposal practices, as concluded in the most-recent assessment of Jamaica’s mining policy framework:

_Jamaica’s legislation and guidance do not clearly and consistently require that water-leaching or percolating waste dumps, tailings storage areas, and leach pads are designed, built, operated, or maintained in alignment with international best practice or with external expert review throughout the mine life cycle._

— _Crawford et al., 2020_

Given the long-term and on-going concerns for groundwater contamination from alumina processing (Karanjak, 2005; WRA Annual Reports, 2010–12), how easily can the public find up-to-date information on the safety of community water supplies?

59 Persuad (2018) used the word “near,” but Evans (2016) was more precise: at the Kirkvine plant, the slurry was discharged out to a 6 kilometre radius around the plant, a considerable distance for an island of only 11,000 km².
In 1994, JBI was delegated responsibility by the NRCA to monitor water quality in collaboration with the Underground Water Authority (the precursor to the current Water Resources Authority [WRA]). Although JBI’s website confirms that it is engaged in water quality monitoring (https://jbi.org.jm/environment/monitoring/), and other documents archived on the website make reference to the fact that e.g. sodium chloride is monitored at production and monitoring wells in proximity to the alumina factories (Bauxite/Alumina Industry Review, 1998–99), no monitoring data, quarterly summary statistics, or annual quantitative reports on water quality parameters could be located on JBI’s website. A monthly bulletin presents alumina production and export statistics, but nothing on environmental monitoring data (e.g. https://jbi.org.jm/wp-content/uploads/Jamaica-Bauxite-March-2020-Bulletin.pdf). Thus, for this study, JBI’s website proved of no use for learning about the quality of ground-water in the catchment areas of factories and bauxite residue storage areas. Submitting requests to JBI for monitoring data was beyond the scope of the study.

In contrast, WRA’s online Ground Water Information System (GWIS) includes a comprehensive database (including date drilled, well lithology, depth-to-water, owner, etc.) of the over 1,000 wells drilled in Jamaica. However, of the 150 wells owned by bauxite companies, only 19 have been monitored for water quality for at least one year, and all of those 19 are associated with the Nain facility in St Elizabeth (i.e., on WRA’s publicly-accessible website, there were no water quality reports for Williamsfield, Hayes, or Ewarton, the other factories were alumina processing occurs (Figure 23a).

Similarly, of the more than 70 wells owned by the GOJ which are within 15 kilometres of the “down aquifer” flow of the alumina factories, only six had water quality reports available on the GWIS database; five of the six are associated with Nain while the 6th well would have been affected by the now-derelict Revere facility (Figure 23a; Figure 24). The Nain wells are part of the set of Pepper wells which provide water for Mandeville, the capital of Manchester parish.

Unfortunately, even for the neighbouring communities around Nain, WRA data are presented as monthly totals, so pulse discharge events (e.g. such as can occur during the passage of tropical storms) will be presented as diluted by the average of any given month. Water quality data for 18 of the 19 wells end at 31 December 1999. Presumably, WRA has up-to-date files which have not been uploaded to the GWIS. For the 19th well, post-1999 water quality data are limited to August 2000, August 2001, February 2002, August 2002, September

---

60 http://webmapjam.dyndns.pro/webmap/app/db/index.php?login=0
61 Well lithology refers to the general physical characteristics of the rocks through which the well is drilled, changes in rock type, the thickness of each rock type, and the total length and depth of the well.
62 Manchester Comparison of water quality reports for the Duff House-Bull Savannah well (drilled by Kaiser in 1951 and currently owned by ALPART) and the National Water Commission’s New Forrest #2 well (drilled in 1965). All reports available on WRA’s GWIS online database reveal significant contamination between May 1989 and March 1991, the only period where both bauxite company and GOJ monitoring of water quality coincided. As a caveat, the Duff House well was drilled to a depth approximately 60 meters below resting water level while the New Forrest #2 well was drilled to a depth of approximately 18 meters below resting water. The railway line to Port Kaiser appears as the solid black line on the map, just on the western side of the wells.
2003, and June 2004. In contrast, the GWIS online database does have data through 2019 for ground water levels of 43 company-owned wells.

Thus, although WRA has claimed that its web-based hydrological database provides “timely access to stakeholders to data on the quantity, quality, and variations in time and space of the surface and underground water resources (WRA Annual Report 2016–17, pg. 24), for communities in proximity to alumina processing factories, the only easily-accessible data of water quality are 20 years out-of-date. As best as could be determined, real-time (at least within one week of collection) data of aquifer water quality have never been easily available to the public.

BACK TO THE “DRY” STACKS . . .

The irony of “dry” stacking is that, if the surface is not kept moist either by rainfall or by controlled sprinklers, dust becomes airborne. The very fine-grained Jamaican bauxite demands extra attention for its fugitive dust (see also US Congress 1982).

The critical importance of “dry stack” moisture management became salient during the 2007–2009 global recession and the concomitant reduction in management operations by the bauxite sector:

“... the vast open red mud disposal (mud lakes) areas have dried up and become in most cases dust-bowls. These areas can only be managed by continued wetting and during dry seasons become increasingly difficult to manage leading to the high levels of particular matter reported during 2010.”

How well the mining sector is performing management operations during the COVID-19 pandemic, where an individual’s history of respiratory health assumes an important dimension for public health, remains to be seen. Meanwhile, as climate change models predict prolonged drought cycles and more frequent and intense hurricanes for the insular Caribbean, the recurrent problems of fugitive dust and overtopping of “mud lakes” will only get worse (ESL, 2009) until sustainable permanent vegetation cover is established on all bauxite residue disposal areas (BRDAs; Evans, 2016, Di Carlo et al., 2019).

Vegetation remediation efforts have been underway since the mid-1990s on a small subset of the old residue storage ponds in-and-around Kirkvine (Manchester Parish) (Evans 2016) and are reportedly underway for the Mount Rosser (Ewarton) mud lake, which was created through the damming of a valley in 1959 (RPS Group & ALCAN, 2006) and has been undergoing drainage and remediation under a closure process guided by The Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013. These regulations, which identify red mud as “industrial sludge,” govern the removal of infrastructure and contamination but do not define any end state criteria (see also Persaud, 2018).

As made salient in a 2005 vegetation assessment for the Kirkvine Pond #6 (which was experimentally planted in 1998 with five species (two non-native grasses, one non-native shrub, one non-native tree, and one native tree; [Webber et al, 2006]), if the rehabilitation end state is for e.g. a self-sustaining forest of native species (as, for example, occurs in Western Australia; Grant & Koch, 2007) then progressive, spatially-based performance indicators are critical. For example, while some describe Kirkvine Pond #6 rehabilitation as “comparable to a dry limestone forest in Jamaica” because 53 plant species were identified in 2005 (Evans, 2016; Persaud, 2018; http://bauxite.world-aluminium.org/refining/case-studies/jamaica/), the authors of the 2005 field survey were careful to point out that “despite this richness, diversity was low, as the distribution of individuals among the species and the sampling sites was poor” (Webber et al., 2006, pg. 2). They further noted that the centre of the pond was characterized by open patches of bare ground and the vegetation was dominated by three of the experimentally planted species; the other 50 species occurred at the edges of the pond where the slope and soil appeared different (i.e., where the land had not been subjected to mining or reclamation prior to the pit being used as a slurry pond). Their conclusion was that re-vegetation was creeping in from the peripheral forest found naturally on the adjacent hillside. The authors also noted that the maximum root depth of trees halted noticeably at 1.4 metres below the surface, as if the roots had encountered an impenetrable hard pan. This reveals the importance of reconstructing soils post-mining to a depth greater than 15 centimetres if trees are to be the desired end-state, while also indicating that the functional hydrology of the Kirkvine rehabilitation effort remained compromised.

As outlined by Dybowska et al., (2006), Macdonald et al., (2015) and multiple others, progressive performance indicators for the rehabilitation of waste storage areas include:

- soil quality indicator – physical properties (texture and structure);
- soil quality indicator – soil chemistry (especially pH, salinity, exchangeable sodium percentage, carbon-nitrogen-phosphorous availability);
• water-holding potential;
• micronutrient availability (including copper, zinc and magnesium);
• elevated concentrations of toxic heavy elements, especially aluminum-bearing minerals, arsenic, and lead;
• accumulation of organic material in the soil;
• microbial activity;
• colonization by soil-dwelling fauna;
• vegetation succession; and
• terrestrial invertebrate and vertebrate communities.

The bioaccumulation of toxic elements, especially heavy metals, needs particular attention for ensuring the long-term safety of environmental and public health.

WILL ENVIRONMENTAL DAMAGE CONTINUE?

The irony for Jamaica is that, in attempting to identify and resolve a problem of poor soil fertility in agriculture, an industry was established which removes the very feature which makes agriculture possible in a tropical karst environment – the accumulated bauxitic soils. Where native forests have not been converted to agriculture, the trees themselves serve as biological indicators that deep ore bodies have a functional role: it is not through random chance that the largest trees are found in the deep pockets of soil, it is the fundamental properties of physics and fluid dynamics which explain why the soil (and its depth) matters to any plant, regardless of whether it is a corn stalk or a centuries-old Cotton Tree (Ceiba pentandra). By ignoring a fundamental ecological fact that was well-documented prior to mining (Swabey 1939), the die was cast for mining to be prioritized over the environment and, consequently, all the ecosystem services provided by the karstscape.

The truth for Jamaica and all its citizens, who are guaranteed the right to enjoy a healthy and productive environment free from the threat of injury or damage from environmental abuse and degradation of the ecological heritage (The Charter of Fundamental Rights and Freedoms (Constitutional Amendment) Act, 2011, Chapter III, 13.(3)(l)) is not that mining per se takes place, but the egregious facts that:

• It was impossible in this review to independently verify the total surface area which has been altered by bauxite mining (including haul road construction) since the Mining Act and the Mining Regulations were established in 1947; nor was it possible to assess the spatial configuration and extent of land cover fragmentation, especially of remnant forests on hillsides. These simple quantitative calculations could not be undertaken because MGD, the entity responsible for enforcing the act and regulations, was unable to provide any printed maps or electronic, spatially-explicit GIS data files showing the boundaries of ore bodies which have been mined.
• Also, because of the absence of GIS files, it was impossible to independently verify
whether the reported land use of any given rehabilitation certification did, indeed, correspond to field conditions and it was impossible to randomly evaluate any rehabilitated ore body for changes in land use over time as a function of time-since-certified-rehabilitated.

- NEPA, the agency which has responsibility for environmental monitoring, confirmed that it does not have GIS data files of ore bodies (either un-mined, mined-but-unreclaimed, or rehabilitated); thus, NEPA cannot independently verify reports on rehabilitation claims submitted by JBI.

- Although the industry has known since at least the early 1970s that 15 centimetres (6 inches) of returned soil is a completely inadequate depth for rehabilitating a pit to its pre-mined level of agricultural (as distinguished from pastoral) productivity, the NRC created guidelines which specify that 15 centimetres (6 inches) is an acceptable minimal soil depth; at this depth reclaimed pits are consigned to *growing grass in perpetuity* (Morgan 1974).

- As recorded in meeting minutes, NRC members know that 15 centimetres (6 inches) of reconstructed soil is too shallow to support the growth of large trees (i.e., under current guidelines, pits certified as rehabilitated will need additional management interventions if anything other than pasture is desired by a current or future landowner; in addition to the cost which would not be borne by the mining companies, it is not clear from where a source stock would come in order to construct a deeper soil bed).

- Under the ALCOA/Jamalco-funded Soil Microbial Project, the industry has known since at least 2010 that soil function and soil fertility remain compromised for at least 20 years after an ore body has been rehabilitated. There is nothing in the current guidelines prepared by the NRC which addresses these core failures of soil management (see World Aluminum 2018).

- For an estimated 60–70 percent of pits which have been rehabilitated under the currently active Special Mining Leases, Napier grass was planted purportedly to stabilize the movement of reclaimed soil; however, no published data could be found to verify this claim.

- Napier grass is recognized globally as an invasive alien species because, once established, it prevents colonization by other species and is difficult to eradicate. Its usage, therefore, contravenes Jamaica’s responsibilities to the Convention on Biological Diversity, to which the country acceded in 1995.

- Based on rehabilitation data provided by MGD, under the currently active SMLs, less than 0.5 percent of mined-out ore bodies have been planted with a “forest” land use designation.

- Within the rehabilitation guidelines prepared by the NRC, the terms “biodiversity”, “functional forest”, “ecosystem”, “karst” or “watershed/water catchment”, do not appear; thus, the components which establish the processes for new development and maintenance of healthy soils for agriculture and forest communities, with the special management considerations required for karst systems, are not a part of the NRC’s post-mining vision for Jamaica.
Owing to the fact the bauxite mining began in Jamaica long before there were regulatory requirements for descriptions of environmental conditions prior to mining leases being issued, the true and complete extent to which Jamaica’s ecological heritage has been damaged can never be fully known. The data describing the terrestrial productivity of agriculture and forests, the delineation of occurrences of endemic plants and animals, the quality of tank epiphyte communities, and every other ecological activity we would recognize today simply were never collected before the 1990s. The absence of data, of course, does not mean that irreversible damage has not occurred. Indeed, mining industry stakeholders acknowledge there is a legacy of damage and sustained abuse, from the nearly ¼ of mined-out ore bodies which have yet to be reclaimed (C. Thompson in NRC Meeting Minutes, 13 February 2014; Drakapoulos, 2018) through to inadequate storage of bauxite residue (Persaud, 2018). The question which remains to be answered is: who will pay for this legacy?

What could we learn from data which are inferred to exist? The spatially explicit, geo-referenced data on bauxite reserves which the Cartographic Unit at JBI reportedly maintains (JBI Annual Report 2012–13, pg. 18) must have been provided to the bauxite companies. They would have needed these data to construct volumetric models, to calculate bauxite tonnage and thickness to develop and report to JBI their mining schedules (Price 2004a) and to map surface land ownership (Price 2004b). What could such data tell us about past, present, and possible future impacts, particularly as bauxitic soils are one of key systems-signatures in predicting groundwater storage characteristics and groundwater flow dynamics in karst (Hartmann et al., 2013)?

Until bauxite mining in Jamaica is evaluated within a holistic framework of karst characteristics and processes – the distributions and functions of soils, the surface and subsurface movements of water, and the adaptations of plants and animals to karst geology and hydrology, etc. – the ecosystem services of karstscapes, such as Cockpit Country, will never be effectively protected from mining impacts.

REFERENCES


---

63 The Forest Law was enacted in 1937, with explicit reference “for the preservation of the soil on the ridges and slopes and in the valleys of hilly tracts” (The Forest Law, 1937; Swabey, 1939, 1942).


Degradation of Ecological Heritage: The Impact of Bauxite Mining on Karst Ecosystems in Jamaica


Selvaraju, R. (2013). Climate change and agriculture in Jamaica: agriculture sector support analysis. FAO


DEGRADATION OF ECOLOGICAL HERITAGE: THE IMPACT OF BAUXITE MINING ON KARST ECOSYSTEMS IN JAMAICA


APPENDIX 1

Examples of maps created by Mines and Geology Division (MGD), for use during rehabilitation certification exercises. In the various legends, the inclusion of file names with the suffix “shp” (e.g. “Transprt.shp”; “not shown.shp”) denotes a GIS file was used to create the displayed features.

Appendix 1 – Figure 1: Ewarton Mines Certification : 8 December 1999
APPENDIX 1: Examples of maps created by Mines and Geology Division (cont’d)

Appendix 1 – Figure 2: Alcan Ewarton Certification Results December 2000
APPENDIX 1: Examples of maps created by Mines and Geology Division (cont’d)

Appendix 1 – Figure 3: Kaiser December 2000 Certification Results Block 2 – Trysee
APPENDIX 2

Guidelines for the rehabilitation of lands disturbed for mining bauxite

These guidelines are meant to ensure that a reasonable level of sustainable productivity is maintained, and to address the negative environmental and aesthetic impacts of mining.

1. Stripping should not be less than 30 centimetres (12 inches) deep. Topsoil removed shall be placed outside the extremities of the pit to be mined so as to be preserved for rehabilitation of the mined-out area after reclamation is complete.

2. For lands to be used for agricultural purposes topsoil shall be spread on a layer of non-compacted or ripped up material.

3. Restored lands shall have a minimum of 15 centimetres (6 inches) of soil depth (topsoil).

4. Where slopes exceed 15 degrees (27 %), contour barriers or terracing shall be implemented for soil conservation, as well as any other suitable and sustainable methods as agreed by the Commissioner of Mines.

5. Vertical faces shall not exceed 3 metres (10 feet) except (a) where there is a property boundary, (b) where there are specific challenges and prior approval is obtained from the Commissioner of Mines. In such cases adequate protection shall be in place to ensure the safety of people and livestock. To preserve the adjoining landowner’s property the minimum offset of the vertical face from the property boundary should be equal to the height of the vertical face.

6. Where stones are strewn on the surface of the restored land they should be collected and safely stockpiled.

7. Reclamation procedures shall ensure that no rock outcrops or large stones are left exposed in the reclaimed area, except in the case of a vertical slope being left in accordance with the regulations (refer to Guideline 5).

8. Measures should be put in place to prevent erosion of unconsolidated material from roads, berms etc.

9. Four categories of plants/vegetation can be used for restoration utilizing strict soil erosion control measures.

   a) Field crops e.g. sweet potato, cassava, thyme and peanuts; tree crops, e.g. citrus, oil nut (castor bean), june plum, sour sop, sweetsop,

   b) naseberry, apple and pimento;

   c) Forest trees, e.g. Calliandra, Leucaena, Gliricidia, mahoe, and Caribbean pine, and

   d) Grass, e.g. Napier, african star, king grass, Brachiaria, lemon grass and khus khus.
10. Where grass is used, surfaces should be fully covered, and other conservation measures put in place where necessary.

11. Where other vegetation (crops and trees) are used for restoration on slopes other than those in the range 0–5 degrees (0–9 %), strict erosion control measures should be in place e.g. strip cropping, stone barriers etc.

12. All sinkholes which receive storm water discharge shall not be filled but left open to remove storm water from the site.

13. If lands are being used for housing:
   
   - The subdivision plan should include the grading plan for the site with the areas of the land modified by cut and fill identified.
   
   - A caveat should be placed on titles to highlight areas unsuitable for housing.

*Adopted on December 6, 2012 by the National Restoration Committee (NRC)*
APPENDIX 3:

The National Restoration Committee

The National Restoration Committee (NRC), chaired by the Commissioner of Mines, Mines and Geology Division (MGD), was established primarily to develop the best practices for the lands disturbed for mining and quarrying (although no representatives of the quarry sector were/are members of the NRC nor attended any meetings). As noted in the minutes of the first meeting, held on October 21st 2019, “MGD was of the view that restoration required urgent attention”. Although the NRC still exists on paper (S. Plummer pers. comm. to L. Creary, 21 April 2020), it was last convened on June 30th, 2016.

Attendance records denote the number of individuals from each entity. Invited guest-speakers are not included.

Discussion topics of key importance to forest rehabilitation are highlighted below the attendance records.

Acronyms:

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALMD</td>
<td>Agricultural Land Management Division</td>
</tr>
<tr>
<td>CARDI</td>
<td>Caribbean Agriculture Research &amp; Development Institute</td>
</tr>
<tr>
<td>CASE</td>
<td>College of Agriculture Science and Education</td>
</tr>
<tr>
<td>FD</td>
<td>Forestry Department</td>
</tr>
<tr>
<td>JBI</td>
<td>Jamaica Bauxite Institute</td>
</tr>
<tr>
<td>MGD</td>
<td>Mines and Geology Division</td>
</tr>
<tr>
<td>NCU</td>
<td>Northern Caribbean University</td>
</tr>
<tr>
<td>NEPA</td>
<td>National Environment and Planning Agency</td>
</tr>
<tr>
<td>RPPU</td>
<td>Rural Physical Planning Unit</td>
</tr>
<tr>
<td>UTech, Ja</td>
<td>University of Technology, Ja</td>
</tr>
<tr>
<td>UWI</td>
<td>The University of the West Indies (Dept of Geography and Geology)</td>
</tr>
</tbody>
</table>

Mining Sector:

**ALPART**: Aluminum Partners of Jamaica was founded in 1969 as a joint venture by Kaiser Aluminum, Reynolds Aluminum, and Anaconda. In 2016 UC RUSAL sold all of its stake in ALPART to the Chinese state industrial group, Jiuquan Iron & Steel (Group) Company, Ltd (JISCO). The local businesses are registered as ALPART Mining Venture (# 738/2000) and JISCO ALPART Jamaica (# 109/1967) (www.orcjamaica.com)
Jamalco: The entity was created as a partnership venture by USA-based Alcoa in 1959. In its current iteration, it is an unincorporated joint venture between Hong Kong-based Noble Group (55 percent) and Jamaica-registered [#26570 [Local]] Clarendon Alumina Production, Ltd (45 percent), which represents the Ministry of Mining and Energy (GoJ). Despite the inclusion of “co” in the acronym, Jamalco has never been a registered, limited-liability company.

Noranda: Canada-based Noranda entered the Jamaican market when it acquired a 50 percent interest in the Gramercy (Louisiana) alumina refinery, which was part of the Kaiser empire. Various iterations of the Kaiser/Noranda-Jamaica bauxite partnership have existed, but as of 2018 the business of Noranda Jamaica Bauxite Partners II has been registered (# 2019/2018) in association with the company Noranda Bauxite Ltd (# 68766 [Local]).

WINDALCO: the West Indies Alumina “Company” is a joint venture between UC Rusal and GOJ (i.e., it is business (# 2074/2015), not a limited liability company).

<table>
<thead>
<tr>
<th>Date</th>
<th>MGD</th>
<th>FD</th>
<th>NEPA</th>
<th>RPPU</th>
<th>ALMD</th>
<th>JBI</th>
<th>WINDALCO</th>
<th>JAMALCO</th>
<th>ALPART</th>
<th>Noranda</th>
<th>UWI</th>
<th>UTech</th>
<th>NCU</th>
<th>CARDI</th>
<th>CASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-Oct-091</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>17-Mar-102</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>21-Apr-103</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23-Jun-10</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-Oct-10</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-Nov-10</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Mar-11</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Sep-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Minutes not provided but were confirmed in the subsequent meeting6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-Jan-12</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-Apr-12</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-Dec-12</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-Nov-13</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-Feb-14</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td></td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-Jun-14</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-Dec-14</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Jul-15</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Oct-15</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Mar-16</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-Jun-16</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. In addition to highlighting the need for further research into the options for restoration (*sic*) of both mined-out and quarried lands, participants noted that sources of funding for research need to be identified. Given that the mining sector is causing the damage, the mining sector should be the source of 100% of all research and rehabilitation funding.
2. The NRC was advised that funding was available for two projects – one on mined-out bauxite lands and one in a quarried-out area – under the UNDP-funded project *Capacity Building and Sustainable Land Management in Jamaica*. Ultimately, MGD had responsibility for the eventual quarry project in Flankers, St James and Forestry Department had responsibility for the bauxite project in Mocho, Clarendon.

3. Under “New Matters Discussed” the NRC outlined what can only be described as the need for proper Environmental Impact Assessments (EIA) before mining activities begin in an area and for Strategic Environmental Assessments (SEA) – post-mining landscape planning; Forestry Department raised concern for the removal of limestone forests during reclamation as this deforestation affects the species that rely on these habitats for survival. The representative further not that, while the aim is for no net loss of forest cover, planting of trees on mined-out lands is not enough as this cannot replace the limestone forests with regard to maintaining biodiversity.

4. It was reported that UNDP representatives expressed concerns about the use of a plant which is considered to be an invasive species for the quarry project located near Flankers, St James. The UNDP was referencing an invasive alien species of *Calliandra*. On the Action Sheet, Forestry Department was tasked with providing a list of appropriate trees for different areas as well as an explanation of the rationale for their selection.

5. The ALPART representative stated that research is needed with regard to enhancing the subsoil to the level of topsoil. Surprisingly, the UWI representative suggested that the Environmental Foundation of Jamaica (EFJ) could be approached for funding instead of saying that the mining sector must fund such research.

6. Based on the minutes of the January 19th, 2012 meeting, a recommendation was made that the NRC, with inputs from Forestry Department, would identify and designate specific areas to be reforested.

7. The minutes confirm that a plan for “Designation of Areas to be Re-forested” will be formulated for the bauxite/alumina companies, with Forestry Department to participate in deciding on and implementing the reforestation of the designated areas.

8. The ALPART representative reminded the NRC that “the push needs to come from the government to the owners/principals of the bauxite/alumina companies” to identify areas for plant forest trees in mining areas. He further stated that this did not have to only occur on mined-out lands and will help with watershed management.

9. Under “Another Other Business”: *A letter is to be sent to Peter Knight to select a new representative for the committee since Mr Richard Nelson has not been attended*. It is astonishing to note that NEPA was represented in only TWO meetings since it was invited to join the NRC in 2010.

10. In what appears to be the last meeting of the NRC, the task *Designation of Areas to be Planted with Forest Trees* was never completed. The minutes noted that *Contact is to be made with Ms Headley to ensure that a representative of the Forestry Department attends the meeting.*

In light of the fact that Howard and Proctor (1957) presented a detailed checklist of the trees found on the limestone hillsides peripheral to mined and un-mined ore bodies, as well as of the forest on un-mined ore bodies, it is almost inconceivable that trees suitable for rehabilitating native forest have not yet been identified (ref. guidelines developed by the NRC) nor have areas been designated for forest tree plant by the NRC.
The Social Costs of Bauxite-Alumina Production in Jamaica

ERNIE NIEMI

“Following millennia in which Nature was broadly resilient, a variety of compelling scientific evidence shows that humanity’s demands on Nature are outstripping its ability to meet that demand on a sustainable basis.”

—The Dasgupta Review – Independent Review on the Economics of Biodiversity, April 2020

OVERVIEW

The bauxite-alumina industry generates some important economic benefits for Jamaica: industrial products exported to the global economy, jobs for workers, sales and income for local vendors, and revenue for the government. The industry’s contribution to gross domestic product (GDP), a common measure of the cumulative benefits, is about USD1 billion per annum. As it generates these benefits, though, the industry also imposes many costs on workers, families, businesses, communities, and future generations. Economists use the term “social costs,” or externalities, to describe these costs, because they diminish the well-being of society. This report provides an overview of the many types of social costs the bauxite-alumina industry imposes on Jamaicans. Sufficient data exist to support detailed, quantitative estimates for just two types of social costs – increases in human illnesses and premature deaths from the industry’s emissions of particulates, sulphur dioxide, and nitrogen oxides; and intensification of the climate crisis from its emissions of carbon dioxide. Combined, these costs total USD4.7 billion – USD19 billion per annum. These numbers show that the social costs the industry imposes on Jamaicans far exceed the economic benefits.
SOCIAL COSTS OF BAUXITE-ALUMINA PRODUCTION: KEY CONCEPTS

This section explains concepts embedded in the social costs the bauxite-alumina industry imposes on Jamaicans, and two different perspectives for measuring these costs.

Social Costs

Economic costs resulting from the industry’s activities that are borne not by the industry’s owners but, instead, by society at large, are known as social costs or externalities. This report uses the term, social cost, to represent a reduction in Jamaicans’ well-being resulting

---

1 In this report, “social cost” refers to a reduction in wellbeing as the bauxite-alumina industry causes:
   - The loss of life, health, security, social harmony, or quality of life.
   - Increased expenditure of time or money to maintain a given standard of living.
   - Reduction in the quantity or value of goods and services available to families, businesses, communities and future generations.
   - Increase in the risk of undesirable events.
from the bauxite-alumina industry and related activities. This reduction can occur in many ways and accrue to individuals, families, landowners, businesses, communities, and future generations. This report considers costs that might materialize through several mechanisms, including:

- **Loss of life, health, security, social harmony, or quality of life.** These costs materialize, for example, as pollution from the bauxite-alumina industry and related activities make people sick; or when industry-caused dislocation of families from their homes disrupts long-established patterns of social interaction and increases levels of crime; or as Jamaicans adversely affected by industry-related damage to their natural environment and culture experience degradation in their quality of life.

- **Reduction in the supply of an existing good or service.** Pollution from the industry, for example, imposes a cost on farmers and their families whenever it decreases the size of their crop.

- **Reduction in the per-unit value of an existing good or service.** The industry imposes costs on business owners, workers, and communities associated with the tourism industry, for example, whenever its activities and pollution diminish Jamaica’s attractiveness to potential visitors, causing some to spend less while in Jamaica and inducing others to stay away.

- **Increase in the price that must be paid to obtain a good or service.** For example, when the industry displaces families and even communities, some individuals must pay more to visit relatives, conduct business, attend school, and find meaningful employment.

- **Forgone economic activities.** When the bauxite-alumina industry occupies lands, they no longer can be used for other activities, including farming. In some cases, the forgone economic productivity can exceed Jamaica’s earnings from the bauxite-alumina industry’s use of the lands.

- **Increase in risk.** Individuals, families, businesses, and communities would experience a reduction in their wellbeing when subjected to industry-based risks. These include, for example, risks of death, injury and property damage if mud lake dams were to fail. Other risks accompany industry-related activities at the port that involve handling of hazardous materials, creating a risk of accidents, spills, or explosions that would injure or kill individuals, poison the environment, and keep people from engaging in their preferred activities.

### Measuring the Industry’s Social Costs

Economists measure the importance of the social costs from two distinct perspectives. One of these, commonly called Willingness to Pay (WTP), assumes that if Jamaicans do not want these costs imposed on them, then they must pay to make industry stop. The amount Jamaicans are willing to pay (WTP) to the industry indicates the value of the harm: they will be willing to pay more to stop the activities that impose the costs they consider to be more harmful, but willing to pay less to stop those they consider less harmful.
The other perspective for measuring social costs, called Willingness to Accept (WTA), turns things upside down. It assumes that industry does not have the right to impose costs on Jamaicans, and can proceed with the activities that generate these costs only if it pays Jamaicans enough compensation to persuade them to agree to tolerate the harms imposed on them. From this perspective, the amount that Jamaicans are willing to accept (WTA) as compensation indicates the value of the social costs.

In theory, the two perspectives should yield similar measurements of the value of the social costs industry imposes on Jamaicans. In reality, WTP often yields a smaller value – perhaps a much smaller value – than WTA. One important reason for the difference is that people typically require more compensation to relinquish something than they are willing to pay to acquire the same thing. For example, the amount they would require to give up their good health by allowing industry to emit pollutants into the air would exceed the amount they would pay to induce industry to stop on-going pollution and thereby restore good health. WTP estimates of the importance of social costs also fall below WTA estimates because the former depends on how much money Jamaicans have, i.e., their ability to pay industry to stop activities that impose costs on them. Most Jamaicans do not have an unlimited supply of spare cash they can use to pay industry not to impose costs on them. Hence, their willingness to pay to prevent these costs is constrained by their ability to pay. This constraint does not apply under the WTA perspective.

Economists have long used the WTP approach to examine the value of goods and services traded in markets, and applied these approaches when measuring social costs, which typically materialize outside markets. It is important, however, to anticipate that WTP-based estimates of social costs understate their true magnitude. This bias affects the (limited) data regarding the social costs the bauxite-alumina industry imposes on Jamaicans.

**BRIEF DESCRIPTIONS OF THE SOCIAL COSTS THE BAXITE-ALUMINA INDUSTRY IMPOSES ON JAMAICANS**

A comprehensive description of the ways in which the Jamaican industry imposes social costs has not yet been compiled. But the evidence that is available identifies and provides a partial description of many of these costs, which materialize in varied, overlapping pathways (Table 10).
### Table 10: Potential Social Costs Imposed on Jamaicans by the Bauxite-Alumina Industry

<table>
<thead>
<tr>
<th>Activity</th>
<th>Resulting Social Costs</th>
</tr>
</thead>
</table>
| Displacement of families/communities, and out-migration | Companies and government displace people occupying the sites for proposed mines, roads, etc. Displacement breaks up communities and families. It can diminish the economic well-being for those displaced from that area and those living in the area to which they are relocated. People relocated involuntarily realize a reduction in well-being through:  
  • Direct relocation costs, e.g. to move into new housing and secure adequate transportation.  
  • Loss of asset value (home, farm land, site-specific knowledge, etc.).  
  • Reduction in future income.  
  • Reduction in production of subsistence food.  
  • For those who are displaced, reduction in access to family and community left behind, and to places with spiritual and historical importance.  
  • For those left behind, reduction in access to those who have moved away.  
  • Reduction in access to important natural resources (existing residents of the community receiving the relocates likely already have the best access to water, clean air, etc.).  
  • Increase in risk (exposure to unhealthy air and water, finding replacement jobs in the new location, hostility from within the receiving community, exposure to extreme weather (existing residents of the receiving community likely already occupy the safest locations, etc.).  

For example, evidence from the district of Mocho suggests that full compensation was not received.\(^2\) Many were forced to accept replacement lands and other compensation that they found unacceptable. Few received sustained training (or, indeed, any training whatsoever) to qualify for new jobs, grow crops successfully, adapt to new neighbours, etc. in the receiving community. Few, if any, received sustained compensation to offset on-going reductions in income and production of subsistence food, and increased costs to visit family members left behind, etc. Few, if any, received insurance coverage for increases in risk. Few relocations provided full compensation for reductions in economic well-being stemming from impacts on individuals, families, and the community.  

\(^2\) World Bank. FAQs for Involuntary Settlement.  
\(^3\) See, for example, Panos Caribbean. 2007. Voices from Mocho.
Increased bureaucracy (corporate and governmental)

Industry’s impacts on many Jamaicans result in distrust between citizens and government/businesses. This degradation in interpersonal interactions (what economists call “social capital”) occurs, for example, when industry promises compensation for negative impacts but then fails to deliver. Residents also experience a reduction in their disposable incomes (the money they spend on normal daily living) when they must repeatedly travel to industry or government offices seeking redress. Inequities in the treatment different people receive from industry and government representatives cause discord within families and communities, degrading social capital further.

In-migration

Nearby communities can experience an in-flux of people from elsewhere as a new mine attracts workers and their families, vendors, and others. More distant communities can receive individuals and families displaced from the mining site. Both types of in-flux can create stresses on and diminish the economic well-being of existing residents of these communities. For example, in-migration has resulted in cutting down trees that provided fruit for the community, greater competition for water and other resources, and more noise. These and similar impacts diminish the quality of life for, and impose economic costs on, residents of the receiving community.

Noise & light pollution

Bauxite-alumina production generates a lot of noise – at the mines, processing plants, and port facilities, as well as along the haul roads (Coke et al, 1987). Noise harms those exposed to it, with the extent of the harm determined by the sound pressure and frequency, the distance to local communities, etc. (OECD, 2011). These same facilities and activities likely would also generate light pollution (Bailey et al, 2004).

The currently available information about the levels of noise and light pollution, and the populations exposed to them, is not sufficient to support a detailed description of the resulting reduction.

Table 10 continued

---


<table>
<thead>
<tr>
<th>Activity</th>
<th>Resulting Social Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Noise &amp; light pollution (cont’d)</strong></td>
<td>in economic well-being. It is clear, though, that, if not adequately controlled, noise and light pollution impairs the health and performance of workers and nearby residents. Noise pollution has been found to correlate with hearing impairment, interference with speech communication, hypertension (high blood pressure), heart disease, sleep deprivation, reduced performance, aggressive behaviour, and acceleration of mental disorders (Berglund et al, 1999). Light pollution has been found to correlate with sleep deprivation, depression, insomnia, cardiovascular disease, female breast cancer, and colorectal cancer (Chepesiuk, 2009). Noise and light similarly harm species other than humans. Noise increases chronic stress for wildlife, diminishes the efficiency of their use of energy, reduces their reproductive success, and can threaten long-term survival (Radle, 2007). Light affects both flora and fauna. It can alter the growth patterns of trees, and the behaviours, foraging areas, and breeding cycles of insects, turtles, birds, fish, reptiles, and other wildlife (Chepesiuk, 2009).</td>
</tr>
</tbody>
</table>
| **Transportation (truck and rail) of bauxite and alumina** | The movement of bauxite ore imposes costs on Jamaicans in multiple ways:  
  • Negative effects on the health of humans, livestock, and wildlife from emissions of hazardous materials from fuels for large trucks and heavy equipment, traffic on haul roads, operation of mines and processing facilities.  
  • Degradation of biota, land, and water resources from the construction & usage of haul roads (dusting of communities and the environment, noise, opening formerly remote areas to deforestation).  
  • Degradation of biota, land, and water resources from the construction of railways (to take the ore from the mines to the ports). |
| **Port facilities and shipping-related water pollution** | The development, maintenance, and operation of port facilities supporting the bauxite-alumina industry prevent the realization of a healthy marine ecosystem. These activities involve:  
  • Clearing of coastal resources (mangroves, beach vegetation);  
  • Dredging (impacts to coral reefs);  
  • Dust from loading;  
  • Oil spills; and  
  • Accumulation of metals in sediments on the sea floor. |
Experience around the globe indicates that industry-related shipments into and out of Jamaica almost certainly have resulted in spills of oil and other hazardous materials, and will continue to do so in the future. These spills likely have adverse effects on human health and the productivity of the environment. Of particular concern is pollution from these sources:

- **Ballast water.** A ship’s crew pump ballast water into and out of tanks to control the vessel’s centre of gravity and improve its flow through the sea. Ballast water acquired elsewhere may contain organisms and substances that would be harmful when released into the waters at or near Jamaica (OECD, 2011).
- **Bilge water.** Water that leaks into a ship often contains oil products and other contaminants that can be hazardous or even explosive.
- **Sewage and wastewater.** Sewage and wastewater generated by a ship’s crew can contain organic, biological, chemical, and toxic pollutants, including oil products, resulting from accidental spills of cargo and the ships’ operations. About 90 percent of ships lack the ability to separate oil from the wastewater stream and discharge it into open water (Bailey et al., 2004).
- **Hazardous-material spills.** Accidental spills of oil and other hazardous materials can occur from collisions or equipment malfunctions.
- **Antifouling substances.** Paint used on a ship’s outer hull often contains additives intended to deter the growth of marine organisms. These additives can leach into the water as the ship sits in port, with toxic effects on humans and other organisms.
- **Stormwater and wastewater runoff.** Water that flows over the land’s surface and into the port can carry harmful pollutants. This water can come from precipitation (stormwater) or from spills (wastewater) from industrial activities, motor vehicles, or other sources.

---

5 The USA illustrates the high likelihood and economic importance of spills: “Each year, there are thousands of oil and chemical spills in coastal waters around the nation. These spills range from small ship collisions to fuel transfer mishaps to massive spill events like the BP Deepwater Horizon oil spill. The release of oil and chemicals into our coastal waterways is a major problem. Spills can kill wildlife, destroy habitat, and contaminate critical resources in the food chain. Spills can also wreak havoc on the economies of coastal communities by forcing the closure of fisheries, driving away tourists, or temporarily shutting down navigation routes. And these environmental and economic damages can linger for decades.” USA National Oceanic and Atmospheric Administration. 2014. “Oil and Chemical Spills.” oceanservice.noaa.gov/hazards/spills/.

---

<table>
<thead>
<tr>
<th>Activity</th>
<th>Resulting Social Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port facilities and shipping-related water pollution (cont’d)</td>
<td>Experience around the globe indicates that industry-related shipments into and out of Jamaica almost certainly have resulted in spills of oil and other hazardous materials, and will continue to do so in the future. These spills likely have adverse effects on human health and the productivity of the environment. Of particular concern is pollution from these sources:</td>
</tr>
</tbody>
</table>

- **Ballast water.** A ship’s crew pump ballast water into and out of tanks to control the vessel’s centre of gravity and improve its flow through the sea. Ballast water acquired elsewhere may contain organisms and substances that would be harmful when released into the waters at or near Jamaica (OECD, 2011).

- **Bilge water.** Water that leaks into a ship often contains oil products and other contaminants that can be hazardous or even explosive.

- **Sewage and wastewater.** Sewage and wastewater generated by a ship’s crew can contain organic, biological, chemical, and toxic pollutants, including oil products, resulting from accidental spills of cargo and the ships’ operations. About 90 percent of ships lack the ability to separate oil from the wastewater stream and discharge it into open water (Bailey et al., 2004).

- **Hazardous-material spills.** Accidental spills of oil and other hazardous materials can occur from collisions or equipment malfunctions.

- **Antifouling substances.** Paint used on a ship’s outer hull often contains additives intended to deter the growth of marine organisms. These additives can leach into the water as the ship sits in port, with toxic effects on humans and other organisms.

- **Stormwater and wastewater runoff.** Water that flows over the land’s surface and into the port can carry harmful pollutants. This water can come from precipitation (stormwater) or from spills (wastewater) from industrial activities, motor vehicles, or other sources.

---

Table 10 continued
<table>
<thead>
<tr>
<th>Activity</th>
<th>Resulting Social Costs</th>
</tr>
</thead>
</table>
| Port facilities and shipping-related water pollution (cont’d) | Shipping-related spills can directly and indirectly harm human health, via several mechanisms (Ordinhioha and Brisibe, 2013):  
   • Oil spills can cause known carcinogens to spread in the water and soils. As with all known carcinogens, they do not have any safe levels, as even a few molecules can damage human genetic material.  
   • Oil spills also can contaminate water, air, soils, and food with other harmful materials, including heavy metals and hydrocarbons.  
   • Eating contaminated fish or other foods can have serious health consequences. Oil spills and clean-up activities correlate with higher incidence of respiratory problems, and some evidence suggests exposure to oil can lead to reproductive problems, for example. |
| Industry-related air pollution               | Industry-related air pollutants have negative health effects on humans, livestock, fish, and wildlife. Pollution results from mining, processing, onshore transportation, shipping, and electricity generation. Dangerous substances include particulates, sulphur oxides, nitrogen oxides, and ozone. Much of this pollution comes from the burning of diesel fuel or similar fuels. Extensive reviews of relevant studies of the human-health effects of air pollution from diesel engines concluded (California Office of Environmental Health Hazard Assessment, 2007; Ammann and Kadlec, 2008):  
   • Diesel exhaust contains more than 40 toxic air contaminants.  
   • Higher levels of fine-particulate pollution correlate with increase in premature deaths, hospital admissions, and asthma attacks.  
   • Long-term exposure to diesel exhaust can lead to cancer. The risk of lung cancer is greatest for people – such as dock workers, truck drivers, railroad workers, and equipment operators – who operate or work near diesel equipment. The risk also is high for people who live near roads and other locations where diesel exhausts are high.  
   • Compounds in diesel exhaust correlate with higher incidence of pneumonia, influenza, other respiratory infections, heart attack, stroke, and bladder cancer.  
   • Males’ exposure to diesel exhaust correlates with diminished reproductive performance by reducing sperm quality, and increased frequency of birth defects among their children. |

*Table 10 continued*
Currently available information from within Jamaica about the levels of pollution, and the populations exposed to them, is not sufficient to support a detailed description of the resulting reduction in economic well-being, but research from around the globe demonstrates that these pollutants will have these negative effects on human health:

- premature death;
- hospital admissions (respiratory causes);
- hospital admissions (cardiovascular causes);
- asthma and other lower respiratory symptoms;
- acute bronchitis;
- work loss days;
- minor restricted activity days; and
- school absence days.

Mining activities and the movement of trucks and other vehicles along haul roads also generate high levels of dust. Dust from roads settles on nearby properties, diminishing quality of life for inhabitants. People incur additional costs to clean laundry, homes, crops, vehicles, etc. Each of these negative effects represents a social cost imposed on Jamaica and Jamaicans by the bauxite-alumina industry.

Past and current activities by the bauxite-alumina industry diminish biological diversity locally and across the island.

Cutting down trees for a new mine and roads eliminates the ability of forests and other biota to provide beneficial services to residents of nearby communities, Jamaicans living farther away, and tourists. Tree removal, for example, can increase local temperatures and decrease rainfall, diminishing quality of life, crop productivity, reliability of food supplies, and access to water supplies for residents.

Lands cleared for mining activities, roads, and processing facilities exhibit productivity far below what would exist absent these activities. At least one-quarter of lands that have exhausted ore bodies have been reclaimed (Drakapoulos, 2018), but reclaimed sites experience a reduction in productivity.

Industry activities can diminish the quantity and degrade the quality of water supplies. Hazardous waste spills associated with alumina-refining operations degrade the quality of water in receiving streams and can render the water harmful to humans, livestock, fish, and wildlife (Wilson, 2019).

Table 10 continued
Activity | Resulting Social Costs
---|---
Environmental degradation (cont’d) | Industry emissions of hazardous materials degrade air quality and harm wildlife.
Some industry activities, e.g. the construction of ponds at the bottom of reclaimed pits, encourages the spread of disease-transmitting mosquitoes and invasive species (JBI, n.d.).
Mine-related roads fragment ecosystems, reducing their biodiversity and productivity, and degrading their ability to recharge aquifers. They also increase access to adjacent areas and facilitate poaching, unlicensed logging, and other illegal activities that result in ecosystem degradation.

Ecosystem services | A healthy ecosystem contributes to human well-being by providing benefits, known as “ecosystem services,” to the individuals, families, businesses, and communities of Jamaica, and to the global society. Some ecosystem services, such as attracting and providing pleasant experiences for tourists, involve market transactions: the tourists spend money for gear and equipment, transportation, guide services, and meals and accommodation. The associated market prices for their expenditures can indicate the economic importance, or value of the recreational benefits they enjoy from visiting the area. Many ecosystem services, however, do not intersect with markets – they are not bought and sold and have no market prices. The absence of market prices, though, does not mean these benefits have no value. Instead, the absence of markets occurs because it is too difficult to trade an ecosystem service or because the ecosystem service is too valuable to be traded, i.e., buying and selling the service would violate cultural norms. In these instances, the economic importance of the ecosystem service must be measured using non-market techniques.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) – an institution comparable to the Intergovernmental Panel on Climate Change (IPCC) – has developed a framework that recognizes the importance of “nature’s contributions to people” coming from both market and non-market ecosystem services. (Diaz et al., 2018). The IPBES identifies these 18 categories of ecosystem services:

1. Habitat creation and maintenance
2. Pollination and dispersal of seeds and other propagules
3. Regulation of air quality
4. Regulation of climate
5. Regulation of ocean acidification
6. Regulation of freshwater quantity, location, and timing
7. Regulation of freshwater and coastal water quality

Table 10 continued
### Ecosystem services (cont’d)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Resulting Social Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Formation, protection, and decontamination of soils and sediments</td>
</tr>
<tr>
<td>9.</td>
<td>Regulation of hazards and extreme events</td>
</tr>
<tr>
<td>10.</td>
<td>Regulation of detrimental organisms and biological processes</td>
</tr>
<tr>
<td>11.</td>
<td>Energy</td>
</tr>
<tr>
<td>12.</td>
<td>Food for humans and feed for livestock</td>
</tr>
<tr>
<td>13.</td>
<td>Materials, companionship, and labour</td>
</tr>
<tr>
<td>14.</td>
<td>Medicinal, biochemical, and genetic resources</td>
</tr>
<tr>
<td>15.</td>
<td>Learning and inspiration</td>
</tr>
<tr>
<td>16.</td>
<td>Physical and psychological experiences</td>
</tr>
<tr>
<td>17.</td>
<td>Supporting identities</td>
</tr>
<tr>
<td>18.</td>
<td>Maintenance of options</td>
</tr>
</tbody>
</table>

The bauxite-alumina industry – through mining, roads, refining activities, shipping activities, and the emission of pollutants – diminishes the supply of these ecosystem services that are available from Jamaica’s ecosystems. These reductions in ecosystem services impose social costs, i.e., reduce the economic well-being of Jamaicans, now and in the future.

### Damage to property

Industry activities – road construction, mining, traffic on haul roads, emissions of harmful materials – can diminish the value of property, both private and public:

- Airborne alumina and bauxite dust corrode the galvanized iron (zinc) roofing in the area.
- Damage from dust, etc. to cars, clothes drying on outside lines, vegetation.
- Dusting of water-catchment areas providing water supplies for families, businesses, and communities.
- Changes in the water cycle.

### Soil

Industry activities – road construction, mining, traffic on haul roads, emissions of harmful materials – can degrade the productivity of soils through:

- Contamination by heavy metals.
- Loss of water-holding properties of bauxitic soils.
- Reduction of soil quality, loss of soil processes.

### Carbon footprint

The bauxite-alumina industry increases greenhouse-gas levels in the atmosphere via three pathways:

- Direct emissions from the burning of fossil fuels, e.g. by trucks and heavy equipment.

*Table 10 continued*
<table>
<thead>
<tr>
<th>Activity</th>
<th>Resulting Social Costs</th>
</tr>
</thead>
</table>
| **Carbon footprint (cont’d)** | • Indirect emissions, e.g. by consuming electricity generated by the burning of fossil fuels.  
• Reductions in the sequestration of carbon dioxide from the atmosphere, resulting from the cutting of trees and soil degradation that prevents reforestation. |
| **Ore-reserve depletion** | Mining depletes the current and future value of its natural resource assets – bauxite ore, water resources, forest resources, biodiversity, etc. – without fully compensating for the depletion. Consequently, the nation will have diminished assets available for sustaining and improving the well-being of future generations. |
| **Risks** | Any increase in risk diminishes the economic well-being of those bearing the risks. The bauxite-alumina industry imposes increased risks on Jamaicans in several ways:  
• Intensification of climate-related risks.  
• Reductions in biodiversity and environmental degradation increase risks that ecosystems will not have the ability to recover from stresses and, instead, will exhibit reduced ability to provide water, tourism attractions, etc. that contribute to Jamaicans’ well-being.  
• Air and water pollution increase health risks for current and future Jamaicans, livestock, fish, and wildlife.  
• Governmental incentives for the bauxite-alumina industry diminish resources and programmes for other sectors of the economy and increases risks for entrepreneurs, investors, and workers in other sectors.  
• Mud lakes from past, current, and future operations embody risks – leakage or catastrophic failure – to downstream communities and resources. These risks will increase over time without comprehensive efforts to diminish the risks (Water Resources Authority, 2011; Roche et al., 2017). |

**HOW BIG ARE THE SOCIAL COSTS BAXITE-ALUMINA PRODUCTION IMPOSES ON JAMAICANS?**

To measure the social costs imposed on Jamaicans, economists look at the economic value of the reductions in well-being that they experience from the activities of the bauxite-alumina industry. Some components of this value can be measured in a straightforward manner: for example, the money people pay to secure healthcare for their children made ill by the industry.
try’s air pollution, although direct causation can be challenging to prove. Many components of the social costs, however, are more difficult to measure, because they are not traded in markets and have no price. These include the pain and suffering that people endure when they are made ill by air pollution, as well as reductions in well-being that result from degradations in the environment – water, air, forests, soils, marine systems, etc.

Jamaica has not compiled sufficient data to develop a thorough estimate of the value of the social costs – both priced and unpriced – the industry imposes on Jamaicans. The available information is sufficient, however, to provide preliminary estimates of some of the social costs. These estimates come from looking at Jamaica and the bauxite-alumina industry in the context of research conducted in other countries or globally.

**Illustration of the Social Costs from Mining: Cesar, Colombia**

Most Jamaicans appear to be aware of some of the social costs resulting from the bauxite-alumina industry’s operations – such as the costs homeowners endure to cope with dust from traffic on nearby haul roads, or the costs families and communities incur when they are displaced by the expansion of mines and roads. They have not, however, had access to a comprehensive assessment of the magnitude of the industry’s social costs. Hence, many may not be aware of the different types of social costs, or of the potential that these costs might outweigh the industry’s economic benefits. This section provides some context, by describing recent research in the region – of coal mining in Colombia – that shows it is not unusual for a mining industry to generate a broad set of social costs that, in sum, outweigh the economic benefits.

Researchers recently developed sufficient data to estimate the social costs imposed on the local community and the nation by coal mining in Cesar, Colombia (Table 11) (Cardoso, 2015). Their findings are useful because they demonstrate that, with sufficient time and appropriate data, similar estimates of social costs could be developed for Jamaica’s bauxite-alumina industry. They also illustrate the rough, potential general magnitude of the social costs from bauxite-alumina industry, insofar as many of the categories of social costs from coal overlap with those imposed by the bauxite-alumina industry. For example, the health costs from air pollution (gas emissions and dust) from coal mining in Colombia are about USD0.23–7.31 per tonne.

Overall, the estimates of social costs imposed on the local community and on Colombians as a whole sum to USD110.10–161.01 per tonne of coal mined and shipped from the country. The researchers compared the social costs with the market price of coal, which, in 2012, fluctuated between USD90.3 and USD100.57, and concluded that the social costs per tonne of coal exceed the market price per tonne. In other words, the costs of producing coal exceed the benefits and the net effect on economic welfare is negative, with the benefits accruing to the corporations and government revenues, while the costs are incurred by citizens. The negative effects are even larger than indicated by this research, because the lack of suitable data kept the researchers from estimating all of the social costs, especially those associated with the loss of ecosystem services that result from coal mining.
### Table 11: Social Costs from Coal Mining in Cesar, Colombia

<table>
<thead>
<tr>
<th>Social Cost</th>
<th>Cost (USD/tonne 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social costs imposed on local community</strong></td>
<td></td>
</tr>
<tr>
<td>Air pollution (health impacts from gas emissions and coal dust)</td>
<td>0.23 - 7.31</td>
</tr>
<tr>
<td>Soil degradation (mine waste)</td>
<td>39.78 - 59.61</td>
</tr>
<tr>
<td>Water quality loss</td>
<td>0.38 - 0.50</td>
</tr>
<tr>
<td>Loss of agricultural land (crops and livestock)</td>
<td>1.82 - 6.50</td>
</tr>
<tr>
<td>Involuntary relocation (912 families)</td>
<td>0.58 - 1.02</td>
</tr>
<tr>
<td>Ecosystem services loss</td>
<td>Insufficient data</td>
</tr>
<tr>
<td>Public health loss</td>
<td>42.72 - 52.13</td>
</tr>
<tr>
<td><strong>Social costs imposed on the nation as a whole</strong></td>
<td></td>
</tr>
<tr>
<td>Transportation to port and shipping (noise and coal-dust pollution)</td>
<td>18.84 - 18.84</td>
</tr>
<tr>
<td>Transportation accidents (mortalities and injuries)</td>
<td>0.30 - 2.01</td>
</tr>
<tr>
<td>Coal-reserve depletion</td>
<td>5.44 - 13.09</td>
</tr>
<tr>
<td><strong>Total Local and National Social Costs</strong></td>
<td><strong>110.10</strong></td>
</tr>
</tbody>
</table>

### Air Pollution

The bauxite-alumina industry imposes social costs on Jamaicans when its emissions of harmful air pollutants create health risks for Jamaicans and have negative impacts on their health. Of particular concern are emissions of PM$_{2.5}$ (particulates, with diameter of less than 2.5 micrometres), SO$_2$ (sulphur dioxide), and NO$_x$ (nitrogen oxides). These pollutants come largely from the combustion of fossil fuels (and particulates also can materialize in the dust from traffic on haul roads, and the movement of materials at mines, industrial facilities, and waste disposal sites). The pollutants can cause illness and premature death for humans, livestock, and wildlife; diminish visibility; and degrade quality of life for those exposed to them.

Data from Jamaica and the USA provide initial estimates of the human-health-related social costs resulting from the bauxite-alumina industry’s emissions. Data from Jamaica show the approximate amount of each type of pollutant emitted by the industry each year. For example, the industry emits about 4,500 tons of PM$_{2.5}$ (Table 12), which was determined by adjusting data for the emissions of PM$_{10}$ (particulates, with diameter of less than 10 micrometres) and assuming that PM$_{2.5}$ constitutes two-thirds of PM$_{10}$ emissions. Data from the USA show the social costs resulting from each ton of each pollutant emitted into the atmosphere, and these figures are used to estimate the social costs for emissions in Jamaica, assuming that the pollutants have impacts on the health of Jamaicans similar to their impacts...
on the health of Americans. The social cost for PM$_{2.5}$ emissions is USD120,000–USD750,000 per ton. Multiplying the industry’s annual emissions, for each type of pollutant, times the corresponding human-health-related social cost per ton yields the social cost per annum for each pollutant: USD540 million–USD3.4 billion.

Existing research indicates that the numbers shown in Table 12 represent reliable cost estimates for the industry’s emissions of SO$_2$ and NO$_x$. New research findings for PM$_{2.5}$, however, indicate that the actual, true social costs from the industry’s particulate emissions are higher than those shown in Table 12. These new findings show that previous research significantly understated the actual, true social costs from the negative impacts of these air pollutants on human health. Specifically, the research shows that the combustion of fossil fuels causes health-related costs that are “roughly twice as bad as previously estimated” (Roberts, 2020). This adjustment raises the estimated social costs from PM$_{2.5}$ emissions to USD1.1 billion – USD6.8 billion. With this adjustment, the bottom row of Table 12 shows that the industry’s emissions of these three pollutants cause total human-health-related costs totalling USD2.9 billion–USD13 billion. Emissions of SO$_2$ and PM$_{2.5}$ are responsible for most of the costs.

### Table 12: Potential Social Cost (Mortality and Morbidity) from Industry Emissions of PM$_{2.5}$, SO$_2$, and NO$_x$ (USD 2010)

<table>
<thead>
<tr>
<th></th>
<th>PM$_{2.5}$</th>
<th>SO$_2$</th>
<th>NO$_x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry emissions (tons/per annum)$^a$</td>
<td>4,500$^b$</td>
<td>31,000</td>
<td>4,400</td>
</tr>
<tr>
<td>Social cost per tonne$^c$</td>
<td>$120,000 – $750,000</td>
<td>$31,000 – $210,000</td>
<td>$4,900 – $16,000</td>
</tr>
<tr>
<td>Social cost per annum$^c$</td>
<td>$540m – $3.4b</td>
<td>$960m – $6.5b</td>
<td>$22m – $70m</td>
</tr>
<tr>
<td>2X adjustment (recent research)$^d$</td>
<td>$1.1b – $6.8b</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Social Cost Per Annum</strong></td>
<td><strong>$2.9 billion–$13 billion</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*a* Emissions calculated by Dr Mark Chernaik, Staff Scientist, Environmental Law Alliance Worldwide (ELAW) using emissions data for PM$_{10}$ (particulates, with diameter of less than 10 micrometres), SO$_2$ and NO$_x$ from Jamaica National Environment and Planning Agency, and assuming that PM$_{2.5}$ constitutes two-thirds of PM$_{10}$ emissions. (Jamaica’s air-quality standards do not include PM$_{2.5}$ emissions, so bauxite-alumina companies are not required to report them and report PM$_{10}$ emissions, instead.)

*b* This number does not include PM$_{10}$ emissions in the dust generated by traffic on haul roads. Hence, it understates the full amount of PM$_{2.5}$ emissions resulting from the industry’s operations.

*c* Value represents the sum of the value of mortality impacts (premature mortality for young adults and infants), and morbidity impacts (non-fatal heart attacks; hospital admissions-respiratory; hospital admissions-cardiovascular (age>20); emergency-room visits for asthma (all ages), acute bronchitis (age 8–12), lower respiratory symptoms (asthmatics age 9–11); asthma exacerbation (age 6–18); lost work days (age 18–65); minor restricted-activity days (age 18–65)). U.S. Environmental Protection Agency. 2013. Estimating the Benefit per Ton of Reducing PM$_{10}$ precursors from 17 sectors: Technical Support Document.

*d* Recent research shows that the actual, human-health-related costs from particulate emissions are about twice previous estimates. Shindell, D. 2020 Health and economic benefits of a 2°C climate policy.
Data from the State of California in the USA provide additional detail regarding different ways in which humans experience health-related costs from exposure to airborne particulate pollution (Table 13). The data indicate that the costs per case range from USD17, for a person who suffers asthma or other respiratory symptoms, to almost USD8 million for a premature death resulting from exposure to the pollutants (Kniesner and Viscusi, 2019).

<table>
<thead>
<tr>
<th>Health Outcome</th>
<th>USD per case(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature death</td>
<td>$7,917,000</td>
</tr>
<tr>
<td>Hospital admissions (respiratory causes)</td>
<td>$33,500</td>
</tr>
<tr>
<td>Hospital admissions (cardiovascular causes)</td>
<td>$40,963</td>
</tr>
<tr>
<td>Asthma and other lower respiratory symptoms</td>
<td>$17</td>
</tr>
<tr>
<td>Acute bronchitis</td>
<td>$431</td>
</tr>
<tr>
<td>Work loss days</td>
<td>$180</td>
</tr>
<tr>
<td>Minor restricted activity days</td>
<td>$59</td>
</tr>
<tr>
<td>School absence days</td>
<td>$91</td>
</tr>
</tbody>
</table>

\(^a\) Values are expressed in 2005 US dollars.

Social Costs from Damage to Ecosystem Services

A healthy ecosystem can produce many distinct streamflow-related ecosystem services that provide benefits to different groups including these:

- **Downstream farmers**, who use water the ecosystem delivers in amounts and at times useful for irrigating crops.
- **Downstream municipal/industrial consumers**, who use water the ecosystem delivers in suitable amounts and with appropriate quality characteristics (e.g. without harmful compounds).
- **Downstream communities**, which rely on rivers and streams for domestic purposes, and which enjoy reduced flooding as the ecosystem regulates water runoff and diminishes peak flood flows.
- **Subsistence, commercial, and recreational fishers**, who catch fish that exist because the ecosystem provides suitable habitat.
- **Educators and students**, who study fish and other riverine organisms that exist because the ecosystem provides suitable habitat.
- **Visitors and local people**, who use rivers for recreation, and are willing to pay to enjoy a high-quality environment but are not willing to pay for the experience if the environment is degraded.
These examples show that a healthy ecosystem can provide economically important benefits to people through different activities, or with no activity at all; at scales from local to global; and involve individuals, families, business and other organizations, communities, and society as a whole.

Research conducted for the World Bank estimated the WTP value of four types of ecosystem services provided by Jamaica’s forests: recreation, habitat and species protection, non-wood forest products, and water (Siikamäki et al, 2015). The estimates indicate that each year, these four ecosystem services have a value of about USD154.20 per hectare (2013 dollars), and this value, applied across all the country’s forests, totals about USD52 million (Table 14). These estimates indicate that the present value of these services would total about USD2,340 per hectare. This amount indicates the asset value of these economic benefits that would be forgone if a hectare of forest were rendered unable to provide these services. It also indicates the value of the ecosystem services forgone when a new forest cannot be established on a mining site because mining activities have degraded soil productivity.

Table 14: Estimated Value (2013 USD) of Ecosystem Services Provided Annually by Jamaica’s Forest Ecosystems: Average per Hectare and Country Total

<table>
<thead>
<tr>
<th>Total</th>
<th>Recreation</th>
<th>Habitat</th>
<th>Non-wood Forest Products</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per hectare, average</td>
<td>154.2</td>
<td>17.1</td>
<td>0.1</td>
<td>72.9</td>
</tr>
<tr>
<td>Country total</td>
<td>52 million</td>
<td>5.8 million</td>
<td>21 thousand</td>
<td>35 million</td>
</tr>
</tbody>
</table>

A separate study looked at the value of ecosystem services derived from the ecosystem of the area known as Cockpit Country (Edwards, 2011). It found that the ecosystem provides aesthetic and other ecosystem services with a value of JMD2.6 billion–JMD4.2 billion dollars per annum. The study covered 1,160 square kilometres of roadless area, which indicates the value was JMD2.2 million–3.6 million per km². The analysis used the WTP approach for estimating the value of the ecosystem services and, hence, it probably understates the true value, insofar as the numbers reflect what Jamaicans are able to pay for the services, not what they believe the services are actually worth.

Climate-Related Social Costs

In 2012, the bauxite-alumina industry emitted 1,791,827.91 tonnes of CO₂ (NEPA, 2013) as it produced 9,372,801 tonnes of bauxite, or about one tonne of CO₂ for every five tonnes of bauxite (JBI, 2020). In 2018, the industry produced 10,272,268 tonnes of bauxite, indicating that the industry’s CO₂ emissions had risen to 1,963,780 tonnes.
Each tonne of CO$_2$ emitted intensifies the damage from the climate crisis (global warming, ocean acidification, etc.) for decades. The most recent peer-reviewed analysis shows that, with mid-level assumptions, these damages, called the social cost of carbon dioxide (SCCO$_2$), are expected to total USD417 per tonne CO$_2$ (tCO$_2$) (Ricke et al, 2018). The researchers who produced this estimate of the SCCO$_2$ reported that their analysis also indicates the true value could be USD800 per tCO$_2$, or about two times the expected value. Other research demonstrates that the social costs from CO$_2$ emissions could be perhaps eight times higher than the expected level (Cai et al, 2016; Schwalm, 2020; Slater, 2020). Eight times USD417 is about USD3,300 per tCO$_2$.

Combined, these numbers show that the social costs resulting from the CO$_2$ emissions of the bauxite-alumina industry are at least USD0.8 billion – USD6.5 billion (Table 15). It is important to note that this estimate represents only the industry’s direct emissions, i.e., the emissions from the fossil fuels it burns. The industry also bears responsibility for the social costs resulting from its indirect emissions – fossil fuels burned to generate electricity consumed by the industry – and from the industry’s negative impacts on Jamaica’s forests and their ability to sequester CO$_2$ from the atmosphere.

### Table 15: Estimated Social Costs of CO$_2$ Emitted by the Industry, for Range of Estimates of the Social Cost per Tonne of CO$_2$

<table>
<thead>
<tr>
<th></th>
<th>Social Cost per Tonne of CO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USD417</td>
</tr>
<tr>
<td>Direct emissions</td>
<td>$0.8 billion</td>
</tr>
<tr>
<td>Indirect emissions</td>
<td>Unknown</td>
</tr>
<tr>
<td>Forgone CO$_2$ sequestration</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Social Costs from Degradation of Biodiversity

The Government of the United Kingdom (UK) recently assessed the economic costs resulting from actions that degrade biodiversity (HM Treasury, 2020). The assessment concluded that actions conserving or improving biodiversity have an average rate of return on investment of about 19 percent, whereas actions that degrade biodiversity or prevent its conservation have an average rate of return of about five percent.

Rate of return is what society receives from making an investment, expressed as a percent of the investment. In this instance, an investment of USD100 million in bauxite-alumina production would earn USD5 million per annum. The same investment in conserving biodiversity would yield a return of USD19 million, realized through improvements in water supplies, better air quality, reductions in pollution-related illnesses, etc.”

The difference in the rates of return between actions conserving or improving biodiversity
(on the one hand) and actions degrading biodiversity or preventing its conservation (on the other hand) allows an assessment of the costs to biodiversity of the bauxite-alumina industry in Jamaica. Considering that financial resources are finite, whenever the bauxite-alumina industry in Jamaica degrades biodiversity – by establishing a new mine or haul road, failing to comprehensively reclaim lands harmed by previous mining, or emitting materials harmful to flora or fauna, etc. – it results in a social cost compared to a scenario in which the industry is investing the same funds on actions conserving or improving biodiversity. These social costs far exceed the benefits enjoyed by the industry (the industry’s rate of return on its investments in actions harming biodiversity or foregoing expenditures on actions conserving biodiversity). Although the industry takes these actions to earn or save itself money, the social costs in terms of biodiversity are about four times what the industry reaps by its choices. The difference is even greater when comparing these social costs against the share of the income or savings the industry shares with Jamaicans, through wages, government revenues, etc.

**CONCLUSIONS**

The preceding sections demonstrate that the bauxite-alumina industry imposes social costs on Jamaicans in many ways. Currently available data support quantification of just two categories of social costs. One represents costs associated with increases in human illness and premature death resulting from the industry’s emissions of harmful airborne pollutants: PM$_{2.5}$, SO$_2$, and NO$_x$. The social costs resulting from the industry’s emissions of these three pollutants are about USD2.9 billion – USD13 billion per annum (Table 16).

<table>
<thead>
<tr>
<th>Social Costs</th>
<th>Annual Benefits and Costs (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pollution (PM$_{2.5}$, SO$_2$, NO$_x$ emissions)</td>
<td>$2.9b–$13b</td>
</tr>
<tr>
<td>Climate change (CO$_2$ emissions)</td>
<td>$0.8b–$6.5b.</td>
</tr>
<tr>
<td>Other (loss of ecosystems services, etc.)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Benefits (GDP)</td>
<td>$1b</td>
</tr>
<tr>
<td><strong>Net Annual Cost</strong></td>
<td><strong>At least $2.7b–$18b</strong></td>
</tr>
</tbody>
</table>

The other measurable category of social costs is associated with the intensification of climate-related damages – stemming from increases in heatwaves and extreme weather, changes in ecosystems, acidification of the oceans, etc. – resulting from the industry’s emissions of carbon dioxide. The social costs resulting from the industry’s emissions of carbon dioxide are about USD0.8 billion – USD6.5 billion per annum.
Combined, these two categories of social costs total about USD4.7 billion–USD19 billion per annum.

Currently available data are not sufficient to support quantification of several categories of costs, such as the loss of ecosystem services, illness and death for livestock and wildlife, negative impacts on tourism, and loss of biodiversity, so the actual total social costs from the industry’s operations are larger.

A common metric for measuring these benefits is the industry’s contribution to Jamaica’s gross domestic product (GDP). In 2018, the nation’s GDP totalled about USD27 billion, and the bauxite-alumina industry contributed less than five percent of the total, or about USD1 billion (IMF, 2019; Theodora.com, 2020). The bottom row of Table 16 shows that the industry’s social costs exceed its economic benefits by at least USD2.7 billion to USD18 billion per annum.

These numbers show that the industry’s social costs exceed its benefits for Jamaica as a whole, but the disparity between the costs and benefits are especially large for some groups. The negative net effects are most notable, for example, for families and communities displaced by new mines and roads without full compensation, for those who live and own homes nearby and are subjected to harmful dust from traffic on haul roads, for the many Jamaicans who experience negative health effects from the industry’s emissions of hazardous air pollutants, and for Jamaicans harmed by changes in climate exacerbated by the industry’s emissions of carbon dioxide.

---

6 GDP measures the monetary value of all goods and services produced by businesses, non-governmental organizations, and government. It is important to note that payments from the industry to others – workers, displaced landowners, and government – represent components of the total benefit measured by the industry’s contribution to Jamaica’s GDP. They are not additional benefits, to be added to GDP.
REFERENCES


http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate2964.html


https://www.jstor.org/stable/27862879?seq=1


The Authors

(in order of appearance)

DIANA McCaulay is Founder and current Director of the Jamaica Environment Trust (JET). She holds a Master’s in Public Administration from the University of Washington in Seattle, USA, and a Graduate Certificate in International Development Policy. She has received many awards for her environmental work, including a Bronze Musgrave Medal from the Institute of Jamaica, and the Order of Distinction (Officer class) from the GOJ. She also contributed to the report of the Intergovernmental Panel on Climate Change, which received the Nobel Peace Prize in 2007.

TINA RENIER is the Policy Officer at the Atlantic Council for International Cooperation. She specializes in labour and development and international development policy, strategy and evaluation. She was an editorial assistant for a prominent Canadian labour studies journal, ‘Labour, Capital and Society’ in 2019. Her research paper focuses on the connections between development strategies and decent work. She holds a Bachelor of Science in International Relations from the University of the West Indies, Mona, and a Master of Arts in International Development Studies from Saint Mary’s University in Canada.

JORDAN HOWELL is a PhD candidate at Harvard University. He specialises in the political economic history of the North American West and Caribbean in the twentieth century. For three summers, Jordan worked in the potrooms of ALCAN’s aluminum smelter in Kitimat, British Columbia. His dissertation is about land, labour, and energy in the aluminum industry.

DR ANTHONY GREENAWAY is a laboratory management and data (chemical/environmental) interpretation consultant. He recently retired from The University of the West Indies, Mona, where his focus was on environmental and industrial chemistry, particularly issues of the bauxite-alumina industry and water quality, including data quality.

HORACE LEVY is a civil society advocate and former Senior Lecturer in the Department of Sociology, Psychology and Social Work, the Social Work Unit, of the University of the West Indies (UWI); he was a member of the research team, International Centre for Environment and Nuclear sciences, UWI, in study of cadmium on health/agriculture in bauxite mining in central Jamaica and is the author of several publications on community, violence, and civil society.
**DR PETA-ANNE BAKER** is a professional social worker with a master’s degree in Development Studies from Sussex University in England and a PhD in Social Welfare from Case Western Reserve University in the USA. She has extensive experience in the non-governmental sector, including serving as Chair of the Board of the Environmental Foundation of Jamaica. Her practice has focused on helping to establish and strengthen grassroots, community-based or intermediate service organizations; designing, implementing, and evaluating development programmes; and contributing to policy formulation and advocacy.

**DR PATRECE CHARLES** is a public health specialist, holding a Doctorate in Public Health from the University of the West Indies with a specialty in Environmental Health Management which she obtained from Johns Hopkins University in the USA. Dr Charles also holds a master’s degree in Public Health from Florida International University and a Master of Science degree in Counselling Psychology. She is also currently enrolled as a PhD student in Counselling Psychology at the Northern Caribbean University. She is a commissioned Justice of the Peace in the parish of St Andrew.

**DR SUSAN KOENIG** is a wildlife ecologist with a Doctorate in Forestry and Environmental Studies from Yale University. She operates Windsor Research Centre (WRC), a site-based NGO which she co-founded in 2002 to improve the protection of Jamaica’s globally unique Cockpit Country. She currently serves on Jamaica’s scientific delegation to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and is an honorary member of the Jamaica Veterinary Medical Association, which supports the One Health global alliance – an approach that recognizes that the health of people is closely connected to the health of plants and animals in a shared environment.

**ERNIE NIEMI** is President of Natural Resource Economics, a consultancy in Eugene, Oregon, USA. He has a Master’s degree in city and regional planning from Harvard University and specializes in applying the principles of cost-benefit analysis, economic valuation, and economic-impact analysis in the context of natural resource management, economic development, and public policy decisions. He has described the social costs and benefits of activities that affect communities associated with many types of ecosystems: forest, dryland, montane, riparian, lake, river, grassland, urban, savannah, estuarine, marine, coastal, and island.
The following organizations received a copy of this study before publication and were invited to submit their input within a specified timeframe. No input was received by JET in time for inclusion.

- Access to Information Unit
- Forestry Department
- Jamaica Bauxite Institute (JBI)
- Mines and Geology Division (MGD)
- Ministry of Health and Wellness (MOHW)
- Ministry of Housing, Urban Renewal, Environment and Climate Change (MOHUECC)
- Ministry of Transport and Mining (MOTM)
- National Environment and Planning Agency (NEPA)
- Office of the Prime Minister (OPM)
- Water Resources Authority (WRA)
- Statistical Institute of Jamaica (STATIN)
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidic</td>
<td>Having the properties of an acid, with a pH less than 7.</td>
</tr>
<tr>
<td>Alkaline</td>
<td>Having the properties of an alkali, with a pH greater than 7.</td>
</tr>
<tr>
<td>Alveoli</td>
<td>Tiny air sacs at the end of the bronchioles (air tubes in the lungs). The alveoli are where the lungs and the blood exchange oxygen and carbon dioxide during the process of breathing in and breathing out.</td>
</tr>
<tr>
<td>Ambient, Ambient Temperature</td>
<td>Relating to immediate surroundings. Ambient temperature is the outside air temperature.</td>
</tr>
<tr>
<td>Anthropogenic</td>
<td>Originating in human activity.</td>
</tr>
<tr>
<td>Aquatic, Aquatic Biota</td>
<td>Related to water. Aquatic biota are organisms living in or dependent on water at some stage of their life cycle.</td>
</tr>
<tr>
<td>Aquifer</td>
<td>A body of rock and/or sediment that holds ground water.</td>
</tr>
<tr>
<td>Bauxite, Bauxitic soils</td>
<td>The name applied to aluminum-bearing rocks and soils when the aluminum content is considered high enough for commercial mining.</td>
</tr>
<tr>
<td>Bayer Process</td>
<td>The principal industrial means of refining bauxite to produce alumina (aluminium oxide) developed by an Austrian chemist, Carl Josef Bayer, in 1888.</td>
</tr>
<tr>
<td>Bioaccumulation</td>
<td>The gradual accumulation of substances, such as pesticides or chemicals, in an organism.</td>
</tr>
<tr>
<td>Biodiversity, Biological Diversity</td>
<td>All of the different kinds of life (species) on Earth.</td>
</tr>
<tr>
<td>Biomass</td>
<td>Organic material that comes from plants and animals.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Biota</td>
<td>The animal and plant life or a particular region, habitat or geological period.</td>
</tr>
<tr>
<td>Bromeliad</td>
<td>A family of flowering plants, found mostly in the tropical Americas. Many bromeliads store water in the base of tightly overlapping leaves, which is then used by a range of organisms.</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>A chemical compound composed of one carbon and two oxygen atoms. It is present in the Earth’s atmosphere at a low concentration and is one of the so-called greenhouse gases which cause global warming.</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>A dangerous odourless, colourless gas produced by the incomplete burning of carbon-containing materials, such as fossil fuels.</td>
</tr>
<tr>
<td>Cumulative Impacts</td>
<td>Changes to the environment and natural processes caused by the combined impact of past, present and future human activities.</td>
</tr>
<tr>
<td>Desiccation</td>
<td>Dryness resulting from the removal of water.</td>
</tr>
<tr>
<td>Doline karst</td>
<td>A doline (or sinkhole) is a natural enclosed depression found in karst landscapes.</td>
</tr>
<tr>
<td>Dry stacking</td>
<td>A method of treating insoluble residues produced by the Bayer Process.</td>
</tr>
<tr>
<td>Ecology, ecological</td>
<td>The study of the relations of organisms to one another and to their physical surroundings.</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>A community or group of living and non living organisms that live in and interact with each other in a specific environment.</td>
</tr>
<tr>
<td>Epiphyte</td>
<td>A plant that grows on another plant, and derives its moisture and nutrients from air, water or nearby debris.</td>
</tr>
<tr>
<td>Fauna</td>
<td>The animals of a particular region, habitat or geological period.</td>
</tr>
<tr>
<td><strong>Flora</strong></td>
<td>The plants of a particular region, habitat or geological period.</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Food web</strong></td>
<td>A graphical model depicting the many food chains linked together to show the feeding relationships of organisms in an ecosystem.</td>
</tr>
<tr>
<td><strong>Fossil fuel</strong></td>
<td>Buried combustible geologic deposits of organic materials, formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the Earth’s crust over hundreds of millions of years.</td>
</tr>
<tr>
<td><strong>Heavy metals</strong></td>
<td>Any metallic chemical element that has a relatively high density. Several, like mercury, cadmium and lead, can be poisonous at low concentrations.</td>
</tr>
<tr>
<td><strong>Humus, humic</strong></td>
<td>An organic component of soil, formed by the decomposition of leaves and other plant material by soil microorganisms. Humic substances are organic components of humus.</td>
</tr>
<tr>
<td><strong>Invasive species, invasive alien species</strong></td>
<td>Invasive alien species are plants, animals, pathogens and other organisms that are not native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health due to their spread in the absence of natural predators.</td>
</tr>
<tr>
<td><strong>Invertebrate</strong></td>
<td>Animals without a backbone (spine), like worms, jellyfish or spiders.</td>
</tr>
<tr>
<td><strong>Karst, karst systems, karstcape</strong></td>
<td>Terrain which is created by the chemical solution (in contrast to mechanical erosion) of a bedrock under conditions of high rainfall. In a karst landscape, there will be distinctive landforms and water drainage patterns of: (a) closed depressions on the land surface (like dimples on a golf ball); (b) disrupted (i.e., sinking/disappearing) surface drainage; and (c) caves and underground conduits through which water moves.</td>
</tr>
<tr>
<td><strong>Microbial, microbial activity</strong></td>
<td>A very small organism, such as a bacterium. The activity of very small organisms.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Moisture gradient</td>
<td>The difference in moisture content at different levels, for example in soil or wood.</td>
</tr>
<tr>
<td>Neutralized</td>
<td>Make an acidic or alkaline substance chemically neutral (pH=7).</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂),</td>
<td>Compound(s) of oxygen and nitrogen.</td>
</tr>
<tr>
<td>oxides of nitrogen (NOₓ)</td>
<td></td>
</tr>
<tr>
<td>Ozone, ground level ozone</td>
<td>A colourless, unstable toxic gas. Ground-level ozone is a highly irritating gas produced when nitrogen oxides (NOₓ) and volatile organic compounds (VOCs) in stagnant air react in the presence of sunlight.</td>
</tr>
<tr>
<td>Particulates, Particulate Matter (PM)</td>
<td>Solid and liquid particles suspended in air, many of which are hazardous.</td>
</tr>
<tr>
<td>Permeable</td>
<td>A substance that allows liquids or gases to pass through it.</td>
</tr>
<tr>
<td>Slurry</td>
<td>A mixture of solids suspended in a liquid, usually water.</td>
</tr>
<tr>
<td>Sodicity</td>
<td>The presence of sodium attached to clay in soil.</td>
</tr>
<tr>
<td>Substrate</td>
<td>A physical layer of rock or soil.</td>
</tr>
<tr>
<td>Sulphur dioxide (SO₂)</td>
<td>A toxic gas released naturally by volcanoes and anthropogenically as a by-product of several industries and the burning of fossil fuels.</td>
</tr>
<tr>
<td>Vertebrate</td>
<td>An animal with a backbone (spine), for example, mammals, birds and fish.</td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOCs)</td>
<td>Organic chemicals with a low boiling point, which allows their molecules to evaporate and enter the air. VOCs are numerous and varied and include both manmade and natural-occurring chemical compounds. They are often a source of odours.</td>
</tr>
<tr>
<td>Watershed</td>
<td>An area of land that drains into a specific waterbody.</td>
</tr>
</tbody>
</table>