RIVER MINING:
ENVIRONMENTAL AND SOCIAL IMPACTS
Report Title
Scoping and Assessment of the Environmental and Social Impacts of River Mining in Jamaica.

DFID project
R7814 – Effective Development of River Mining

Authors [affiliation]
Dr Magnus Macfarlane [MERN/Corporate Citizenship Unit, University of Warwick)
Dr Paul Mitchell [MERN Associate, University of Warwick/Environmental Consultant]

Bibliographic reference

Keywords
River mining, sand and gravel, environmental impacts, social impacts, Jamaica, in-river, floodplain

Cover picture: Typical small-scale (and in this case, illegal) in-river mining operation, Longville, Jamaica.
CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>4</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>6</td>
</tr>
<tr>
<td>1.0 SUMMARY</td>
<td>7</td>
</tr>
<tr>
<td>2.0 INTRODUCTION</td>
<td>9</td>
</tr>
<tr>
<td>3.0 METHODOLOGY FOR ASSESSING ENVIRONMENTAL AND SOCIAL IMPACTS</td>
<td>10</td>
</tr>
<tr>
<td>3.1 ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS</td>
<td>10</td>
</tr>
<tr>
<td>3.2 POSTDICTIVE SOCIAL IMPACT ASSESSMENT METHODOLOGY</td>
<td>11</td>
</tr>
<tr>
<td>4.0 ENVIRONMENTAL AND SOCIAL IMPACT SCOPING AND REVIEW</td>
<td>15</td>
</tr>
<tr>
<td>4.1 INTRODUCTION</td>
<td>15</td>
</tr>
<tr>
<td>4.2 POTENTIAL IMPACTS DURING EXTRACTION</td>
<td>19</td>
</tr>
<tr>
<td>4.2.1 Impact Group ‘P’ – Physical Impacts</td>
<td>19</td>
</tr>
<tr>
<td>4.2.2 Impact Group ‘W’ – Water Impacts</td>
<td>22</td>
</tr>
<tr>
<td>4.2.3 Impact Group ‘B’ – Biological Impacts (including Ecosystem Health)</td>
<td>28</td>
</tr>
<tr>
<td>4.2.4 Impact Group ‘H’ – Socio-Health Impacts</td>
<td>29</td>
</tr>
<tr>
<td>4.2.5 Impact Group ‘C’ – Socio-Cultural Impacts</td>
<td>31</td>
</tr>
<tr>
<td>4.2.6 Impact Group ‘E’ – Socio-Economic Impacts</td>
<td>33</td>
</tr>
<tr>
<td>4.2.7 Impact Group ‘L’ – Socio-livelihood</td>
<td>34</td>
</tr>
<tr>
<td>4.3 POTENTIAL IMPACTS DURING PROCESSING</td>
<td>35</td>
</tr>
<tr>
<td>4.3.1 Introduction</td>
<td>35</td>
</tr>
<tr>
<td>4.3.2 Impact Group ‘P’ – Physical Impacts</td>
<td>38</td>
</tr>
<tr>
<td>4.3.3 Impact Group ‘W’ – Water Impacts</td>
<td>38</td>
</tr>
<tr>
<td>4.3.4 Impact Group ‘B’ – Biological Impacts (including Ecosystem Health)</td>
<td>39</td>
</tr>
<tr>
<td>4.3.5 Impact Group ‘H’ – Socio-Health Impacts</td>
<td>39</td>
</tr>
<tr>
<td>4.3.6 Impact Group ‘C’ – Socio-Cultural Impacts</td>
<td>39</td>
</tr>
<tr>
<td>4.3.7 Impact Group ‘E’ – Socio-Economic Impacts</td>
<td>39</td>
</tr>
<tr>
<td>4.3.6 Impact Group ‘L’ – Socio-livelihood</td>
<td>40</td>
</tr>
<tr>
<td>4.4 POTENTIAL IMPACTS DURING TRANSPORT</td>
<td>40</td>
</tr>
<tr>
<td>4.4.1 Impact Group ‘P’ – Physical Impacts</td>
<td>40</td>
</tr>
<tr>
<td>4.4.2 Impact Group ‘W’ – Water Impacts</td>
<td>40</td>
</tr>
<tr>
<td>4.4.3 Impact Group ‘B’ – Biological Impacts (including Ecosystem Health)</td>
<td>40</td>
</tr>
<tr>
<td>4.4.4 Impact Group ‘H’ – Socio-Health Impact</td>
<td>40</td>
</tr>
<tr>
<td>4.4.5 Impact Group ‘C’ – Socio-Cultural Impact</td>
<td>41</td>
</tr>
<tr>
<td>4.4.6 Impact Group ‘E’ – Socio-Economic Impact</td>
<td>41</td>
</tr>
<tr>
<td>4.5 CONCLUSIONS</td>
<td>41</td>
</tr>
<tr>
<td>5.0 DESCRIPTION OF FIELD STUDIES IN JAMAICA</td>
<td>46</td>
</tr>
<tr>
<td>5.1 Overview</td>
<td>46</td>
</tr>
<tr>
<td>5.2 Impacts Relative to Scale and Type of Operation</td>
<td>47</td>
</tr>
<tr>
<td>6.0 CODE OF PRACTICE</td>
<td>53</td>
</tr>
<tr>
<td>7.0 CONCLUSIONS AND RECOMMENDATIONS</td>
<td>78</td>
</tr>
<tr>
<td>8.0 REFERENCES</td>
<td>80</td>
</tr>
<tr>
<td>9.0 GLOSSARY</td>
<td>85</td>
</tr>
</tbody>
</table>

---

[1] It is recommended that this section is read in conjunction with the report by Weeks et al (2003).
Preface

Throughout the developing world, river sand and gravel is widely exploited as aggregate for construction. Aggregate is often mined directly from the river channel as well as from floodplain and adjacent river terrace deposits. Depending on the geological setting, in-stream mining can create serious environmental impacts, particularly if the river being mined is erosional. The impacts of such mining on farmland, river stability, flood risk, road and bridge structures and ecology are typically severe. The environmental degradation may make it difficult to provide for the basic needs (water, food, fuel-wood, communications) of communities naturally located in the river valleys.

Despite the importance of this extractive industry in most developing countries, the details of its economic and environmental geology are not fully understood and therefore do not adequately inform existing regulatory strategies. The main problem is therefore a need to strengthen the general approach to planning and managing these resources. Compounding the problem is the upsurge of illegal extractions along many river systems. There is therefore a need to foster public awareness and community stewardship of the resource.

The project ‘Effective Development of River Mining’ aims to provide effective mechanisms for the control of sand and gravel mining operations in order to protect local communities, to reduce environmental degradation and to facilitate long-term rational and sustainable use of the natural resource base. The UK’s Department FOR International Development (DFID) has funded this project (Project R7814) as part of their Knowledge and Research (KAR) programme. This programme constitutes a key element in the UK’s provision of aid and assistance to less developed nations. The project started in October 2000 and terminates late in 2004.

Specific objectives of the project include:

- Resource exploration and resource mapping at the project’s field study sites (Rio Minho and Yallahs rivers in Jamaica)
- Analysis of technical and economic issues in aggregate mining, particularly river mining
- Determination and evaluation of the environmental impacts of river mining
- Evaluation of social/community issues in the context of river mining
- Investigation of alternative land and marine aggregate resources
- Review of the regulatory and management framework dealing with river mining; establishment of guidelines for managing these resources and development of a code of practice for sustainable sand and gravel mining.

The ‘Effective Development of River Mining’ project is multidisciplinary, involving a team of UK specialists. It has been led by a team at the British Geological Survey comprising David Harrison, Andrew Bloodworth, Ellie Steadman, Steven Mathers and Andrew Farrant. The other UK-based collaborators are Professor Peter Scott and John Eyre from the Camborne School of Mines (University of Exeter), Dr Magnus Macfarlane and Dr Paul Mitchell from the Corporate Citizenship Unit at the University of Warwick, Steven Fidgett from Alliance Environment and Planning Ltd and Dr Jason Weeks from WRe-NSF Ltd. The research project is generic and applicable to developing countries worldwide, but field studies of selected river systems have been carried out in Jamaica and review studies have been undertaken in Costa Rica. Key participants in these countries have included Carlton Baxter, Coy Roache and Larry Henry (Mines and Geology Division, Ministry of Land and Environment, Jamaica), Paul
Manning (formerly Mines and Geology Division, Ministry of Land and Environment, Jamaica) and Fernando Alvarado (Instituto Costaricencense de Electricidad, Costa Rica).

This report forms one of a series of Technical Project Output Reports listed below:

- **Geology and resources of the lower Rio Minho valley and Yallahs Fan-delta, Jamaica, 2003.** AR Farrant and SJ Mathers, British Geological Survey.
- **Aggregate production and supply in developing countries with particular reference to Jamaica, 2003.** PW Scott, JM Eyre (Camborne School of Mines) and DJ Harrison, British Geological Survey.
- **Assessment of the ecological effects of river mining in the Rio Minho and Yallahs rivers, Jamaica, 2003.** JM Weeks, I Sims and C Lawson, WRc-NSF Ltd.
- **Scoping and assessment of the environmental and social impacts of river mining in Jamaica, 2003.** M Macfarlane and P Mitchell, Warwick Business School, University of Warwick.
- **Alluvial mining of aggregates in Costa Rica, 2003.** Fernando Alvarado Villalon (Costa Rican Institute of Electricity) and DJ Harrison, British Geological Survey.
- **Planning guidelines for management of river mining, 2003.** S Fidgett, Alliance Environment and Planning Ltd.

Details of how to obtain these reports and more information about the ‘Effective Development of River Mining’ project can be obtained from contacting the Project Manager, David Harrison at British Geological Survey, Keyworth, Nottingham, UK, email: djha@bgs.ac.uk
Acknowledgements

The authors would like to thank the many organisations in Jamaica and Costa Rica who have contributed to the project. In addition to the collection of data, many individuals have freely given their time and advice and provided the local knowledge so important to the field investigations. In particular the authors wish to thank the project team at British Geological Survey including David Harrison, Andrew Bloodworth, Ellie Steadman, Steven Mathers and Andrew Farrant and the other UK-based collaborators including Professor Peter Scott and John Eyre from the Camborne School of Mines (University of Exeter), Steven Fidgett from Alliance Environment and Planning Ltd for his work on the Code of Practice and Dr Jason Weeks from WRC-NSF Ltd, all of whom have been enormous fun to work with.

In Jamaica and Costa Rica, the authors want to thank Carlton Baxter, Coy Roache and Larry Henry (Mines and Geology Division, Ministry of Land and Environment, Jamaica), Paul Manning (formerly Mines and Geology Division, Ministry of Land and Environment, Jamaica) and Fernando Alvarado (Instituto Costarricense de Electricidad, Costa Rica) for their facilitation of field and review work. Finally, the authors want to give very special thanks to Rochelle Wright (Mines and Geology Division, Ministry of Land and Environment, Jamaica) whose efficiency and kindness made our work in Jamaica a highly productive, informative and enjoyable experience.
1.0 SUMMARY

The work presented here is part of DFID project R7814 – ‘Effective Development of River Mining’, which seeks to decrease the environmental and social impacts associated with river mining while increasing sustainable economic activity.

The primary objective of the work reported here was the assessment of environmental and social impacts of river mining in Jamaica. The secondary objective was the development of a ‘Code of Practice’ that outlined potential measures and that – if adopted – would prevent or mitigate the major environmental and social impacts of river mining activities in Jamaica and elsewhere.

The impact assessment has been undertaken in two stages:

1. A comprehensive desktop review of the potential impacts, based on existing literature relating to river mining. This literature is relatively extensive, but the degree to which Jamaica is specifically referenced is limited.
2. Fieldwork to identify the significance of the potential impacts in the specific environmental and social context of Jamaica and to identify any additional impacts not highlighted during the desktop review.

The scope of the fieldwork visit to Jamaica included the identification of significant social and environmental impacts at all phases of development, positive as well as negative, direct, indirect, and cumulative, permanent and temporary as well as the identification of appropriate technical and strategic mitigation measures to address these impacts. The sites broadly designated for investigation included all significant legal and illegal operations on the Yallahs river basin southeast of Kingston and the lower Rio Minho river basin west of Kingston on the southern side of Jamaica.

For the Yallahs river basin, visits were made over three days to the areas affected by river mining operations of Albion, Ghetto Lane, South Avon and Poor Mans Corner. In addition, the quarrying operations of Caribbean Aggregate Ltd. and Jamaica Pre-mix Ltd were visited. On the Rio Minho river basin visits were made over three days to the areas affected by river mining operations of Cotton Tree gully, Water Lane, Easington and Broken Bank. In addition, the quarrying operations of Sha-Gore, Black Brothers and Paul Chi were visited. The assessment of social impacts at the local level involved investigating the impacts of the river mining activity and the response of affected stakeholders based on the assessors’ own opinion, checklists, local secondary sources, participant observation and the result of semi-structured interviews with local project stakeholders. The project stakeholders included, but were not limited to, the management of operations and their employees, residents, health and police officials, council officials, customers, suppliers and local businesses.

Two additional days of fieldwork were dedicated to data gathering from key stakeholders of river mining at the strategic level. The assessment of social and environmental impacts at the strategic level involved investigating the impacts of the river mining activity and appropriate mitigation measures through semi-structured interviews with strategic project stakeholders. This included interviews with representatives of the Water Resources Authority, the National Environment and Planning, the Mines and Geology Division, the Quarry Advisory Committee, the National Works agency, and the Department of Tourism.
As might be expected, the two principal impacts of river mining activities are physical and aquatic – the remaining impacts are largely secondary ones that arise from the physical and water impacts. However, some ‘socio’ impacts cannot strictly be assigned to the environmental aspects alone, as they are often a hybrid of environmental, social and economic parameters. Some of these parameters may improve the social condition (such as income and local revenue generation) and some may reduce it (such as loss of access to clean water).

The critical factors affecting the nature and degree of environmental and social impacts observed during the course of this research include; the legal status of the mine operators; regulatory development and enforcement; government agency co-ordination; agency funding and corruption. These interrelated factors are in no way unique to the Jamaican context and are typical of the natural resources sector and regulatory environments of many developing and even developed countries around the world.

The legal status of the mine operators themselves will clearly affect the ability of government agencies and the will of mine operators to mitigate environmental and social impacts. However, while by definition any unlicensed operator will be running an illegal operation, it has also been demonstrated that licensed operators may undertake illegal operations, although the potential for this diminishes from small/medium-scale to large-scale. This should not be taken to imply that large-scale operations will be in compliance with environmental and social regulations, but rather that the potential risk of them operating outside their licensed area is low. However, this partly relies on an assumption that appropriate existing regulation, the effective enforcement of that regulation, and consistent and regular monitoring are managed by well-resourced government agencies with comprehensively trained staff. This assumption does not appear particularly robust in the Jamaican context for a number of reasons. The first, though probably least significant, reason relates to the existence of appropriate regulation.

Monitoring and enforcement are undermined by regulatory inconsistencies and a lack of clarity regarding responsibilities and strategic priorities among and between government departments. As a result, responsibility for the monitoring of social and environmental impacts and the enforcement of mitigation and enhancement measures are falling between the various governmental departments. For instance, dust monitoring is the responsibility of Mines and Geology, NEPA and Department of Health and yet there is no co-ordinated monitoring programme between them. Legislative inconsistencies compound the problem of agency co-ordination. While NEPA has the legal right to demand an environmental impact assessment, there are conflicts and gaps between the NRC Act, Mining Act and Quarries Control Act.

There is, therefore, a need to synthesise the legislation and develop a memorandum of understanding between departments regarding monitoring and enforcement responsibilities. In this, the collaborative efforts of the NRCA, the Environmental Warden Services of the Ministry of Environment and Housing, the National Security Force and the Judicial System will be critical. However, equally critical is clarifying and streamlining the process. One measure would be to ensure that agencies charged with monitoring have the enforcement authority. In this respect, NEPA should be given greater enforcement rights and capacity. Moreover, enforcement should not be the responsibility of departments like Mines and Geology who have an economic stake in mining as this places them in the position of ‘poacher and gamekeeper’.
2.0 INTRODUCTION

The primary objective of the work reported here was the assessment of environmental and social impacts of river mining in Jamaica. The secondary objective was the development of a ‘Code of Practice’ that outlined potential measures and that – if adopted – would prevent or mitigate the major environmental and social impacts of river mining activities in Jamaica and elsewhere.

The impact assessment has been undertaken in two stages:

1. A comprehensive desktop review of the potential impacts, based on existing literature relating to river mining. This literature is relatively extensive, but the degree to which Jamaica is specifically referenced is limited.
2. Fieldwork to identify the significance of the potential impacts in the specific environmental and social context of Jamaica and to identify any additional impacts not highlighted during the desktop review.

Within the report, environmental and social issues and impacts are considered holistically where possible, reflecting the fact that in many cases, social impacts derive from environmental issues and impacts. The report structure follows the same logical sequence adopted during the work programme:

- Identification of most appropriate methodological approach.
- Desktop review of potential environmental and social impacts.
- Field-based identification of the most significant impacts.
- Development of conclusions and recommendations.

In addition to the final conclusions and recommendations, a preliminary ‘Code of Practice’ has also been developed that outlines potential measures that can be adopted at technical (operational) and strategic levels to prevent or mitigate major environmental and social impacts.

The work presented here is part of DFID project R7814 – ‘Effective Development of River Mining’, which seeks to decrease the environmental and social impacts associated with river mining while increasing sustainable economic activity. Within the overall DFID project, a number of complementary research projects have been undertaken, including an assessment of the impact of river mining on river biota and ecosystem; a technical and economic evaluation of existing and alternative aggregate resources and an analysis of mineral planning, legislative and policy issues relating to river mining. The authors of this report have worked closely with the teams responsible for research on these interrelated projects, and suggest that their reports be read in conjunction with the work presented here. In particular the work of Weeks, Sims and Lawson (2003) represents a complementary perspective, offering preliminary biodiversity indicators as a means of directly measuring and monitoring many of the environmental impacts discussed here.
3.0 METHODOLOGY FOR ASSESSING ENVIRONMENTAL AND SOCIAL IMPACTS

3.1 ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS

Any industrial activity may cause directly or indirectly some degree of environmental impact, whether this is localised or of a wider significance in temporal or spatial terms. Consequently the concept of Environmental Impact Assessment (EIA) has rapidly grown in importance, and by the early 1990s, over 40 countries had EIA legislation, and this number has continued to grow (Treweek, 1999). However, it is important to recognise that a formal EIA is not always required – some activities may be so limited in terms of size or nature of their operations, or may be located in non-sensitive (e.g. urban) environments that the risk of environmental impacts is insignificant. In this project, the EIA concept has been used as it applies to a sectoral activity (i.e. river mining) rather than to one or more specific sites.

In its most simple form, an EIA represents the process of identifying, estimating and evaluating the environmental consequences of current or proposed actions (Vanclay & Bronstein, 1995). Traditionally, EIAs focus on direct impacts and their potential mitigation. However, many countries now require EIAs to address social issues, and most companies produce some form of integrated assessment, bringing together environmental and social issues. The two sets of approaches are sometimes difficult to combine: data collection methods, stakeholder groups and assessment timeframes may vary significantly between the two. Within this project, separate (but overlapping) assessments of environmental and social impacts were made. However, they were conducted at the same time, using the same sites and through interviews with identical stakeholder groups and therefore the analysis of environmental and social issues and impacts has been combined (as presented in Section 4, below). This approach is effective because to a large extent, social issues result directly or indirectly from impacts of river mining on the environment.

The EIA is a key component of the business planning process, which should be used at an early stage to identify and help consider projects or activities likely to cause significant adverse impacts and to ensure that such potential impacts are evaluated, minimised and mitigated as appropriate. The focus in this project was an evaluation of current river mining operations, the results of which could also be used to develop recommendations for preventative and mitigating measures at future operations.

A typical EIA will include the following stages:

(a) Initial environmental evaluation and screening – to determine if an EIA is required.
(b) Definition of environmental issues.
(c) Identification of impacts.
(d) Assessment of impacts.
(e) Prediction of impacts.
(f) Identification of mitigation measures and monitoring requirements.
(g) Monitoring.
(h) Auditing and review.
In the context of this project, stages (a) and (b) were undertaken as a desktop environmental evaluation, capturing all the potential issues and impacts (see Section 4, below). Stages (c) and (d) were undertaken as a means of identifying significant impacts within the longer list of potential impacts via direct observation and interviews with a range of stakeholders during visits to specific sites in Jamaica (see Section 5). Finally, stages (e)-(h) are represented by the ‘Code of Practice’ developed from the findings of the previous stages (see Section 6). It is clear therefore, that while conceptually an EIA framework has been used to structure the research, the authors have not undertaken a formal EIA, which lies outside the scope and remit of the project’s aims and objectives.

In many respects, an EIA only offers a ‘snapshot’ of an operation at a specific point in time. The nature of the operation may change as it proceeds through its lifecycle (from planning, development, and operation through to closure or abandonment). Therefore, ideally, an EIA should be undertaken for each lifecycle phase or major operational change, in order to identify positive and negative impacts of both the overall project, and of individual operations. However, this issue has been addressed in the context of this project by ensuring that sites at all stages of the project lifecycle were reviewed using existing literature, and visits to a range of sites made during field visits to Jamaica.

3.2 POSTDICTIVE SOCIAL IMPACT ASSESSMENT METHODOLOGY

According to the Interorganisational Committee for Guidelines and Principles of Social Assessment (ICGP, 1995):

‘Social impacts are the social consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organise to meet their needs, and generally cope as members of a society.’

Social impacts also include changes to the norms, values and beliefs of individuals and the society in which they live (Burdge & Vanclay, 1995). A simple way of describing the nature of social impacts would be as changes to one or more of the following:

- People’s ways of life - how they live, work, play and interact with one another.
- Their culture - shared beliefs, customs and values.
- Their community - its cohesion, stability, character, services and facilities.
- Their environment - the quality of the air and water people use, the availability and quality of the food they eat, the level of dust and noise they are exposed to, their safety, and their access to and control over resources (Vanclay, 1999).

As noted in Section 3.1, Environmental Impact Assessment (EIA) is already a well-established activity within many industrial sectors and is a requirement of many legislative authorities and multilateral and bilateral agencies. Until recently, however, the Social Impact Assessment (SIA) was an inconspicuous component of the EIA process, including those undertaken for large-scale mining operations (which out of a broad range of industrial operations have the greatest degree of commonality with river mining projects). However, in
the last few years, recognition of the potential of SIA to contribute to the planning of mining projects has grown considerably (McPhail and Davy, 1998). This has been reinforced by the mounting social activism of affected communities and pressure from other key stakeholders such as government, employees and NGOs.

SIA has been defined by the ICGP as:

\[\text{The process of assessing or estimating, in advance, the social consequences that are likely to follow from specific policy actions or project developments} \]

(ICGP, 1995)

The SIA process is designed to inform project planning, decision-making and ongoing management (Boggs, 1991). At the most fundamental level, the SIA process can provide direction in:

(a) Identifying social impacts.
(b) Projecting and predicting social impacts.
(c) Mitigation of negative social impacts, and enhancement of positive social impacts.

The approach to SIA used for this project departed from the traditionally predictive orientation of SIA. The focus of the research was instead to assess the social impacts of river mining, at both the generic and field level, after the impacts had occurred. This is sometimes referred to as ‘Postdictive SIA’. As a result, the SIA of river mining did not involve Stage (b) above. Instead, the focus and scope of the SIA of river mining was undertaken in three stages:

- **Stage One.** Identification, through desktop research and literature reviews, of general mining and river mining social impacts. This involved desk research to scope issues of mine developments and their socio-economic impact at the most general level. The results of this initial scoping study are presented in Section 4, below. Stage One is the most important preparatory procedure in the SIA process and helps to clarify the issues relevant to the field including the key social variables to be considered for analyses. The main method used to conduct the general scoping exercise is the review of relevant general secondary sources of information.

- **Stage Two.** Identification, through fieldwork in Jamaica, of the specific social impacts of river mining in the local context. This involved fieldwork in Jamaica to assess impacts relevant to the specific sites being assessed, including the identification of impacts at all phases of development, positive as well as negative, direct, indirect, or cumulative, permanent or temporary. The assessment of social impacts involved investigating the impacts of the river mining activity and the response of affected stakeholders based on the assessors’ own opinion, expert opinion, checklists, local secondary sources, participant observation and the result of semi-structured interviews with project stakeholders. This fieldwork is documented in greater detail in Section 4 of the report.

- **Stage Three.** Recommendations for mitigating negative and enhancing positive social impacts at the strategic and technical levels. Involved making recommendations for the mitigation of negative impacts and the enhancement of positive impacts at the river
mining sites. This was based on the assessors’ own experience as well as some expert opinion from key project stakeholders. It was important to recommend measures that involve, first, avoiding all adverse impacts, second, minimising any adverse impacts that cannot be avoided, and, third, compensating for unavoidable adverse impacts. Mitigation and enhancement measures were made both at the strategic and the technical level.

The italicised methods above, used during the stages of the SIA research, and their specific relevance to the SIA process, are described below:

**Checklists** are comprehensive generic listings of potential impacts based on past experience to aid data gathering and insure that no important factors are overlooked (Graham-Smith, 1993). Their task is therefore primarily one of impact identification. Checklists do not usually include direct or indirect cause-effect links to project activities, although there may be some prediction of the character and nature of the impact itself. Glasson et al. (1996) identify two main checklist used in SIA. Descriptive checklists give guidance on how to assess impacts and Questionnaire checklists formulate a set of questions to be answered regarding positive and negative impacts e.g. will the project provide job opportunities?

**Expert opinion** can contribute to the identification and prediction of impacts possibly neglected by the public or by mandatory considerations. There are several techniques for effectively obtaining expert input, including the Delphi technique (Finsterbusch, 1995). Delphi involves several iterative rounds of individually conducted interviews and questionnaires with the experts, returning to them with the results of earlier rounds for reassessment (Leistritz & Murdock, 1981).

**General Secondary Sources** provides a major guideline for future expectations can be general and past social experience. To know the probable impacts of a proposed project in location B, one of the best places to start is to assess, through general secondary sources, the impacts of an established project in location A. Finsterbusch (1995) suggests that such case studies and literatures should be summarised in a Standard Information Module (SIM). SIMs focus on the dominant impact patterns relevant to the type of project intervention under review. If these patterns are repeatedly documented then the new case, it is held, will approximate the patterns of the previous cases.

**Local Secondary Sources** are particularly useful in providing baseline information on the social, demographic and cultural context within which project-related social changes occur (Leistritz & Murdock, 1981; Bender-Motz, 1983). This can include sources such as census data, geographical data, administrative reports, and community accounts and newspaper reports. Relevant local literature searches are cheap and simple to conduct, reducing the financial and logistical requirements of the SIA and, used in conjunction with primary sources of data, provide a means of verifying the SIA (ICGP, 1995).

**Semi-Structured Interviews** are based on a checklist of general questions that can be revised at any time (Chambers, 1985). This leaves a degree of flexibility, so that if other questions are raised during the interview they can be explored. Interviewees are typically key informants, focus or mixed groups. It is important that those interviewed are made to feel at ease. It has therefore been suggested that interviews start with general questions before moving on to more sensitive areas (WHO, 1988). Gueye and Freudenberger (1991) suggest that interviews should be preceded by an explanation of why it is requested.
Participant Observation involves the SIA practitioner living among the people being researched, even learning their language and sharing as many of their experiences, customs and practices as possible. It is carried out in a relatively unstructured, free ranging and exploratory manner. Unlike classical anthropology, in SIA the emphasis tends to be on obtaining data over a shorter period, rather than dialogue over a more protracted period. As well as providing a good method of crosschecking alternative methods, participant observation allows for a rich contextual understanding of social groups and can inform the SIA from initial profiling through to long-term monitoring (Roper, 1983).

ICGP (1995) outlines a number of critical guiding principles that should govern the use of SIA. Seebohm (1997) provides a useful précis of these principles, which is outlined below. These principles were used during the planning and conduct of the research to structure and focus the SIA of river mining.

1. Identify data sources: use published scientific literature, secondary data and primary data from the affected area.
2. Identify and involve the public: including all potentially affected groups and individuals.
3. Focus the assessment: deal with the issues and concerns that really count not those that are easy to handle.
4. Provide feedback on social impacts to project planners and identify problems that can be solved with changes to the proposed action through mitigation or enhancement.
5. Make developments more socially sound.
4.0 ENVIRONMENTAL AND SOCIAL IMPACT SCOPING AND REVIEW

4.1 INTRODUCTION

The following section is based both upon a review of literature related to in-stream and flood plain exploitation of sand and gravel, and also upon relevant fieldwork carried out in Jamaica. However, the emphasis is very much on the former, as this was intended to be a broad-based assessment of the potential impacts rather than a site-by-site or country-specific analysis that would identify the major potential impacts to be considered in more detail during the limited period of fieldwork (see Section 5). As anticipated, the fieldwork proved useful in confirming many of the predicted impacts, and at demonstrating that some specific impacts could be correlated with certain types of operation, operator or environment. In many respects, the literature review can be viewed as an assessment of the causes of impacts, while the fieldwork was a social and environmental assessment of the effects of impacts.

Environmental and social impacts may be positive or negative in nature. For example, projects that enhance quality-of-life and that make people feel better about themselves and where they live have a positive impact. In contrast, projects or policies that debilitate the vitality of a community, or make people feel worse about themselves and where they live, have a negative impact. A distinction can be made between processes and impacts. Relocating a community, for example, is not, in itself, a social or environmental impact. It is a process that can cause social and environmental impacts such as anxiety or land degradation (Vanclay, 1999).

In assessing the potential environmental and social impacts of river sand and gravel mining, it is important to first define any limitation that may exist in applying subsequent generalizations to specific sites, environments and types of operation or operator. If a common basis exists for river mining in different countries, it can probably be found in a description of the principal activities that comprise the process of river mining itself:

- Extraction of raw material (including overburden and waste).
- Processing (including screening, crushing and washing).
- Transport (including products and wastes).

While there is a degree of ‘blurring’ between these three principal activities, they are a useful means of breaking the overall river mining lifecycle into smaller parts that aid the assessment of environmental and social impacts, and their causes. The use of this categorisation also allows for distinctions to be drawn between small-scale, and medium/large-scale river mining operations from the outset. Based on fieldwork in Jamaica the relative importance of each activity has been measured against the scale of operation and the results shown in Table 1.
Table 1. Relative importance of activities based on scale of operation

<table>
<thead>
<tr>
<th>Activity</th>
<th>Relevance to small-scale operators</th>
<th>Relevance to medium &amp; large-scale operators</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction</td>
<td>High</td>
<td>High</td>
<td>Extraction of material is the core activity for all scales of operation</td>
</tr>
<tr>
<td>Processing</td>
<td>Low</td>
<td>Medium-high</td>
<td>Small-scale operations tend to use very simple processing methods (e.g. the ‘A’ frame screen) as small volume sales will not support the capital or operating costs of more involved processing. Medium and large-scale operations may use crushing and multiple size separation stages to offer flexibility in meeting market demand for specific products, and to minimise waste</td>
</tr>
<tr>
<td>Transport</td>
<td>Low</td>
<td>High</td>
<td>Small-scale operations tend to offer a greater percentage of extracted materially locally, while larger operations may be required to ‘export’ to elsewhere to avoid local market saturation and also to meet demand for materials in areas where there are no local resources</td>
</tr>
</tbody>
</table>

While it cannot be assumed that they are universally applicable, these assumptions do serve as a useful starting point in trying to move from generalised statements on environmental impacts to those occurring at specific types of site. Consequently, potential impacts are described below according to the three principal activities noted above, and seven ‘Impact Groups’:

- Impact Group ‘P’ – physical impacts.
- Impact Group ‘W’ – water impacts.
- Impact Group ‘B’ – biological impacts (including ecosystem health).
- Impact Group ‘L’ – socio-livelihood impacts

This approach has been used in an attempt to disentangle otherwise complex and interlinked impacts – while simplistic in some respects relative to the ‘real world’; it is a useful tool in categorising impacts, and their sources. In practical terms the two principal Impact Groups are physical and water – the remaining groups are largely composed of secondary impacts that arise from the physical and water impacts. However, impacts in the ‘socio’ Impact Groups H, C and E cannot strictly be assigned to the environmental aspects alone, as they are often a hybrid of environmental, social and economic parameters. Some of these parameters may improve the social condition (such as income and local revenue generation) and some may reduce it (such as loss of access to clean water).
Table 2 shows how the subsequent parts of this section are structured, with each activity being assessed against the seven Impact Groups. The ‘ticks’ shown in Table 2 could theoretically be replaced by a simple ranking scheme for different types of operation, operator or environment by applying the weighting implicit in Table 1. From Table 1 it is clear that there is an immediate distinction between the environmental and social impacts of small-scale operations (that may be largely related to extraction) and those of larger-scale operations (that may be related to all three activities). By extension, for example, it can be inferred that the impact of small operations is at a local or river system level, while that of larger operations may have an extended footprint due to off-site processing, and transport.

The integration of Tables 1 and 2 would be an important step towards adapting the generalised review reported here in order to produce specific impact assessments according to the different types of operation (i.e. it would be possible to generate numerous tables similar to Table 2, with the ‘ticks’ replaced by numbers showing the relative importance of each Impact Group for each activity, within the context of the specific type of operation being considered). The overall ranked matrix would then become the ‘environmental profile’ for that particular operation type (e.g. large-scale formal, small-scale informal, large-scale coastal, large-scale inland and so on).

Before considering the potential environmental and social impacts, it is important to note the significance of synergistic and antagonistic factors that often exist at site or regional levels (some of which are summarised in Table 3). These may increase or reduce the severity of impacts relative to what they might be in the absence of such factors. It is equally important to note that in the case of social impacts a factor that reduces a specific impact for one stakeholder group may cause the same or a different impact to increase from the perspective of a different stakeholder group. Therefore, there is a large degree of subjective assessment and this clearly extends into the environmental arena, as it is environmental impacts that are often the cause of social impacts.

O’Faircheallaigh’s (1991) broad overview of the minerals industry stresses that environmental and social impacts rarely occur in isolation and usually affect and interact with one another. Nevertheless, literature to date relating to mining impacts has concentrated on biophysical impacts to the neglect of social impacts. Although the accumulation of knowledge is the raison d’être of social science, social science has given little attention to the social impacts of many major social system interventions including mining. Given their significance, their connectivity to biophysical impacts and the effort spent on predicting them, the paucity of
literature related to mining’s social impacts is cause for concern. However, if literature related to mining’s social impacts is scarce, literature related to the social impacts of river mining specifically is almost non-existent. Given these constraints, the social impacts referred to in this section draw on relevant examples from the literature related to the social impacts of mining generally, supplementing, where available, with more specific examples from a river mining context.

Table 3. Examples of mitigating or aggravating site or regional specific factors

<table>
<thead>
<tr>
<th>Category</th>
<th>Site-specific factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>Nature of terrain&lt;br&gt;Presence of conservation areas&lt;br&gt;Ownership&lt;br&gt;Indigenous land values&lt;br&gt;Adjacent land use&lt;br&gt;Visibility of area&lt;br&gt;Other land use options e.g. ecotourism</td>
</tr>
<tr>
<td>Water</td>
<td>Sensitivity of river to erosion, incision etc&lt;br&gt;Variation in rainfall&lt;br&gt;Other uses of receiving water e.g. for subsistence fishing, bathing, washing, and drinking&lt;br&gt;Variation in water flow-rate</td>
</tr>
<tr>
<td>Air</td>
<td>Average wind speed&lt;br&gt;Maximum wind speed&lt;br&gt;Wind direction (relative to local communities)</td>
</tr>
<tr>
<td>Climate</td>
<td>Length of dry and wet seasons&lt;br&gt;Tendency for drought&lt;br&gt;Frequency, duration and rainfall of storm events</td>
</tr>
<tr>
<td>Geology</td>
<td>Depth of overburden requiring removal&lt;br&gt;Ratio of clay &amp; silt to sand &amp; gravel</td>
</tr>
<tr>
<td>Community</td>
<td>Proximity to extraction site&lt;br&gt;Urbanisation of rural areas&lt;br&gt;Percentage of community employed directly or indirectly at extraction site&lt;br&gt;Presence of local pressure groups</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Sensitive flora and fauna&lt;br&gt;Unique or rare species&lt;br&gt;Fragile ecosystems (aquatic and terrestrial)</td>
</tr>
</tbody>
</table>

Environmental impacts may be transient (often acute, associated with spills or accidental discharges), temporary (related to operational discharges, ceasing when operations are terminated) or chronic (long-term, often those arising from ore extraction and waste disposal). Typical transfer mechanisms are wind and water erosion of contaminated solids or dissolution of contaminants into the aqueous phase. The movement of raw materials and intermediate products off-site for further processing (e.g. crushing) or modification (e.g. production of cement or tarmac) is another mechanism by which the spatial and temporal environmental impact of an operation can be extended. Ideally, any analysis of the environmental burden arising from a particular operation must address the entire life cycle, from material extraction through to the final product, including any and all off-site operations.
Local and regional factors and the varying perspectives of different stakeholder groups may either aggravate or mitigate the impacts at site-level. Therefore, while it is possible to generalise to a certain degree, the nature and magnitude of environmental and social impacts at each extraction site may vary significantly, even for sites with near-identical deposits, extraction, processing and transport methods. The development of best practice methods specifically for river mining should take into account and allow for the possible existence of these and other relevant factors.

### 4.2 POTENTIAL IMPACTS DURING EXTRACTION

In the context of this review, the extraction process is also assumed to include exploration and supporting activities associated with the physical extraction of material (such as the creation of access roads for example). In general exploration in the aggregates sector is an assessment process that is temporary or periodic in nature, with relatively minimal impacts. It may involve the collection of geological, geophysical and geochemical data to determine the resource potential of an area, although this is less common in the aggregate sector than in the metal mining sector. It is important that a mineral operation, as a temporary use of the land, does not impose any permanent constraints on the options for future beneficial use of the site and adjacent land, nor has any permanent effects on the local water resources, biodiversity and overall landscape quality.

Key aspects of the extraction process include:

- Optimisation of the balance between recovery of valuable material and dilution of recovered material by non-valuable material such as low quality rock, fine material, waste, overburden and soil.
- Minimisation of costs (e.g. labour, energy, and transportation).
- Minimisation of localised environmental impacts (e.g. noise, vibration, and release of contaminants to land and water resources).

Compared to underground mining methods (which are not used in river mining activities), surface mining methods are generally considered safer for workers, more flexible with respect to extraction (e.g. the capacity to practice selective extraction) and to offer lower development and maintenance costs (due to the requirement for fewer specialised systems). However, the major benefit lies in potential economies of scale, as large capacity earth moving equipment can be used for higher productivity. The most cost-effective extraction methods are those that can be applied on a large-scale and that do not involve drilling, stripping or blasting.

#### 4.2.1 Impact Group ‘P’ – Physical Impacts

*Exploration*

A proper commitment to environmental responsibility by the explorer should include consideration of the rights of other land-users and protection of the natural environmental values of the locality. New technology has reduced the environmental impact of exploration, enabling large areas of land to be evaluated by remote sensing methods (particularly during the reconnaissance phase).
For large-scale formal sand and gravel operations exploration may take place in a sequential manner, beginning with the large-scale reconnaissance or area selection stage, progressing to target selection and terminating with the target testing (or evaluation) stage. The potential for environmental impact during exploration tends to grow as the target area decreases and the intensity of activity therefore increases. For example, low intensity exploration at regional-scale has a reduced potential for impact when compared with spatial demarcation of a specific resource at a localised level. This exploration process is not generally applicable to small-scale, informal or illegal sand and gravel operations that may have little or no exploration and planning activity associated with them.

For those operations that do undertake some kind of exploration and extraction planning, conducting the exploration process in three stages facilitates effective management:

- Pre-exploration planning and preparation.
- Implementation of the exploration programme.
- Post-exploration remediation, monitoring and assessment.

Exploration of an area, large or small, previously selected on the basis of geological considerations usually encompasses the following activities:

- Preliminary surveys of remote sensing, aerial photography and satellite imagery so as to identify major topographic features of geological and environmental interest, and to provide baseline data for environmental assessment and planning.
- Detailed geologic mapping of the area, including hand sampling of surface material.
- Trenching and shaft sinking intended to investigate the near surface formations. Shafts, 1 to 2 m² in area, may be sunk to depths of about 10 metres, by pick and shovel, or power backhoes, or motor augers. Trenches, 20 to 30 metres long, can also be excavated by pick and shovel (1 to 2 metres wide) or dozed (4 to 5 metres wide). In order to avoid damaging the environment through excessive earth displacement, usually only a few trenches are excavated in the area of interest.
- Drilling: if warranted or required, drilling is conducted to confirm the sand and gravel deposits at depth.

Drilling equipment may be either freestanding or truck-mounted (ideally low-pressure-tyred); hence provision of a road is usually necessary to permit access to the drilling site. In some cases the provision of access to certain areas can generate indirect impacts across the seven Impact Groups through increased human intrusion and settlement.

**Extraction**

Alluvial deposits are easily worked by heavy equipment. Extraction commonly occurs close to markets for the product, otherwise the cost of transport adds considerably to the cost of aggregate. Alluvial deposits are desirable due to prior size sorting (via fluvial processes) and the elimination of unstable phases by abrasion. Therefore alluvial aggregates often meet the standards for hardness, durability, chemical stability, cleanliness and gradation required in multiple end-uses.
In-stream gravel mining is the direct removal of sand and gravel from the bed of the active river channel. This is often done below the water in perennial rivers using draglines or dredgers. On rivers that dry up during summer and autumn, or in shallower rivers, heavy equipment works directly on the dry riverbed. In some cases in-stream mining is limited to ‘bar skimming’ or ‘bar scalping’, where the top of the gravel bars are removed, usually leaving a surface that slopes at about 2% down to the water.

In-stream mining impacts riparian ecosystems (i.e. the ecosystems in areas adjacent to streams, lakes, ponds, wetlands, and other water bodies) and aquatic ecosystems (i.e. the ecosystems present in the water bodies themselves) by disrupting channel form, introducing fine sediment to the water column at low flow and removing or damaging riparian vegetation (see also Weeks et al, 2003). By interrupting natural continuity of sediment transport through the river system, in-stream mining typically induces incision, bed coarsening, lowered alluvial water tables and channel instability. Incision can propagate up and downstream: upstream by nick-point migration, and downstream by sediment starvation. Propagation of incision is generally greater in sand-bedded than gravel-bedded rivers because of the effecting of armouring in gravel beds.

Incision causes undermining of bridge piers and other structures, and exposure of buried pipelines, cables etc. Incision also increases channel instability, triggering bank erosion in previously stable areas, increasing sediment yield and resulting in ecological effects such as loss of riparian vegetation, wildlife habitat, shade and cover to the channel. Extraction may also take place on floodplains and adjoining terraces (see Figure 1). In this case, pits are normally shallow and wide, exposing large areas of the subsurface to any potential pollution that may occur. Pit lifetime may be relatively short, but successive pits may be developed if demand is high enough. However, pits may also create new habitat areas for species to colonise, improving biodiversity and ecosystem health.

**Figure 1.** Extraction of river terrace deposits, Chin’s Quarry, Rio Minho, Jamaica.
4.2.2 Impact Group ‘W’ – Water Impacts

Any unit operation within the lifecycle of a river mining operation has the potential to produce an environmental effect or impact. Typically the potential with respect to water arises from the deliberate (regulated) and accidental (non-regulated) discharge of solid and liquid wastes and products. The characteristics of the discharges, the nature of the receiving environment and the distance over which the discharges are transported are major factors in determining the magnitude of the effect or impact. Societal values and preferences also play a significant role in determining how certain discharges are viewed by various stakeholder groups: this more subjective adjunct to the quantifiable and measurable discharge and receiving environment characteristics therefore sets, in part, the site-specific environmental “footprint” of an operation. Potential impacts on surface and groundwater are rarely confined to the point of extraction.

Important aspects of mineral working (relating to groundwater and surface water) include:

- Depth of working.
- Surface area of working.
- Duration of excavation.
- Whether extraction below the water table occurs.
- On-site control of potential pollutants.
- Extent to which water table is lowered.
- Rate at which water table is lowered.
- Method of dewatering.
- Extent to which surface landforms are modified.
- Extent to which watercourses are modified.
- Method of backfilling and materials used (including landfill or other off-site wastes).
- Method of waste disposal.
- Final reclamation methods.

It should, however, be remembered that releases can be localised and contained within the site boundary. Impacts may be transient (often acute, associated with spills or accidental discharges), temporary (related to operational discharges, ceasing when operations are terminated) and chronic (long-term).

Water quality can be impacted by three discrete activities associated with aggregate extraction (Thompson et al, 1998):

- Initial ground investigation (for new operations and during the operation of existing quarries).
- The physical presence of the excavation itself.
- The dewatering of operations working below the water table.
The following section examines some of the more important parameters in more detail. It is based on the comprehensive review by Thompson et al. (1998), which should be considered essential reading by all those involved with the protection and management of water resources in the aggregate extraction sector.

**Exploration**

Although generally on a small-scale relative to extraction activities, ground investigations using boreholes and trenches can still potentially cause impacts on ground and surface waters. In order to assess the impact of a quarrying operation on receiving watercourses, a detailed understanding of the local hydrology is essential. Information on background water quality and flow rates may be obtainable from the relevant environment authorities, but in some cases site sampling and flow measurement for relevant watercourses may be necessary. With adequate planning, the development of a site should not lead to long-term deterioration in water quality. However, short-term impacts may arise, particularly from the temporary release of suspended solids:

- Boreholes may generate ‘short-circuits’ that allow groundwater to move between previously isolated strata or rock masses. Two examples of impacts are ingress of saline water from a high pressure to a low-pressure aquifer, or the loss of water from an aquifer as it flows to a new location. Therefore care should be taken in placement and closure of boreholes, and boreholing may need to be preceded by non-invasive techniques if there is uncertainty regarding the risk of substantial changes in groundwater movements or quality.
- Boreholes may also act as points of entry for contaminants, and should therefore always be properly sealed.
- Pumping tests may temporarily affect water levels and lower the local water table, impacting nearby wells. Water discharged from pumping tests may cause erosion or contamination if not properly managed and can be a particular problem if high volumes are discharged into small watercourses.
- Although relatively low risk, the possibility of development in a previously contaminated area cannot be ignored as this could lead to the generation of contaminated wastes and effluents during ground investigations, the sub-surface movement and dispersion of contaminants via boreholes and the discharge of contaminated pumped water to surface waters (with potential impacts on aquatic life and ecosystem health)

**Physical presence of the excavation**

- Modification of the surface catchment area and groundwater recharge may have parallel impacts on groundwater level and flows and the flow of surface watercourses. In extreme cases water features such as ponds, wetlands, and bogs may disappear as a result of changes in the flow and volume of groundwater and surface water. Although these may eventually be reinstated, their absence during the lifetime of the operation can have a severe impact on fauna and flora that are reliant upon them (Thompson et al., 1998).
- Surface waters such as rivers and streams may need to be diverted to allow extraction to occur, potentially causing direct ecosystem impacts (e.g. on invertebrate
communities living in the river sediments) and indirect impacts from the rechanneling of the water, including changes in flood risk and location. There is typically substantial resistance to the relocation of surface waters by local communities and other stakeholders, and therefore this is an extremely high profile activity with substantial reputational risks in the event of subsequent problems.

- Changes to the overall flow of water within and from the catchment area hosting the extraction site are generally only significant when the extraction area is significant compared to the overall catchment area. In some cases this may require modification of the management plans for surface and groundwaters on-site and in the immediate vicinity.

- Removal of the unsaturated zone via extraction (overburden and target rock) can create direct routes between contaminating activities and groundwater/aquifers. Typically the unsaturated zone acts as a buffer, slowing the penetration of contaminants and reducing the risk of groundwater contamination through natural attenuation, adsorption and dilution processes (by which contaminants are removed or reduced in concentration before entering the saturated zone). This increases the significance of preventative measures, as the treatment of contaminated groundwater and aquifers can be long-term, expensive and technically difficult.

- The removal of the unsaturated zone also increases the likelihood of groundwater fluctuations becoming more extreme, with recharge occurring at potentially problematic rates. This may lead to a higher frequency of flooding in groundwater-fed streams and possible problems with the saturation and destabilization of natural and excavated slopes, leading to both environmental and operational problems.

- Although the unsaturated zone is not fully laden with water, it contains a significant portion of the overall water resource, and its removal can reduce the groundwater storage capacity in the vicinity. Once again, this is most likely to be an issue when the volume extracted is a significant part of the total volume of the catchment’s unsaturated zone, or when several extraction sites are located within the same catchment area.

- Excavation below the water table can lead to a loss of groundwater volume and quality during operation (although if the site is allowed to flood on closure the total storage volume will be significantly higher as void spaces in unbroken ground generally only comprise 5-20% of the total rock volume).

**Dewatering**

- Dewatering can lead to the loss of a valuable resource, particularly if it is discharged to surface waters and ‘lost’ to the groundwater zone in which it originated.

- Lowering of the water table by dewatering can result in the drying-up of groundwater abstraction wells in the vicinity, and may result in the need to deepen wells in order to properly intersect the groundwater.

- Dewatering of one aquifer can have ‘knock-on’ effects for other adjacent aquifers that are hydraulically connected.

- Dewatering can lead to impacts on surface water features such as rivers, lakes, ponds, wetlands and bogs, if these are hydraulically linked to the groundwater.
Some areas may be reliant on surface waters for water supplies, and these in turn are reliant on groundwater seeps and springs to maintain flow during drier months. Dewatering can therefore reduce the water resource available in the form of surface waters by decreasing the volumes entering in the forms of seeps and springs.

Discharge of water into watercourses may cause damage to the banks and beds due to the increased water flow and velocity. This particularly the case for smaller watercourses receiving high volumes of water.

Dewatering may reduce the viability of fauna and flora dependent on water in vulnerable or specific ecosystems such as bogs, wetlands and heathland.

Dewatering can ‘draw in’ water from the surrounding area – if that area is host to potentially contaminating industrial activity, there is a possibility that direct discharge will not be possible and that treatment will be required. Equally, the contaminated water ‘drawn’ to the site may impact other groundwater abstraction sites before it reaches the quarry for dewatering, causing a ‘chain’ of contamination events between the source and the end point (i.e. the extraction site itself).

Dewatering in the vicinity of the coast (or in areas where historic saline water remains trapped in isolated strata) can result in the movement of saline water inland, impacting any intermediate abstraction points and the quarry itself, which in most cases is likely to be discharging into fresh rather than saline surface waters.

Contamination of groundwater and surface water
There is a broad range of potential contaminants that may occur on a typical extraction site, arising from a large number of sources. Again the specific contaminants of concern will vary from one site to another, but for the purpose of overviewing the potential issues, contaminants and potential sources can be summarised as in Table 4.
Table 4. Potential contaminants and their sources

<table>
<thead>
<tr>
<th>POTENTIAL CONTAMINANT</th>
<th>POTENTIAL SOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-dissolved contaminants</strong></td>
<td></td>
</tr>
<tr>
<td>Turbidity - suspended solids (silt &amp; sand)</td>
<td>Product, waste and soil erosion</td>
</tr>
<tr>
<td></td>
<td>Truck movements and wheel washing</td>
</tr>
<tr>
<td></td>
<td>Washing plant</td>
</tr>
<tr>
<td></td>
<td>Water treatment plant (e.g. sludge)</td>
</tr>
<tr>
<td></td>
<td>Run-off during periods of rainfall</td>
</tr>
<tr>
<td></td>
<td>Waste and product handling and storage activities</td>
</tr>
<tr>
<td></td>
<td>Exposed quarry faces and benches</td>
</tr>
<tr>
<td></td>
<td>Drilling</td>
</tr>
<tr>
<td></td>
<td>Construction activities</td>
</tr>
<tr>
<td></td>
<td>Lubricants</td>
</tr>
<tr>
<td></td>
<td>Mobile and fixed plant</td>
</tr>
<tr>
<td></td>
<td>Waste oils</td>
</tr>
<tr>
<td></td>
<td>Waste storage and/or recycling facilities</td>
</tr>
<tr>
<td>Petroleum products (e.g. diesel)</td>
<td>Mobile plant</td>
</tr>
<tr>
<td></td>
<td>Central storage facilities</td>
</tr>
<tr>
<td></td>
<td>Parking areas</td>
</tr>
<tr>
<td>Sewage</td>
<td>On-site toilet facilities</td>
</tr>
<tr>
<td>Pathogens</td>
<td>Sewage</td>
</tr>
<tr>
<td><strong>Dissolved contaminants</strong></td>
<td></td>
</tr>
<tr>
<td>Heavy metals</td>
<td>Minerals present within site boundaries (e.g. sulphides)</td>
</tr>
<tr>
<td>Sulphate</td>
<td>Minerals present within site boundaries (e.g. sulphides)</td>
</tr>
<tr>
<td></td>
<td>Process chemicals (e.g. sulphuric acid)</td>
</tr>
<tr>
<td>Chloride - salinity</td>
<td>Minerals present within site boundaries (e.g. salts)</td>
</tr>
<tr>
<td></td>
<td>Saline waters trapped within strata present in or adjacent to extraction site</td>
</tr>
<tr>
<td>Alkalis</td>
<td>Water treatment plant (e.g. calcium hydroxide, sodium hydroxide)</td>
</tr>
<tr>
<td></td>
<td>Cement kiln dusts and wastes</td>
</tr>
<tr>
<td>Flocculants</td>
<td>Water treatment plant (e.g. man-made polymers)</td>
</tr>
<tr>
<td>Eutrophicants (e.g. nitrates, phosphates)</td>
<td>Dissolution of explosives</td>
</tr>
<tr>
<td></td>
<td>Dissolution of excess fertilisers</td>
</tr>
<tr>
<td>Acids (e.g. sulphuric acid)</td>
<td>Leaching activities (e.g. removal of iron staining)</td>
</tr>
<tr>
<td></td>
<td>Minerals present within site boundaries (e.g. sulphides)</td>
</tr>
<tr>
<td>Ammonia-based reagents</td>
<td>Dissolution of explosives</td>
</tr>
<tr>
<td>Process chemicals</td>
<td>Processing plant</td>
</tr>
<tr>
<td></td>
<td>On-site laboratory wastes</td>
</tr>
<tr>
<td>Soaps/detergents</td>
<td>Staff washing facilities</td>
</tr>
<tr>
<td>Flocculants/treatment chemicals</td>
<td>Water treatment plant</td>
</tr>
<tr>
<td><strong>Other contaminants</strong></td>
<td></td>
</tr>
<tr>
<td>“Heat”</td>
<td>Non-contact cooling water</td>
</tr>
<tr>
<td></td>
<td>Quench and other coolant waters</td>
</tr>
</tbody>
</table>

A number of general types of contaminant exist:

- Suspended solids (normally silts and clays) introduced into surface waters as a result of surface runoff and operational activities. The presence of silt and clays in water can increase turbidity, which may limit the use of water for public supply, irrigation, and industrial applications. Silt can damage fish spawning grounds, fish gills and the invertebrate species resident in watercourse sediments, and also reduces penetration by sunlight. It also has an aesthetic impact.
• The release of naturally occurring contaminants (i.e. those that are present in the rock and overburden). Natural water contamination can as result from the presence of metal sulphides, which in the presence of both oxygen and water oxidise to water-soluble sulphates, releasing metals in a readily bioavailable form and also generating acidity as part of the reaction. This is relatively rare in aggregate extraction, but is known to occur. Other minerals may also be present that on contact with water dissolve or partially dissolve, increasing the water concentration to potentially harmful levels.

• Those occurring due to the presence and disturbance of previously contaminated ground – the nature and potential impacts of associated contaminants is entirely dependent on the cause of the original contamination. However, these occurrences are uncommon in the aggregates industry, and with appropriate ground investigations should be identifiable at an early stage, allowing appropriate responses to be planned and implemented.

• Contaminants brought onto the site in the course of operational activities and accidentally released into the environment.

• Discharges from on-site processes, which may include tarmac and concrete plants in addition to the extraction activity itself. These may generate highly alkaline effluents in the case of concrete batching plants and effluents containing dissolved, oily and solid wastes in the case of plants using bitumen to produce tarmac.

Generalised impacts arising from contaminated water can be sub-divided into four broad inter-related categories: chemical, physical, biological and ecological. Examples for each category are shown below for a "typical" surface receiving-water:

• **Chemical**
  Increased acidity/alkalinity, reduced/increased pH, increased dissolved metals, presence of synthetic compounds (e.g. oils, lubricants).

• **Physical**
  Substrate modification, turbidity (total suspended solids) and adsorption of metals/synthetic compounds onto sediments.

• **Biological**
  Death of sensitive species, species migration or avoidance and acute chronic toxicity.

• **Ecological**
  Habitat modification, metal bioaccumulation in food chain, elimination of sensitive species and reduction in primary productivity.

One of the most common water issues associated with extraction is the erosion of fine particulates and the transfer of suspended solids into surface waters during periods of rainfall. This typically increases proportionally with increasing area of disturbance and it is therefore very important that the total disturbed area be minimised. If environmental management is inadequate, water quality may be affected far beyond the site boundary. At the very least water leaving the site should be treated to minimise off-site sedimentation and turbidity problems. Controlling drainage on-site may also reduce waterlogging, improving machine performance and reducing the potential for sediment movement off-site (DPIWE, 1999).
As noted above, the quality of surface and groundwaters may also be affected by inputs from contaminated ground and solid wastes. The intensity and duration of rainfall events, site topography, permeability of the fill materials and presence or absence of vegetation will influence the rate and extent of run-off from the site and directly and indirectly effect the movement of dissolved and solid contaminants into the water. Therefore, to a greater or lesser extent, these parameters are also those that can be managed to prevent or minimise impacts on water quality and availability.

Sites that contain or store liquid wastes or leachate may also influence surface water quality by direct percolation of leachate into adjacent watercourses. In general, the solubility of the contaminants will be the prime determinant of the potential for contamination, although soils and certain types of rock have the capacity to remove certain amounts of contaminants from water via a number of physical and chemical processes.

Dewatering near to rivers may not be possible if there is good hydraulic conductivity between the river and the extraction site. Dewatering may also not be possible if the deposit forms part of a major aquifer due to the potentially large area of the draw down.

Sub water table working is possible by the creation of lake and dredging from pontoons or by use of dragline excavators. These are effective if the deposits are consistent but not if specific areas such as clays and silts need to be avoided. Wet working is more expensive as a larger volume must be extracted to recover the same volume of saleable material. Wet working may be acceptable where wet product is acceptable. Wet working limits the impact on groundwater in areas where water resources are already under stress.

Reclamation of fluvial sand and gravel sites can be difficult as the reduced ground levels elevate the risk of flooding. This makes restoration to agriculture (for example) more difficult. Fluvial sand and gravel extraction can give rise to permanent waterlogged soil conditions unless continuous pumping is used to depress groundwater levels. An alternative is to maximise the reclamation of well-drained land by the placement of overburden and imported materials to create landscaped areas of open water of wetlands in other parts of the site. Done correctly this can lead to the creation of new habitats and stimulation of an increase in biodiversity.

Complications may occur where surface operations cut across old underground workings – water may flow preferentially through the latter, making water movement impossible to predict without thorough ground investigation and groundwater modelling and monitoring. This would be most likely to occur in areas where surface sand and gravel is close to underground extraction of coal, ferrous and non-ferrous minerals.

4.2.3 Impact Group ‘B’ – Biological Impacts (including Ecosystem Health)²

Due to the mediating effect of physical and water impacts, it is difficult to generalise with respect to biological impact and impacts on ecosystem health.

Exploration operations may, to a varying degree, disturb soils, vegetation, fauna and sites of cultural significance and contaminate or pollute ground, water and air resources. Therefore,

² It is recommended that this section is read in conjunction with the report by Weeks et al (2003).
post-exploration remediation may be required to return the environment to its previous state or an agreed, sustainable alternative as quickly as possible. This may include backfilling, removal of soil contaminated with hydrocarbons or drill fluids, sub-surface drill hole capping and revegetation. Periodic inspection is required to ensure that remedial action has been effective and permanent.

In general the extraction of material does not cause direct biological impacts – as is the case for exploration these are typically mediated through the physical and water impacts. These may cause changes in nature and diversity of fauna and flora in, or downstream of, the extraction area.

Depending on the species present, suspended solids, changes in flow regimes, flooding, reduced flow, changes in chemical characteristics and other physical and water impacts noted above may have significant impacts on biological systems and ecosystem health. These impacts may alter and reduce the sustainability of the ecosystem and its long-term durability.

Potential mediated impacts include:

- Exposure to suspended solids – death of fish, biodiversity impacts, food chain disruption.
- Exposure to dissolved solids – death of sensitive species.
- Exposure to dust (plants and soils) – reduced growth or death in extreme cases, changes in soil physical and chemical characteristics.
- Reduced/increased water flow (draining/flooding of sensitive areas).

4.2.4 Impact Group ‘H’ – Socio-Health Impacts

As is the case for biological impacts, human health impacts are typically mediated through physical and water impacts. For example, changes in water flow may increase the prevalence of certain illnesses or diseases via vectors such as mosquitoes, or may cause health problems due to deterioration of the quality of water used for drinking, bathing and other domestic purposes. These effects can range from minor, subtle and imperceptible ‘shadow effects’ involving dust, run-off, seepage and vibration to major permanent and irreversible ecological transformations, rendering mined areas useless for subsequent socio-economic development (Godoy, 1985).

River mining activities can impact the atmosphere through the generation of excessive atmospheric particulates. The generation of excessive atmospheric particulates or dust is of particular concern at open cast mining ventures where activities such as soil stripping and dumping, crushing, blasting, drilling, ripping and haulage all act as particulate generators. Atmospheric dust caused by activities like these has the affect of raising the incidence of respiratory infections such as tuberculosis in the affected communities. Much of this dust can be made up of silica causes a specific form of pneumoconiosis (know as silicosis) (SGS, 1996a).

The impact of extraction on the aquatic environment is an issue that attracts considerable attention in the literature an inevitable consequence of river mining. In a paper specifically
addressing the health impacts of mining, Parker (1996) states that any adverse effects on the hydrological environment of developing countries will tend to have a corresponding affect on the health of local communities. In many parts of the developing world, communities near to extractive operations depend on untreated surface and ground waters as their main water supplies, used for drinking, washing and food preparation (see Figure 2). Extraction from riverbanks and beds and the resultant generation of particulates, chemical pollutants such as diesel in the water therefore pose a particular health risk to those that depend on this natural resource.

Figure 2. Local people use the river for washing and as source of drinking water, Rio Minho, Jamaica

In tropical regions alterations by extraction to the hydrological environment can increase the risk of malaria. The excavations associated with river mining can create stagnant waters that can become breeding grounds for malaria carrying mosquitoes. Resurgence in the incidence of malaria is one of the most worrying changes in disease patterns in recent years in the Amazon basin, where mining activities (albeit not river mining per se) are most concentrated. This had a particularly devastating effect on the indigenous Indian populations, who have no resistance to the emerging strains brought by migratory miners, and have little access to modern medical facilities. In a paper evaluating the impact of mining on malarial incidence in Brazil, Sawyer (1992) reports that in 1990 the mortality of 60% of Yanomami Indians of northern Amazonia, whose lands have been subject to mining incursions since the mid-1980s, was attributable to malaria.

The noise effects of river mining associated diggers and blasting can also have a debilitating impact on health. The vibration effects of blasting and digging can result in the structural
degradation of buildings, rendering them unsafe for habitation, while the noise effects can have an adverse impact on mental and physical health. In their study of the impact of mine blasting in Ghana, Tsidzi and Adofo (1994) note that it has interfered with human activities such as sleep, speech and hearing as well as inducing stress-related illnesses such as hypertension. Finally, following river mining activity adjoining land is often sterilised by ugly high profile waste dumps and excavations, and stripped of its vegetation. Unless these effects are mitigated through revegetation and landscaping this can affect psychological health as the aesthetic appeal of an area can be dramatically reduced.

In addition, the social impacts of mining mentioned already (and in the following Impact Groups) can have subsequent cumulative social impacts, which tend to be predominantly related to health, and to some extent culture. Acquah (1999) holds the view that the cumulative social impacts of mining result from impacts acting together or when added to the impacts of other concurrent developments in a given area. They tend to manifest themselves in alterations to the health, social practice and core cultural identity of the community and tend to occur later and be more irreversible than direct and indirect impacts. It should also be added that the cumulative social impacts of mining are even more poorly documented in the literature than direct or indirect social impacts. Nevertheless, a small number can be discerned:

- **Boothroyd et al (1995)** describe the potential cumulative impacts of concurrent or large-scale mining developments as creating elements of the ‘boomtown’ scenario. This scenario is characterised by increased levels of crime and violence, drug and alcohol abuse, family stress, community instability, depression, school drop-out, juvenile delinquency, welfare caseloads, drunkenness, suicide, child abuse and teenage rebellion (Kohrs, 1974). Wilson (1982) found that the social environment of the Weipa mine typified this scenario and included the highest rate of Aboriginal imprisonment in Australia, profoundly high levels of violent crime, self-inflicted harm and other signs of convincing social and psychological malaise. Wilson concluded that ‘traditions have disappeared and alcohol has wreaked havoc…’

- **The Ranger Uranium Enquiry (Fox et al, 1977)** foreshadowed alcoholism as the single most serious social impact to be created by the incremental effects of mine development. Although excessive drinking rarely impacts whole communities, the minority involved can disproportionately affect the rest of the community. Kesteven (1984) isolates associated problems of alcohol abuse in mining areas such as violence, accidents, neglect of community responsibilities and suicide. However, as O’Faircheallaigh (1991) and Tatz (1982) point out, among Australian Aboriginals, it is difficult to know if alcoholism can be attributed to mining since drinking habits were often firmly entrenched prior to mine development. Nevertheless, both authors agree that mining increased overall alcohol consumption and associated problems.

### 4.2.5 Impact Group ‘C’ – Socio-Cultural Impacts

A significant cultural impact of mining extraction in general is associated with the process of displacing people from the land to be mined. This is usually less significant with river mining extraction because the scale of operations is much smaller, but must nevertheless be considered because, whether directly or indirectly, it will frequently displace at least some
community members. In rural communities land is often the major social resource available to its members, serving as a place of common habitation and identity, a medium of social exchange, a focus of cultural and spiritual belief and a sign of power and status for contemporary and future populations (Roper, 1983). Therefore, displacement from this land by new or existing patterns of mineral ownership can be a very emotional issue for recipient communities and often leads to conflict with the mineral developers (Misra, 1994).

Literature from Australia illustrates just how potentially destructive the loss of land to mining can be to communities. Ross (1990) writes about the ‘cultural decay... and sense of failure’ Aboriginal people felt after losing their ancestral lands to mining. The author stresses that Aboriginal people continue to be gravely concerned for the future generations, seeing the loss as evidence of their own failure to preserve their ancestral land for their children. Researching the Walpiri Aborigines of the Northern Territories, Howitt (1992) found that the landscape involved an important synthesis for them; ‘...the country not only contains the bodies of the ancestors inside it, but it is also thought of as being the metamorphosed forms and imprints of their body parts’. Rickson et al’s (1995) study of the traditional Jawoyn Aboriginals at Coronation Hill in the Northern Territories reveals a community polarised on the spiritual significance of the area. Traditional custodians of the land felt that any physical alterations to the area would have widespread consequences and that ‘sickness’ would spread throughout local settlements and beyond, to the rest of Australia and the world, resulting in critical spiritual and ‘symbolic’ losses.

River mining extraction is linked to some small population increases as a result of its potential direct and indirect employment opportunities. Although the number of migrants workers associated with river mining are likely to be relatively low compared to other forms of mining impacts stem largely from the contrast between the characteristics of the newcomers and those of the entrenched population. Many of these differences derive from rural and urban norms, documented in the sociological tradition of Durkheim (1933). These contrasts can place considerable stress on existing social relationships, based as they are on specific rules and expectations. Such problems are compounded by the transience of migrant workers who are attracted to the community for short-term gain, with little incentive to form attachments to the area or adapt to local social norms. Moreover, migrant workers are typically young and skilled and more likely than locals to be gainfully employed (RSS, 1993). The wages they receive can cause huge disparities of wealth in a concentrated area and contribute to the consolidation of a cash based economy in traditionally subsistence-based communities (Clark 1996, Warhurst & Macfarlane 1999).

In addition to debilitating the vitality and spirit of the community the influx of a migrant population can increase the potential for conflict. Burdge (1987) lists antagonism between established community members and newcomers to industrial projects as a major category of social impact. The conflict is generally multifaceted and can encompass religious, customary, moral and natural resource issues. According to Clark (1996), where there is a culture of respect and power according to seniority or a disdain for individual consumptive wealth, a major axis of conflict tends to emerge between the younger migrant workers and the older generation of host communities. The money earned by younger migrant workers can make them highly influential and able to challenge the traditional lines of authority in host communities.

A particularly widely documented source of conflict concerns sexual practice. Researching Guyana’s mining sector Canterbury (1997) found that Aboriginals were especially angered by
migrant workers engaging in the sexual exploitation of Aboriginal women. Similarly, Tsinoung et al (1989) note that residents expressed considerable discontent that migrant mine workers were trying to turn local women into prostitutes. At the Ok Tedi mine in Indonesia, Hyndman (1992) found that the incidence of adultery and prostitution had become rife where it had previously been rare. Howitt (1989b) reports on Aboriginal women who became the victims of sexual ‘relief’ sought by Hamersley workers on the Roebourne reserve in Australia. He documents the problem of the ‘kids that are not true’ from sexual liaisons between migrant workers and local women, who then received no financial or paternal support.

4.2.6 Impact Group ‘E’ – Socio-Economic Impacts

At many new mining sites indigenous landowners have received compensation for the use of their land and the damage done to it. This can present a positive socio-economic impact for communities affected by mining. However, mine compensation can have negative impacts, often introducing the most mercenary elements of a cash-based system of exchange. Another concern is that increases in disposable incomes from compensation payments can create significantly higher expectations among the recipients that may be difficult to fulfill once mining extraction has seized. Other negative social impacts can emanate from inequitable compensation payments caused by arbitrary land valuation procedures; confusion over land entitlement claims; fluctuations in the profits of the companies; and a tendency to distribute compensation exclusively to landlords rather than tenants (Robinson, 1992).

Recognition of these problems has led some mining companies to adopt the alternative policy of relocation. This refers to the provision of land and property for community members at a more distant place. Relocation maintains social cohesion and minimizes disruption to other aspects of community life. However, relocation is also beset with problems. After evaluating a mine relocation program in Northern India, Bhandari (1994) comments that, ‘the area to be designated for the relocation of Rampura village is unpromising land for an agricultural community... it will result in a severely disadvantaged community’. Similarly, a study of Sierra Rutile Limited’s (SRL) mine in Sierra Leone by Friends of the Earth, concluded that while the new settlements offered enhanced infrastructure, associated land was too poor to establish crops (Kamara, 1997). According to Watkins et al (1992) bulldozing left:

‘sub-soil incapable of supporting plant growth, causing difficulty in the establishment of tree crops as well as shade and wind breaks in such villages. Also, some villages had to be resettled in places where community needs such as water and farmland were grossly inadequate. The general sanitation in these villages has been, and still is, critical. In a few other cases, villages have been sited in places where the immediate farmlands were flooded or again cleared for mining activities’

The potential socio-economic impacts of river mining referred to thus far have been largely negative. However, common arguments favouring mining generally, particularly in developing countries, are that positive socio-economic impacts will result from its investment activities and revenue generating capacity. River mining can potentially provide a significant source of revenue through profit related royalty payments and through fixed taxation (Waelde, 1992). The injection of mining investment and revenues, with its commensurate impact on ‘spin-off’ employment, into areas that are often cash starved can entail a dramatic rise in
material living standards. This has enabled many people to greatly extend the range and quantity of items they consume (O’Faircheallaigh, 1991, Ulijaszek, 1987).

Examples of mining companies making investments directly into the social and economic development of their local communities are widespread. However, while there is some anecdotal evidence to support this happening on a more limited scale among river mining companies, documentary evidence of this remains scarce. One mainstream mining company that has been at the forefront of community development in recent years is Western Mining.

According to Davis (1997), management at their proposed Tampakan mine in the Philippines made a commitment to a three-year community development programme, which proceeded despite mining activity there being frozen. The company’s community workers live in the region and work with the Bla’an people to develop this programme, ‘based on their needs and aspirations, recognising their right to plan their own future’ (Ibid. 1997). The community development initiatives implemented as a result of this process include:

- Infrastructure development - improved road access and housing, the construction of medical clinics, schools and community centres.
- Sustainable agricultural methods - assistance in improving technologies for subsistence farming, livestock upgrading, and agro-forestry.
- Health initiatives - the delivery of on-site medical care, community health education, waste management, and provision of water and sanitation services.
- Education initiatives - the provision of primary education, adult functional literacy programs, and local/indigenous employment and training programs.

4.2.7 Impact Group ‘L’ – Socio-livelihood

It is river mining’s potential for employment creation that is particularly important with regard to livelihoods. Although this potential has been reduced with the trend toward mechanisation, Radetzki (1994) shows that the operational investment of mining can extend far into the domestic economy and through backward and forward linkages create the basis for ‘spin off’ employment. Also related to the livelihood issue is resource availability. Resource availability impacts include:

- Loss of access to clean water – used for drinking, bathing, cleaning, irrigation.
- Loss of land and access to land. A significant economic impact of mining extraction in general is associated with the process of displacing people from the land to be mined. This is usually much less significant with river mining extraction because the scale of operations is much smaller, but must nevertheless be considered since in rural communities land is often the major basis for livelihoods. Floodplain extraction may not be directly in conflict with housing uses due to their tendency to flood. However, adjoining river terraces may see conflict, as they are often a prime location for housing. The following passage from a villager displaced by a mine offers some insight into the potential socio-economic impact of displacement:
‘Land is our life. Land is our physical life - food and sustenance. Land is our social life; it is marriage; it is our only world. When you (the administration) take our land, you cut away the very heart of our existence. We have little or no experience of social survival detached from the land. For us to be completely landless is a nightmare which no dollar in the bank will allay.’ (Dove et al, 1974)

- Reduced access to food. Marcus (1997) notes that the loss or conversion of habitats associated with the clearing and exploration of mined areas to be one of the most significant impacts. Deforestation has had a particularly dramatic affect on habitats (Mondal et al, 1994). At Freeport’s Grasberg mine in Indonesia, Ondawame (1977) considered rainforest clearance to be responsible for heavy rains removing vegetation and reducing the fertility of soil used by locals for producing basic crops. In the case of river mining, impacts on water quality can have indirect impacts on the levels of fish stock and in some developing countries, therefore, local food security.

- Loss of trees and vegetation.

### 4.3 POTENTIAL IMPACTS DURING PROCESSING

#### 4.3.1 Introduction

The final product may be produced in a number of ways, using a combination of screening, washing and crushing:

- Screening is used to produce one or more products with a specific size range (typically less than a predetermined maximum size) from the excavated material.

- Crushing is also used to produce material with a specific size range. However, it is a more flexible approach than simple screening as the operator is not limited to the size ranges contained within the excavated material. Crushing is more energy intensive than screening alone, and typically is used in conjunction with screening (and washing, see below) to produce a product with the desired size range.

- Washing is generally used to remove fine material that is often physically entrained with a coarser product and that is not acceptable to the end-user. This entrained material may be present in excavated materials, and also normally occurs in crushed products.

Processing of sand and gravel is generally undertaken using crushers (e.g. jaw, gyratory, impact and cone crushers) to produce appropriate sized material for sale (see Figure 3).
Different types are employed depending on the planned throughput (tonnes per hour), material characteristics (e.g. friable, “sticky”, “elastic”) and the degree of size reduction required. Crushing is normally undertaken on dry or as-excavated material and may therefore give rise to dust, in addition to noise and vibration. Screening may also be used to recover material of the correct size, with the undersize or oversize material becoming the saleable product, with the other fraction being recrushed, resized or disposed of as waste.

However, in many river mining products, particularly at the small-scale, the material is not crushed; the only processing is done via a simple A-frame screen with the oversize material treated as waste (see Figures 2 and 3).
Figure 4. Simple A-frame screen
4.3.2 Impact Group ‘P’ – Physical Impacts

The physical impact of processing is limited and generally applicable to the local environment only. The main issues are:

- Noise from crushing and other fixed and mobile plant.
- Vibration.
- Land sterilisation from disposal of waste material (which may lead to further health and environmental impacts if dispersed by wind or into surface waters).
- Dust – from crushing operations and generally from the area of the processing plant, including product stockpiles.
- Visual impacts from the extraction scar and the plant and the waste heaps and fines lagoons.

4.3.3 Impact Group ‘W’ – Water Impacts

Water impacts from processing are largely limited to the release of suspended solids from crushing and/or washing and the storage or disposal of wastes and products, lubricants, petroleum products and natural contaminants that may be present in the processed material. The release of chemicals used in processing may also occur, but this is likely to be rare unless specific water treatment products, settling aids and dispersants are used on-site.
4.3.4 Impact Group ‘B’ – Biological Impacts (including Ecosystem Health)

Limited – mediated through the water and physical impacts. As with extraction, the most likely direct impact on biological systems is dust from crushing, and storage and disposal activities. Dust can impact the functioning of plants, and in severe cases alter the physical and chemical characteristics of the soil in fallout areas.

The release of sediments into water resulting from wet screening, waste disposal and product storage may also give rise to impacts on water-dwelling creatures, particularly benthic organisms (for further information on the impact of suspended sediments on benthic organisms see report by Weeks et al (2003)).

4.3.5 Impact Group ‘H’ – Socio-Health Impacts

The processing of sand and gravel is generally undertaken using crushers and is normally undertaken on dry or as-excavated material and may therefore give rise to dust, in addition to noise and vibration. As a result, the effects on human health will be similar to those related to noise, vibration and dust noted previously. The impact of noise and vibration from processing is significant because of its persistence. Processing facilities are not likely to be located in proximity to settlements. As a result, those most highly impacted by these effects are employees.

Screening is also used to recover material of the correct size either in tandem with crushing or on as-extracted material. In either case this process as well as crushing will be a significant source of dust generation and could impact on the respiratory or visual system of local residents and employees. Safety will also be a health issue for employees as the on site transportation and mechanical processing of the material can be a very significant source of accidents unless rigorous controls are implemented.

4.3.6 Impact Group ‘C’ – Socio-Cultural Impacts

It is unlikely that processing will be associated with socio-cultural impacts that are distinct from those noted for the extraction phase. Indeed, because processing can generally be conducted on a much smaller spatial scale, any related socio-cultural impact is likely to be smaller. Where processing and extraction occur together, the socio-cultural impact of processing will be incremental.

4.3.7 Impact Group ‘E’ – Socio-Economic Impacts

It is also unlikely that processing will be associated with socio-economic impacts that are particularly distinct from those noted for the extraction phase.
4.3.8 Impact Group ‘L’ – Socio-livelihoods

In general processing will employ fewer people than extraction. Nevertheless, processing may significantly contribute to direct and, if the operation is large enough, indirect employment. Auty (1995) and Jauch (1996) argue that lower transport costs, through improved infrastructure, make it easier for mining projects to import their inputs and process nearer the markets, actually reducing the incentive to promote domestic linkages near the source of extraction. Therefore, at a strategic level, processing at a distance may actually reduce some employment opportunities locally while increasing them nearer market. Where processing and extraction occur together, the livelihood impact of processing will be incremental.

Resource availability impacts are limited, although processing may impact access to clean air and water. However, in many cases, the actual extraction rather than processing is likely to be the principal source of these impacts. One exception may be the discharge of fine material generated during washing and/or screening, which may directly impact the quality of available water resources and cause indirect impacts to fish stock and thus livelihoods.

4.4 POTENTIAL IMPACTS DURING TRANSPORT

4.4.1 Impact Group ‘P’ – Physical Impacts

Truck damage to roads, including removal of wearing course, removal or slumping of tarmac cover, rock on road due to overloading or inadequate sheeting.

4.4.2 Impact Group ‘W’ – Water Impacts

Generation of sediments reporting to surface waters from road run off, contamination by diesel and lubricant compounds originating is vehicles associated with the sand and gravel operations.

4.4.3 Impact Group ‘B’ – Biological Impacts (including Ecosystem Health)

Limited – impact of road building, increased death of animals on roads, reduced air quality and increased noise may disturb or deter wildlife.

4.4.4 Impact Group ‘H’ – Socio-Health Impact

The social impacts of transportation relate, almost exclusively, to impacts in the socio-health and safety impact group. Any socio-cultural or socio-economic impacts related to transportation of the material are likely to be low and incremental to the socio-cultural and socio-economic impacts noted for extraction. The most significant incremental socio-economic impact will relate to some small employment generation locally and further afield for drivers and to suppliers of driver goods and services. The major source of socio-health impacts of transportation will stem from truck fumes, dust generation, rock spillage and
movement. This will result in a small increase in road accidents, respiratory infection at, and between, material source and market.

4.4.5 Impact Group ‘H’ – Socio-Cultural Impact

Any socio-cultural impacts related to the transportation of the quarried or processed material is likely to be very low and incremental to the socio-cultural impacts noted for extraction.

4.4.6 Impact Group ‘H’ – Socio-Economic Impact

Any socio-economic impacts related to the transportation of the quarried or processed material is likely to be low and incremental to the socio-cultural impacts noted for extraction. The most significant incremental socio-economic impact will relate to some small employment generation locally and further afield both to employ drivers and to supply drivers with goods and services. Additionally, it should be noted that the potential for truck movement to degrade roads is high. This cost is arguably borne by the vehicle operators in their additional road tax. Nevertheless, it is unlikely this revenue will be fed back to the quarry or process areas where their impact is greatest.

4.5 CONCLUSIONS

Ultimately, responses to the negative impacts of river mining should be prioritised according to three criteria – environmental significance, social/community significance and economic significance. Against these must be measured the benefits that operations bring locally, regionally and nationally (and in cases where aggregate is exported, internationally). Environmental impacts are summarised Table 5, below.

The social impacts noted in this section are complex and a function of location, timing, technology and the nature and strength of the pre-existing social system. Nevertheless, many of social impacts are in no way unique to particular projects and have been recurrently documented. In addition to exhibiting generic or unique aspects, the social impacts stemming from river mining developments may also exhibit positive or negative aspects. The literature suggests that mining generally is an ambivalent phenomenon presenting, on the one hand, opportunities for the production of substantial wealth, and on the other hand, social breakdown. A summary of the social impacts of river mining and mining generally is set out in Table 6, below.
Table 5. Overview of the environmental impacts of river mining and their potential causes

<table>
<thead>
<tr>
<th>Environmental impact</th>
<th>Potential cause</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td></td>
</tr>
<tr>
<td>Turbidity; smothering of benthic ecosystems</td>
<td>Dredging, suspended solids from creation of infrastructure, dewatering or surface run-off, disposal of wastes to surface waters</td>
</tr>
<tr>
<td>Groundwater contamination (e.g. degradation of potable water resources); surface water contamination (e.g. rivers, streams and springs); acute and chronic bio-toxicity (e.g. fish kills, growth and reproduction defects).</td>
<td>Regulated or accidental release of process chemicals (rare), spills or leakage of other chemicals (e.g. mineral oil lubricants, petroleum and derivatives, cleaning agents)</td>
</tr>
<tr>
<td>Eutrophication.</td>
<td>Nitrate derived from wash-down of explosive residues (rare)</td>
</tr>
<tr>
<td>Oxygen consumption.</td>
<td>Presence of inorganic and organic chemicals that consume oxygen during changes in chemical speciation or during degradation</td>
</tr>
<tr>
<td>Depression of water table.</td>
<td>Dewatering; hydrological and hydrogeological disruption of surface and at-depth aquifers</td>
</tr>
<tr>
<td>Contamination of riverine and estuarine sediments.</td>
<td>Disposal, erosion or dispersion of contaminated solid wastes into surface waters; discharge of contaminated waters and adsorption of contaminants to existing sediments</td>
</tr>
<tr>
<td>Diversion of surface waters (e.g. rivers and streams); significant alteration of water flow pathways; depletion of groundwater yield</td>
<td>Extraction and subsequent redeposition of solid wastes into river systems</td>
</tr>
<tr>
<td>Creation of stagnant (non-flowing) ponds and larger bodies of water</td>
<td>Extraction</td>
</tr>
<tr>
<td><strong>Soil (land)</strong></td>
<td></td>
</tr>
<tr>
<td>Flooding</td>
<td>Removal of riverbanks; acceleration of water flow (from direct and indirect changes in river route); lowering of ground level through excavation.</td>
</tr>
<tr>
<td>Erosion</td>
<td>Increased water flow (volume and speed) resulting from poorly managed extraction</td>
</tr>
<tr>
<td>On- and off-site contamination of top and sub-soil horizons</td>
<td>Wind and water erosion and dispersion of wastes; transfer from contaminated waters to soil components (e.g. clay minerals, organic matter)</td>
</tr>
<tr>
<td>Land sterilisation and/or destruction of vegetative cover (including rare and endangered species)</td>
<td>Disposal of contaminated and/or inert wastes; surface extraction; “footprint” of the processing plant and associated infrastructure; land-take for extraction; temporary or permanent land-use for waste disposal</td>
</tr>
<tr>
<td>Inhibition of vegetative regeneration and impact on biodiversity (destruction/disruption of species, forests and aquatic ecological communities; disruption of ecosystem function)</td>
<td>Surface and sub-soil contamination; disposal of waste products not readily revegetated</td>
</tr>
<tr>
<td>Loss of land</td>
<td>Flooding; surface removal of overburden and sand and gravel</td>
</tr>
<tr>
<td>Aesthetic impact</td>
<td>Lack of vegetation; high profile waste disposal sites; open pits; severe topographical disruption (e.g. re-routing of rivers); transient and regular noise; excessive glare from security and/or workplace lighting; destruction of geological forms and landscapes; erosion</td>
</tr>
</tbody>
</table>

3 Many of these are site-specific, and may not always be significant.
Environmental and Social Impacts of River Mining in Jamaica

### Environmental and Social Impacts of River Mining in Jamaica

<table>
<thead>
<tr>
<th>Environmental impact</th>
<th>Potential cause</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air</strong></td>
<td></td>
</tr>
<tr>
<td>Dust</td>
<td>Creation of infrastructure; wind erosion and dispersion of fine solids (e.g. tailings); crushing; movement of site vehicles; surface blasting; ventilation outlets; transfer points; processing plants; drilling, and loading; truck haulage routes; conveyor haulage routes; fine waste lagoons; blasting; storage areas; waste heaps</td>
</tr>
<tr>
<td>Contaminant emissions</td>
<td>Localised occurrences of other process chemicals or degradation products; diesel fumes; smoke; dusts; carbon and nitrogen oxides</td>
</tr>
<tr>
<td>Noise</td>
<td>Creation of infrastructure; blasting; operation of heavy plant</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
</tr>
<tr>
<td>Damage to bridges, roads, housing</td>
<td>Erosion and undercutting of banks and load-bearing surfaces; flooding</td>
</tr>
</tbody>
</table>

### Table 6. Summary of social impacts and their potential causes.

<table>
<thead>
<tr>
<th>Social Impact</th>
<th>Potential Cause</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Socio-Health</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STD including AIDS</td>
<td>Prostitution can become rife in areas where it had been rare or non-existent, because of lack of alternative employment options for women. Commentators also document the problem of illegitimate children from sexual liaisons between migrant mine workers and local women, rarely in receipt of subsequent financial or paternal support.</td>
<td>Tsinoung <em>et al.</em> (1989) Canterbury (1997) Hyndman (1992) Howitt (1989b)</td>
</tr>
<tr>
<td>Stress, hypertension, depression</td>
<td>The vibration effects of mine blasting can result in the structural degradation of buildings, while the noise effects of mine blasting can have an adverse impact on the mental and physical health, interfering with human activities such as sleep, speech and hearing. It can also induce stress-related illnesses such as hypertension and depression.</td>
<td>Tsidzi and Adofo (1994)</td>
</tr>
<tr>
<td>Eye and respiratory infection</td>
<td>The generation of excessive atmospheric particulates or dust from activities such as soil stripping and dumping, heap leach crushing, blasting, open pit drilling, ripping and haulage all act as particulate generators. Atmospheric dust caused by mining activities like these raise the incidence of respiratory infections such as tuberculosis in mining communities.</td>
<td>SGS (1996a).</td>
</tr>
<tr>
<td>Digestion and gastric disorders</td>
<td>The release of mine oxides is linked to the generation of acid rain. In some areas this has created acid lakes and a drastic decline in fish stocks due to the ability of acids to leach aluminium to surface waters. Trees and crops may also be affected by acid rain due to the leaching of key nutrients impacting then on human health and nutrition.</td>
<td>Franklin (1998)</td>
</tr>
<tr>
<td>Liver failure, delirium, skin infection</td>
<td>Chemical solutions such as cyanide, mercury and arsenic to extract soluble ore are often left untreated either in pools or allowed to seep into the groundwater, posing a particular health risk. Exposure to high levels of mercury, cyanide and arsenic can be fatal or result in disorders e.g. conjunctivitis, delirium, dermatitis, blindness, and liver failure.</td>
<td>Parker (1996)</td>
</tr>
<tr>
<td>Malaria</td>
<td>In tropical regions alterations by mining to hydrological environment can significantly increase the risk of malaria. The excavations and tailings ponds associated with mining create stagnant waters that can become breeding grounds for malaria carrying mosquitoes.</td>
<td>Sawyer (1992)</td>
</tr>
<tr>
<td>Depression</td>
<td>Following mining activity land is often denuded by ugly high profile waste dumps and excavations, and stripped of its vegetation. Unless these effects are mitigated through re-vegetation and landscaping the aesthetic appeal of an area can be much reduced.</td>
<td>Wilson (1982)</td>
</tr>
<tr>
<td>Accidents, violent assault, kidney, liver &amp; nervous disorder, depression</td>
<td>The Ranger Uranium Enquiry foreshadowed drug and alcohol abuse as most serious incremental impact of mining. Excessive drinking rarely characterises whole communities, but the minority involved can disproportionately impact other community members with associated problems of domestic violence and accidents.</td>
<td>Fox <em>et al.</em> (1977) Kesteven (1984)</td>
</tr>
</tbody>
</table>
### Table 6. Summary of social impacts and their potential causes.

<table>
<thead>
<tr>
<th>Social Impact</th>
<th>Potential Cause</th>
<th>References</th>
</tr>
</thead>
</table>
| Loss of community identity and cohesion.          | Displacement from land by new or existing patterns of mineral ownership through land seizures and clearances can impact on the social and cultural fabric of the indigenous community. Land often serves as a place of habitation, a medium of social exchange, a focus of cultural and spiritual belief and a sign of status for communities. | Emberson-Bain (1994)  
Ross (1990)  
| Loss of social control and order                  | Population increases caused by a large and diverse migratory population seeking employment can lead to housing shortages, inflationary pressures, income disparities and consolidation of cash economy. The contrast between newcomers and entrenched population can also destroy existing informal mechanisms of social control. | Freudenburg (1980)  
Wright (1998)  
Macfarlane (1999) |
| Increased levels of crime, delinquency, suicide, sexual abuse | Cumulative impacts of major resource developments like mining are associated with the ‘boomtown’ scenario, characterised by increased levels of crime and violence, drug and alcohol abuse, stress, community instability, depression, school drop-out, juvenile delinquency, welfare caseloads, drunkenness, suicide, and child abuse. | Boothroyd et al (1995)  
Kohrs (1974) |
| Urbanisation and dissolution of existing cultural norms | In the longer-term mining causes both subtle and explicit cultural changes. The influx of migrant, often western mine workers, can lead to the dissolution of existing traditional cultures and the emulation of western culture among indigenous community members resulting in rapid rural-urban migration with its attendant social impacts. | Hyndman (1992)  
Renner (1997) |
| Accidents and crime                               | Other cumulative impacts associated with mining activities include a marked rise in crime. This has been specifically attributed to the mining’s displacement of traditional livelihoods and exposure to migrant material goods. Generally elevated levels of fatal and non-fatal accidents result from increased vehicle movements in and around mine. | Avotri (1997)  
Seyditz et al. (1999) |
| **Socio-Economic**                                |                                                                                                                                                                                                             |                                                                            |
| Unrealistic expectations, entitlement conflict, inequality | Compensation for the use of the land and damage done to it can significantly contribute to livelihoods of recipients, but can be misused and create expectations that may be difficult to fulfill. Impacts can also stem from inequitable payments, conflict over entitlement and distribution of compensation to landlords rather than tenants. | Robinson 1992  
Howitt (1992)  
O’Faircheallaigh (1984) |
| Loss of productive land                           | Relocation refers to the provision of land and property for community members at a more distant place. Relocation maintains social cohesion and minimises disruption to other aspects of community life but is also potentially fraught with its own problems including the provision of unpromising replacement land for agricultural communities. | Kamara 1997:25  
Bhandari (1994) |
| Increased national revenue                        | Mining can provide a significant source of national revenue through profit related royalty payments and fixed taxation. Mine developments can also potentially benefit the local economy through the payment of local taxes and government royalties if they are fed back through localised minerals development and re-investment funds. | Waelde (1992).  
Macfarlane (1999) |
| Material and consumption gains                    | Mining investment and services has enabled many mining communities to extend the range and quantity of items they consume. Diets, in particular, have often been greatly transformed, in some areas contributing to improved nutrition, in others a growing dependence on imported foods has led to a growth in non-communicable diseases. | Ulijaszek 1987).  
O’Faircheallaigh (1991) |
| Lost investment potential                         | Potential impact of mining investment and revenue generation is not fulfilled. Improved infrastructure, make it easier for mining projects to import and process nearer markets, reducing the incentive to promote domestic linkages. Also, bulk of new mining investment not in non-metallic ores that have higher domestic linkages. | Abugre and Akabzaa (1998)  
Jauch (1996)  
ECA (UN) (1997) |
| Infrastructure, housing, training, health and education improvements | Increasingly, mining companies have been at the forefront of corporate / community initiatives and partnerships for social development. Many are now directly facilitating and financially supporting community infrastructure development, house building, institution building and development, agricultural methods training, health and education. | Davis (1997b) |
| **Socio-Livelihood**                              | Displacement from land by new or existing patterns of mineral ownership through land seizures and clearances can alienate existing communities from their traditional livelihoods like farming, hunting and artisanal mining. These | Aubynn (1997) |
### Table 6. Summary of social impacts and their potential causes.

<table>
<thead>
<tr>
<th>Social Impact</th>
<th>Potential Cause</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>activities can be large employers and sources of sustainable livelihoods for the existing community member.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct employment</td>
<td>Mining’s employment generation is well expounded. Major mining projects can employ upward of 20000 workers at project inception. With appropriate training local people may gain employment at mine. However, for many this is exception rather than the rule, and most of the employment benefits of mining are not localised.</td>
<td>Redwood (1997) Quodling (1991) Boothroyd et al (1995)</td>
</tr>
<tr>
<td>Conflict, dependency and unemployment</td>
<td>Unemployment at closure is made particularly problematic because of lack of transferable skills and miner’s typical psychological profile. In isolated mining areas closure impacts whole community as it has been the focus of livelihood dependency, and tensions and divisions between migrant workers and the indigenous community become exacerbated.</td>
<td>Kieselbach (1987) Mckee and Bell (1986) Neil et al (1992)</td>
</tr>
<tr>
<td>Indirect and secondary employment</td>
<td>While the potential for direct or localised employment at mining projects is decreasing with increased mechanisation, the potential for localised, secondary or ‘spin off’ employment remains high. In the gold mining industry this is generally calculated on the basis of the ratio 10 indirect jobs to every 1 direct job.</td>
<td>Radetski (1994) Young (1995)</td>
</tr>
<tr>
<td>Dependency and unemployment</td>
<td>The impact of mine closure on people in ‘spin-off’ employment will vary according to the degree to which the local economy has become dependent or integrated with mining. Mine communities that have evolved over many generations (where diversification opportunities are limited) are likely to experience most severe social problems at closure.</td>
<td>Neil and Brealey (1982) Eikeland (1992)</td>
</tr>
</tbody>
</table>
5.0 DESCRIPTION OF FIELD STUDIES IN JAMAICA

5.1 Overview

Field studies in Jamaica were carried out early in February 2002. The scope of the fieldwork visit to Jamaica included the identification of significant social and environmental impacts at all phases of development, positive as well as negative, direct, indirect, and cumulative, permanent and temporary as well as the identification of appropriate technical and strategic mitigation measures to address these impacts. The sites broadly designated for investigation included all significant legal and illegal operations on the Yallahs river basin southeast of Kingston and the Rio Minho river basin west of Kingston on the southern side of Jamaica.

Visits were made over three days to the Yallahs field area to the areas affected by river mining operations of Albion, Ghetto Lane, South Avon and Poor Mans Corner. In addition, the quarrying operations of Caribbean Aggregate Ltd. and Jamaica Pre-mix Ltd were visited. In the lower Rio Minho, visits were made over three days to the areas affected by river mining operations of Cotton Tree gully, Water Lane, Easington and Broken Bank. In addition, the quarrying operations of Sha-Gore, Black Brothers and Paul Chi were visited. The assessment of social impacts at the local level involved investigating the impacts of the river mining activity and the response of affected stakeholders based on the assessors’ own opinion, checklists, local secondary sources, participant observation and the result of semi-structured interviews with local project stakeholders. The project stakeholders included, but were not limited to, the management of operations and their employees, residents, health and police officials, council officials, customers, suppliers and local businesses.

Two additional days of fieldwork were dedicated to data gathering from key stakeholders of river mining at the strategic level. The assessment of social and environmental impacts at the strategic level involved investigating the impacts of the river mining activity and appropriate mitigation measures through semi-structured interviews with strategic project stakeholders. This included interviews with representatives of the Water Resources Authority, the National Environment and Planning Agency, the Mines and Geology Division, the Quarry Advisory Committee, the National Works Agency, and the Department of Tourism.

The following sections detail the findings of the fieldwork.
5.2 Impacts Relative to Scale and Type of Operation

The three principal activities in river mining are extraction of the raw material, processing (including screening, crushing and washing) and transport (including products and wastes). The findings and conclusions from fieldwork undertaken in Jamaica have been categorised under these activities. While there is a degree of ‘blurring’ between these three principal activities, they are a useful means of breaking the overall river mining lifecycle into smaller parts that aid the assessment of environmental and social impacts, and their causes. The use of this categorisation also allows for distinctions to be drawn between small-scale, and medium/large-scale river mining operations from the outset.

There is an immediate distinction between the environmental and social impacts of small-scale operations (that may be largely related to extraction) and those of larger-scale operations (that may be related to all three activities). By extensions, it can be inferred that the impact of small operations is at a local or river system level, while that of larger operations may have an extended footprint due to off-site processing, and transport (which can extend across large areas or regions).

Unlicensed operations do not by default cause environmental impacts as this relates to the management of the operation rather than to the legality or illegality (i.e. theoretically it is possible to run an environmentally-benign illegal operation, just as it is possible to do so for a legal operation). However, limited exposure to illegal operations by a licensed operator during fieldwork indicated that environmental impacts are likely to be higher due to limited planning and the fact that illegal operations may be sited in areas in which river mining is restricted for specific environmental reasons. This is reflected in Table 7, which notes the magnitude of the likely environmental impacts, which is a product of degree of regulation and scale of operation.

<table>
<thead>
<tr>
<th>SCALE OF OPERATION</th>
<th>LICENSED OPERATOR</th>
<th>UNLICENSED OPERATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Large</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>

Unregulated, small operations have only limited environmental impacts, although collectively these may be substantial when considering a specific catchment area. Medium and large-scale unregulated operations have the potential to generate much larger environmental impacts. Regulated (licensed) operations in theory have lower environmental impacts, even for large-scale operations. However, this relies on the effective enforcement of regulation, and consistent and regular monitoring undertaken by a well-resourced and trained staff.

Tables 8 and 9 summarise the causes and effects noted (i.e. seen firsthand) and inferred (i.e. deduced or derived from discussions and interviews) during the fieldwork. Significance relates to the overall importance with respect to river mining in Jamaica and is based on discussions
with local experts working in the areas of geology, mining, quarrying and environmental management and protection. However, the wider significance of some causes and effects, and the clearer definition of cause-effect relationships will require further work. In Table 9, ‘mitigation level’ refers to whether technical remedial action or strategic (i.e. regulatory, policy, enforcement etc) changes are the immediate solution to the issue (ultimately all issues will have a strategic solution, but not all issues have a technical solution). Where appropriate, additional comments have also been given.

Table 8. Summary of causes of environmental and social impacts

<table>
<thead>
<tr>
<th>CAUSES</th>
<th>Noted</th>
<th>Inferred</th>
<th>Significance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction-related</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removal of soil (no replacement)</td>
<td>✓</td>
<td>Medium</td>
<td>Medium</td>
<td>Soil also ‘mined’, increasing erosion potential</td>
</tr>
<tr>
<td>Removal of overburden</td>
<td>✓</td>
<td>High</td>
<td>High</td>
<td>Management critical to restoration</td>
</tr>
<tr>
<td>Extraction of sand and gravel – in-stream</td>
<td>✓</td>
<td>High</td>
<td>High</td>
<td>Major source of direct impacts</td>
</tr>
<tr>
<td>Extraction of sand and gravel – floodplain</td>
<td>✓</td>
<td>High</td>
<td>High</td>
<td>Major source of direct impacts</td>
</tr>
<tr>
<td>Waste disposal (oversized/sub-standard material)</td>
<td>✓</td>
<td>Medium</td>
<td>Medium</td>
<td>Some sites have limited waste production</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>✓</td>
<td>High</td>
<td>High</td>
<td>Priority – cause of multiple impacts</td>
</tr>
<tr>
<td>Dissolved solids</td>
<td>✓</td>
<td>Low</td>
<td>Low</td>
<td>River mining may not be primary cause</td>
</tr>
<tr>
<td>Processing-related</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process machinery operation</td>
<td>✓</td>
<td>Low</td>
<td>Low</td>
<td>Limited crushing activities for many sites</td>
</tr>
<tr>
<td>Discharge – suspended solids</td>
<td>✓</td>
<td>High</td>
<td>High</td>
<td>Management of sedimentation ponds is critical</td>
</tr>
<tr>
<td>Discharge – dissolved solids</td>
<td>✓</td>
<td>Low</td>
<td>Low</td>
<td>Low input relative to other potential sources</td>
</tr>
<tr>
<td>Discharge – diesel etc</td>
<td>✓</td>
<td>Low</td>
<td>Low</td>
<td>Limited mobile plant, but normally in or near to surface waters</td>
</tr>
<tr>
<td>Discharge – other chemicals</td>
<td>✓</td>
<td>Low</td>
<td>Low</td>
<td>Limited use on-site</td>
</tr>
<tr>
<td>Discharge – metals</td>
<td>✓</td>
<td>Low</td>
<td>Low</td>
<td>Some metals released by leaching (minor or insignificant)</td>
</tr>
<tr>
<td>Discharge – sewage/municipal waste</td>
<td>✓</td>
<td>Low</td>
<td>Low</td>
<td>Low input relative to other potential sources</td>
</tr>
<tr>
<td>Transport-related</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lorry movements</td>
<td>✓</td>
<td>High</td>
<td>High</td>
<td>Linked to medium-large operations</td>
</tr>
<tr>
<td>Lack of lorry sheeting</td>
<td>✓</td>
<td>Medium-high</td>
<td>Many poorly sheeted</td>
<td></td>
</tr>
<tr>
<td>Lorry overloading</td>
<td>✓</td>
<td>Medium-high</td>
<td>Most lorries overloaded</td>
<td></td>
</tr>
</tbody>
</table>

48
Table 9. Summary of potential environmental and social impacts

<table>
<thead>
<tr>
<th>IMPACTS</th>
<th>Noted</th>
<th>Inferred</th>
<th>Significance</th>
<th>Mitigation level</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical contamination</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Technical</td>
<td>Endemic</td>
</tr>
<tr>
<td>Chemical contamination</td>
<td>✓</td>
<td></td>
<td>Low</td>
<td>Technical</td>
<td>Unlikely – general industry, aluminium production, farming, metalliferous mineralisation (minor) and sugar cane production are all greater potential sources</td>
</tr>
<tr>
<td>(including pesticides and metals)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss/reduction of water resources</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Technical</td>
<td>Quantity and quality may be impacted</td>
</tr>
<tr>
<td>Boreholes – groundwater depression</td>
<td>✓</td>
<td></td>
<td>Medium</td>
<td>Technical</td>
<td>Limited to population in immediate vicinity of extraction?</td>
</tr>
<tr>
<td>Release of sugar cane wastes (erosion/flooding)</td>
<td>✓</td>
<td></td>
<td>Low</td>
<td>Technical</td>
<td>Could be highly significant during flood events</td>
</tr>
<tr>
<td>Flooding</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Strategic</td>
<td>Technical solutions at individual sites will have limited impact on controlling the risk of flooding</td>
</tr>
<tr>
<td><strong>Land</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of amenity land</td>
<td>✓</td>
<td></td>
<td>Medium</td>
<td>Technical</td>
<td>Could be highly significant during flood events</td>
</tr>
<tr>
<td>Loss of housing land</td>
<td>✓</td>
<td></td>
<td>Medium</td>
<td>Technical</td>
<td>Could be highly significant during flood events</td>
</tr>
<tr>
<td>Loss of agricultural land</td>
<td>✓</td>
<td></td>
<td>Medium</td>
<td>Technical</td>
<td>Could be highly significant during flood events</td>
</tr>
<tr>
<td>Contamination</td>
<td></td>
<td></td>
<td>Low</td>
<td></td>
<td>Unlikely – wastes are largely inert, and few chemicals (except diesel and lubricants) are widely used</td>
</tr>
<tr>
<td>Waste disposal</td>
<td>✓</td>
<td></td>
<td>Medium</td>
<td>Technical</td>
<td>Land sterilisation is possible concern, but main waste disposal is to river or on-site at flood plain operations</td>
</tr>
<tr>
<td>Flooding</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Strategic</td>
<td>Technical solutions at individual sites will have limited impact on controlling the risk of flooding</td>
</tr>
<tr>
<td><strong>Air</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Technical</td>
<td>Extensive dust migration may occur – may be difficult to distinguish between mining-related and environmental dust</td>
</tr>
<tr>
<td>Fumes</td>
<td>✓</td>
<td></td>
<td>Low</td>
<td>Technical</td>
<td>Limited to operation and immediate environment</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational noise</td>
<td>✓</td>
<td></td>
<td>Low</td>
<td>Technical</td>
<td>Limited to operation and immediate environment</td>
</tr>
<tr>
<td>Incision</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Technical</td>
<td>Significant direct and indirect consequences</td>
</tr>
<tr>
<td>Bank erosion</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Technical</td>
<td>Significant direct social impacts</td>
</tr>
<tr>
<td>Bed erosion</td>
<td>✓</td>
<td></td>
<td>High</td>
<td>Technical</td>
<td>Biodiversity impacts</td>
</tr>
</tbody>
</table>

[cont’d]
Table 9. Summary of potential environmental and social impacts

<table>
<thead>
<tr>
<th>IMPACTS</th>
<th>Noted</th>
<th>Inferred</th>
<th>Significance</th>
<th>Mitigation level</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding (threat and actual)</td>
<td>✓</td>
<td>High</td>
<td>Strategic</td>
<td>Technical solutions may be implemented</td>
<td></td>
</tr>
<tr>
<td>Shifting of river course</td>
<td>✓</td>
<td>High</td>
<td>Strategic</td>
<td>Technical solutions may be implemented</td>
<td></td>
</tr>
<tr>
<td>Loss of diversity in fauna and flora</td>
<td>✓</td>
<td>Low</td>
<td>Strategic</td>
<td>May have knock on effects on foodchain</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>✓</td>
<td>Low</td>
<td>Technical</td>
<td>May have knock on effects on foodchain</td>
<td></td>
</tr>
<tr>
<td>Bed coarsening</td>
<td>✓</td>
<td>High</td>
<td>Technical</td>
<td>May have knock on effects on foodchain</td>
<td></td>
</tr>
<tr>
<td>Reduced drinking &amp; cooking water</td>
<td>✓</td>
<td>Medium</td>
<td>Technical</td>
<td>There is little piped water thus dependence on river is high, but limited to contiguous populations</td>
<td></td>
</tr>
<tr>
<td>Reduced washing water</td>
<td>✓</td>
<td>Medium</td>
<td>Technical</td>
<td>Rio Minho communities dependent for washing</td>
<td></td>
</tr>
<tr>
<td>Reduced livestock</td>
<td>✓</td>
<td>Low</td>
<td>Strategic</td>
<td>Trespassing cattle may be shot on extraction sites, or at risk of drowning in sediment ponds</td>
<td></td>
</tr>
<tr>
<td>Loss of cultivated land (food and fuel)</td>
<td>✓</td>
<td>Medium</td>
<td>Strategic</td>
<td>Could be highly significant during flood events</td>
<td></td>
</tr>
<tr>
<td>Threat of flooding on land</td>
<td>✓</td>
<td>High</td>
<td>Strategic</td>
<td>Risk is high, occurrence is low</td>
<td></td>
</tr>
<tr>
<td>Impacts on irrigation water</td>
<td>✓</td>
<td>Medium</td>
<td>Technical</td>
<td>Reduction in yield</td>
<td></td>
</tr>
<tr>
<td>Fishing and fish stock</td>
<td>✓</td>
<td>High</td>
<td>Technical</td>
<td>Reduced through effects of suspended solids and bed coarsening</td>
<td></td>
</tr>
<tr>
<td>Alternative employment displacement</td>
<td>✓</td>
<td>Medium</td>
<td>Strategic</td>
<td>In particular illegal mining and tourism. Drugs trade affected at Yallahs by access road. At Rio-Grande tourism rafting is being affected by clouding of the water</td>
<td></td>
</tr>
<tr>
<td>Direct employment</td>
<td>✓</td>
<td>Medium</td>
<td>Strategic</td>
<td>Positive impact</td>
<td></td>
</tr>
<tr>
<td>Indirect employment</td>
<td>✓</td>
<td>Medium</td>
<td>Strategic</td>
<td>Positive impact</td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>✓</td>
<td>High</td>
<td>Strategic</td>
<td>Positive and negative impact possible</td>
<td></td>
</tr>
<tr>
<td>Enhanced services / infrastructure</td>
<td>✓</td>
<td>High</td>
<td>Technical</td>
<td>Positive impact</td>
<td></td>
</tr>
<tr>
<td>Road congestion (slow moving traffic)</td>
<td>✓</td>
<td>High</td>
<td>Strategic</td>
<td>Direct impact – may also have cause knock-on economic impacts</td>
<td></td>
</tr>
<tr>
<td>Road surface degradation</td>
<td>✓</td>
<td>High</td>
<td>Strategic</td>
<td>Once begun, process of degradation can accelerate</td>
<td></td>
</tr>
<tr>
<td>Communications</td>
<td>✓</td>
<td>Low</td>
<td>Technical</td>
<td>Economic impact</td>
<td></td>
</tr>
<tr>
<td>Operator contributions</td>
<td>✓</td>
<td>Medium</td>
<td>Strategic</td>
<td>Most contributions based on request. Sponsorship of local football team noted.</td>
<td></td>
</tr>
<tr>
<td>Threat of flooding on mobility</td>
<td>✓</td>
<td>Low</td>
<td>Technical</td>
<td>Limited to the duration of the flooding (except for infrastructure damage)</td>
<td></td>
</tr>
</tbody>
</table>
Table 9. Summary of potential environmental and social impacts

<table>
<thead>
<tr>
<th>IMPACTS</th>
<th>Noted</th>
<th>Inferred</th>
<th>Significance</th>
<th>Mitigation level</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Socio-health</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker accidents</td>
<td>✔</td>
<td>High</td>
<td>Technical</td>
<td></td>
<td>Hard hats, noise protection, traffic control etc rarely enforced</td>
</tr>
<tr>
<td>Digestion related illness</td>
<td>✔</td>
<td>Low</td>
<td>Technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drowning</td>
<td>✔</td>
<td>Low</td>
<td>Technical</td>
<td></td>
<td>Particular risk for children</td>
</tr>
<tr>
<td>Noise related impairment or disposition</td>
<td>✔</td>
<td>Medium</td>
<td>Technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle accidents</td>
<td>✔</td>
<td>High</td>
<td>Technical</td>
<td></td>
<td>Truck overload can cause material to fall off and threaten other vehicles</td>
</tr>
<tr>
<td>Pedestrian accidents</td>
<td>✔</td>
<td>High</td>
<td>Technical</td>
<td></td>
<td>Little traffic safety restrictions or controls on site, potential impacts on public roads</td>
</tr>
<tr>
<td>Respiratory infection</td>
<td>✔</td>
<td>Medium</td>
<td>Technical</td>
<td></td>
<td>Predominant wind south towards Kingston – Albion therefore more affected by Caribbean Aggregate than Poor Man’s corner at the Yallahs.</td>
</tr>
<tr>
<td>Visual impairment</td>
<td>✔</td>
<td>Low</td>
<td>Technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sexual health</td>
<td>✔</td>
<td>Low</td>
<td>Strategic</td>
<td></td>
<td>Migrant workers can increase prostitution and sexual health threat</td>
</tr>
<tr>
<td>Aesthetic impact</td>
<td>✔</td>
<td>Medium</td>
<td>Technical</td>
<td></td>
<td>Locally significant</td>
</tr>
<tr>
<td><strong>Socio-cultural</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Migrant versus local cultural clash</td>
<td>✔</td>
<td>High</td>
<td>Strategic</td>
<td></td>
<td>There are suggestions of operator political collusion</td>
</tr>
<tr>
<td>Corruption</td>
<td>✔</td>
<td>High</td>
<td>Strategic</td>
<td></td>
<td>Illegal and legal operators pay off police</td>
</tr>
</tbody>
</table>
6.0 CODE OF PRACTICE

The following section addresses the mitigation and enhancement of the key social and environmental issues and impacts associated with river mining either identified in river mining literature or through field study. The recommended mitigation and enhancement measures within this Code of Practice are based on the results of literature review and observation of best practice in river mining and the mining industry generally. The result is an issue led systematised code of practice for the mitigation and enhancement of the respective negative and positive impacts of river mining. Each of the twenty-five key issues are categorised according to the river mining activity they are associated with and the impact group they belong to. The intervention level for that issue is then defined as principally strategic (usually policy level) or technical (usually operational level) and a best practice mitigation or enhancement intervention and measure is suggested.

<table>
<thead>
<tr>
<th>Issue Number: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong> Physical Contamination - Water Management</td>
</tr>
<tr>
<td><strong>Performance Indicator:</strong></td>
</tr>
<tr>
<td>• Has consideration been given to the amount of water and source of water used for supply to the processing plant to minimise impact on water resources?</td>
</tr>
<tr>
<td>• Has consideration been given to the point of discharge of any dewatered water or surplus process water and the means of discharge to prevent pollution to rivers, ditches or pools?</td>
</tr>
<tr>
<td>• Are water recirculation systems (settlement ponds to remove suspended solids and recover water for reuse in processing) used wherever possible in processing sand and gravel to minimise the use and wastage of water?</td>
</tr>
<tr>
<td>• Are the plant site and circulation areas and their associated drainage water controlled to prevent turbidity or suspended solids and grease/oil from entering the surrounding surface water?</td>
</tr>
<tr>
<td>• If dewatering is undertaken, has consideration been given to minimise the effect on neighbouring water bodies?</td>
</tr>
<tr>
<td>• Do the discharges of water from the plant processing, dewatering and yard drainage to surface and groundwater, ditches, streams, rivers and lakes have the necessary consents and do they avoid any pollution to those water bodies?</td>
</tr>
<tr>
<td>• Is discharged water quality monitored on a regular basis (i.e. daily)?</td>
</tr>
<tr>
<td>• Are silt lagoons bunded or fenced and have warning signs been erected (to prevent accidents)?</td>
</tr>
<tr>
<td><strong>Activity or Location:</strong> Exploration, Extraction, Processing, Transport and Restoration</td>
</tr>
<tr>
<td><strong>Impact Group:</strong> Water</td>
</tr>
</tbody>
</table>
| **Issue Description:** Pollution and clouding of rivers and other surface water by suspended solids or other pollution from escape of process water, flooding, disturbance of banks and riverbed. Increase in the level of downstream water turbidity and effluents and changes in river flow as a result of river
mining can have a significant effect on the quality of fish stock and access to suitable drinking waters. The former will need to be monitored and accompanied by health programmes if found to pose a threat to the dietary tract. Response to the latter will be dependent on the existing supply of drinking and cooking water to neighbouring communities (e.g. piped and treated water or fresh water) and dependent on the level of reduction in supply if freshwater supply predominates. These factors should affect consideration of the supply and servicing of treated pumped or piped water from a water source unaffected by the proposed or existing mining activities.

**Intervention Level:**
Technical

**Minimum Acceptable Standard:**
Meet with license conditions and satisfy NEPA requirements.

**Best Practice Guidance:**
Poor drainage management can lead to damage or destruction of existing environments and any restoration or rehabilitation efforts. Generally the best and most cost-effective erosion prevention method is good site design, the separation and containment of processing activities and the establishment of vegetation.

Minimisation of the total disturbed area at any one time is an important factor in reducing erosion potential and transfer of suspended solids to adjacent surface waters.

The rate of run-off increases dramatically following vegetation removal, hence the total area exposed should be kept to a minimum. Where practical, rehabilitation should be undertaken as soon as an area is worked out; to ensure that the total disturbed area is not increased.

While vegetation is becoming established in rehabilitated areas, it may be necessary to employ other erosion prevention techniques. It is generally wise to retain any existing drainage controls, such as contour banks, rock filters and cut-off drains, upslope of the area being rehabilitated, to slow down surface run-off. A rough surface will capture more water and allow rainfall to infiltrate rather than flow directly downhill. Deep ripping may improve water infiltration, again reducing the flow of eroding water over the surface.
Objective: **Chemical Contamination** (including oils, pesticides and metals) – the avoidance of contamination of the water environment including adverse impacts on river quality, drinking, cooking and washing water.

Performance Indicator:
- Are fuel and chemical storage tanks or drums correctly labelled, stored in a secure area and fully contained or bunded by an impermeable base and walls that would contain 110% of the tanks volume to prevent spillage?
- Are all fixtures and fittings on the storage tanks enclosed within the bunding wall?
- Is maintenance of plant carried out away from the river or water and any spillage or waste disposed of appropriately to prevent pollution?
- Are storage and maintenance located away from areas prone to flooding?
- Are any spillages cleared up and removed appropriately?

Activity or Location: Exploration, Extraction, Processing, Transport or Closure

Impact Group: Water

Issue Description: The spillage of oil or chemicals into rivers or water bodies causing pollution of the water environment and downstream water supply.

Intervention Level: Technical

Minimum Acceptable Standard: Prevent escape of oil and chemicals into water.

Best Practice Guidance: Sites should not accumulate rubbish; disused plant, waste oil, other waste materials or general rubbish: these should be removed for recycling or appropriate disposal as soon as possible. On-site sewage treatment should not result in the pollution of surface or groundwater and should be designed and constructed to appropriate standards. Fuel, lubricants, coolant, waste oil and waste chemicals must be stored in an approved manner such as surface tanks with impervious bunds to contain spillage, and located away from operating areas, natural or engineered drainage pathways, waterways and areas prone to flooding. The volumes of such materials stored on-site should be minimised by appropriate purchase or waste disposal control protocols. Specifications for storage will depend on the quantity and class of the material being stored. Above ground storage tanks with impervious bunds should be used in preference to underground storage tanks, as these reduce the risk of groundwater contamination. Bunding should be regularly tested, along with the integrity of storage vessels. Bund walls may also be used to divert storm water away from storage areas. Fluids released during machinery maintenance operations should not be spilled on the ground: this work should be undertaken on impervious pads with wash down sumps where the fluids can be captured and removed for appropriate disposal or recycling.
**Issue Number:** 3  

**Objective:** Water Supply - to avoid the loss or reduction of water resources important to communities or agriculture, including adverse impacts on river flow, groundwater levels and drinking, cooking, irrigation and washing water supply.

**Performance Indicator:**
- Has consideration been given to the existing need for water in the area and the potential impact of river working to avoid adverse impact or minimise disturbance?
- If dewatering of working in the river floodplain is undertaken, has consideration been given to avoid lowering of water levels in adjoining land or water bodies?
- Does the operation increase evaporation or reduce groundwater resources used for drinking or other supply and can this be avoided?
- Does the mining operation increase turbidity, pollution or other quality reductions that prevent usage of water by local people and if so what steps can or are being taken to eliminate such impacts?

**Activity or Location:** Extraction, Processing, Closure or Restoration  

**Impact Group:** Water  

**Issue Description**
The reduction of available water supply to communities or agriculture or adverse impact on water quality.

**Intervention Level:** Technical  

**Minimum Acceptable Standard:** Avoid serious adverse impact.

**Best Practice Guidance:**
To protect groundwater resources where communities are using these, it may be necessary to consider working above the water table, and leaving a suitably thick unsaturated zone above to act as a buffer to water flow and contamination. Flooding of pits in floodplain to form lakes may be considered as a means of the ultimate recovery/restoration in the volume of available water, but consideration needs to be given to increased evaporation.
<table>
<thead>
<tr>
<th>Issue Number:</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective:</td>
<td>Boreholes – to prevent groundwater depression and contamination through the selective use and control of deep boreholes into underlying geology.</td>
</tr>
<tr>
<td>Activity or Location:</td>
<td>Exploration</td>
</tr>
<tr>
<td>Impact Group:</td>
<td>Water</td>
</tr>
<tr>
<td>Issue Description:</td>
<td>The depression of water levels in any underlying aquifer or introduction of contamination leading to impact on or loss of clean drinking water.</td>
</tr>
<tr>
<td>Intervention Level:</td>
<td>Technical</td>
</tr>
<tr>
<td>Minimum Acceptable Standard:</td>
<td>No adverse impact on drinking water supply.</td>
</tr>
<tr>
<td>Best Practice Guidance:</td>
<td>Where practicable the use of boreholes should be limited to areas of no or limited population to avoid or minimise impacts on local populations (especially where knowledge of any local aquifer that may supply drinking or other water is limited). Boreholes should be grouted to prevent the migration of water, and backfilled as soon as they are no longer required to minimise the risk of contaminated surface water entering. Where they are required, lockable covers should be installed to prevent vandalism and the deliberate discharge of foreign materials into them.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Issue Number:</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective:</td>
<td>Release of sugar cane or other important wastes (erosion / flooding) – to prevent the release of potentially polluting waste on adjoining land through mining activity.</td>
</tr>
<tr>
<td>Activity or Location:</td>
<td>Exploration, Extraction, Processing, Transport or Closure (select one or more)</td>
</tr>
<tr>
<td>Impact Group:</td>
<td>Water</td>
</tr>
<tr>
<td>Issue Description:</td>
<td>Release of sugar cane waste through mining activity, causing wider pollution to water environment.</td>
</tr>
<tr>
<td>Intervention Level:</td>
<td>Technical/Policy</td>
</tr>
<tr>
<td>Best Practice Guidance:</td>
<td>Ensure that potential points of entry to surface waters are protected. Develop cooperative strategies with sugar cane operators to ensure best practice waste management and run-off control are implemented.</td>
</tr>
</tbody>
</table>
Objective: Flooding – to ensure the avoidance of flooding of the mining operation or of adjoining land uses or communities.

Performance Indicator:

- Has consideration been given to the location of the site in relation to the frequency of flooding, the likely floodplain or area affected?
- Is there any flood warning system and measures to suspend or move operations or plant to minimise consequent damage?
- Does the location of the site avoid flood risk to communities, roads, agriculture, waste stockpiles or other important land uses?
- If not, are measures in place to protect adjoining land uses from flood risk where this arises as a result of mining or where mining may affect or be affected by flooding?
- Have measures been taken to reduce undue risk for particular activities, such as the plant site, stockpiles or waste, outside of the areas of key risk or through the minimum of earth bunding?
- Have measures been taken in site design and ongoing operation to minimise the disturbance to the riverbed by controlling the depth, area and other impacts on the river channel?
- Have measures been taken to avoid disturbance to the riverbank minimised and have measures been taken to prevent erosion of those points?
- Is the impact of the operation on the depth of the river, on the bank condition and overall condition of river channel monitored on a daily basis?
- Where damage to the riverbed, banks or channel is evident through monitoring, have measures been taken to correct that damage and ensure it does not recur?
- Is there an effective commitment to clear up any adverse consequences to adjoining land uses through flooding caused by mine activity?

Activity or Location: Exploration, Extraction, Processing, Closure

Impact Group: Water

Issue Description: The flooding of mining sites can lead to significant release to the water environment and surrounding land of mine waste and potential pollution. Insensitive mining activity can lead to land erosion or increased flood risk to adjoining land and communities.

Intervention Level: Policy, Technical, Land Use.

Minimum Acceptable Standard: Minimisation of any increase in flood risk or the severity of the likely consequences of flood caused by mining activity.

Best Practice Guidance: Implement best practice in river mining as per this and other related documents. Also, provide flood warning systems, assessing the risk of flooding on any area and advising planning authorities on flood risk.
Objective: Waste Management - To minimise the production of waste and ensure that the disposal of such waste is in accordance with legal requirements.

Performance Indicator:
- Are degradable wastes stored in enclosed bins and disposed at an appropriate waste site?
- Are scrap waste stockpiles kept to a minimum and located in a suitable screened area?
- Are waste oils stored in a contained/bunded area and collected for recycling?
- Have all the necessary waste disposal licences been obtained for any degradable wastes landfilled within the site?
- Have steps been taken to minimise the production of all wastes on site?
- Has action been taken to prevent fly-tipping anywhere within the site or on the site boundary?
- Where fly-tipping has occurred, has action been taken to remove the dispose of the waste as a licensed landfill site?
- Is inert waste (overburden, reject mineral) stored safely and used in site restoration?

Activity or Location: Exploration, Extraction, Processing, Transport or Closure (select one or more)
Impact Group: Land
Issue Description: Control of waste arising from the site to avoid pollution, unsightly rubbish piles, scavenging and health impacts.
Intervention Level: Technical
Best Practice Guidance: Sites should not accumulate rubbish; disused plant, waste oil, other waste materials or general rubbish: these should be removed for recycling or appropriate disposal as soon as possible.
On-site sewage treatment should not result in the pollution of surface or groundwater and should be designed and constructed to appropriate standards.
Fuel, lubricants, coolant, waste oil and waste chemicals must be stored in an approved manner such as in drums or surface tanks with impervious bunds to contain spillage, and located away from operating areas, natural or engineered drainage pathways, waterways and areas prone to flooding. The volumes of such materials stored on-site should be minimised by appropriate purchase or waste disposal control protocols. Specifications for storage will depend on the quantity and class of the material being stored. Above ground storage tanks with impervious bunds should be used in preference to underground storage tanks, as these reduce the risk of groundwater contamination. Bunding should be regularly tested, along with the integrity of storage vessels. Bund walls may also be used to divert storm water away from storage areas. Fluids released during machinery maintenance operations should not be spilled on the ground: this work should be undertaken on impervious pads with wash down sumps where the fluids can be captured and removed for appropriate disposal or recycling. Any hazardous materials stored or used on-site should only be disposed of at designated sites.
Issue Number: 8

Objective: Dust – to avoid the generation of dust from site activity and minimise the consequences of dust affecting nearby communities and land uses.

Performance Indicator:

- Where buffer zones or margins have been designated, have they been left in accordance with license conditions and are there markings to limit the extent of mining operations?
- Are site roads signposted to give speed limit indications, directions and safety warning?
- Are site road signs kept clean and well maintained?
- Have the site entrance and weighbridge access roads been suitably surfaced and kerbed and are they free of standing water?
- Are the site roads adequately drained and maintained?
- Is dust controlled when necessary in dry conditions using a water bowser or other damping agent?
- Has action such as the provision of wheel cleaning facilities or a contract for regular road sweeping been taken to ensure that mud and dust are not carried onto the public highway?
- Are lorries sheeted when using public roads to prevent escape of dust and sand and gravel?
- Has tree planting or vegetation been used to screen the site, reduce wind blow and act to help filter out airborne dust?

Activity or Location: Extraction, Processing, Transport

Impact Group: Air

Issue Description: Escape of dust into surrounding land uses and communities, causing surface soiling.

Intervention Level: Technical

Minimum Acceptable Standard: Minimise off site dust occurrence.

Best Practice Guidance: Continually sprinkling the quarrying environment with water; can serve to contain the fine material and ensure minimal dusting. Ensuring that haulage vehicles are properly covered and material hauled is dampened; this can offer an effective solution for reducing airborne dust and dust spillage while material is in transit. Ensuring that haulage vehicles are equipped with functional tailgates. Slow site speed and damping of haul roads. Site design to retain buffer distances and vegetation.
Environmental and Social Impacts of River Mining in Jamaica

Issue Number: 9
Objective: Fumes – minimise impact of vehicle fumes.
Performance Indicator:
• Is the plant maintained on a regular basis and is it free from visible or other fumes?
Activity or Location: Exploration, Extraction, Processing or Transport (select one or more)
Impact Group: Air
Issue Description: Emission of vehicle fumes.
Intervention Level: Technical
Minimum Acceptable Standard: Minimisation of emissions through effective maintenance of plant and equipment.
Best Practice Guidance: Routine maintenance of quarrying equipment – ensuring that trucks and industrial machinery are in proper working condition to minimise avoidable exhaust fumes.

Issue Number: 10
Objective: Noise – to ensure that the effects of noise and vibration on the environment and the local community are minimised and kept within acceptable levels.
Activity or Location: Exploration, Extraction or Processing
Impact Group: Physical
Issue Description:
• Where plant and machinery are operating near communities or houses or other sensitive properties, has action been taken to minimise any impact of noise and vibration?
• Have silencers been installed to static motors and mobile plant?
• Where appropriate, have reversing alarms been fitted?
• Have rubber linings and suspension systems been used on vehicles, chutes and hoppers?
• Have noise monitoring surveys been undertaken?
• Are plant and noise operations located away from houses or sensitive land uses and are they screened from view by soil mounds, fencing or other solid barriers (which also reduce sound)?
• Are the operating hours within the normal working day to avoid night or evening disturbance?
Intervention Level: Technical
Minimum Acceptable Standard: Avoid unacceptable noise to local communities and site operatives (generally operations should be below World Health Organisation recommended limits)
Best Practice Guidance: Ensure regular monitoring of noise. Plan operations so noise activities are away from houses or communities. Maintain plant and equipment and ensure appropriate silencing. Coincide audible activities such as crushing, generator use, loading etc. with peak operation times when there are periods of high ambient noise. Provide a “buffer zone” between operations and settlements and use screen bunds and solid fences where needed to reduce noise at sensitive locations.
<table>
<thead>
<tr>
<th>Issue Number:</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective:</td>
<td><strong>Incision</strong> – minimise the impact of river mining on the river channel and prevent progressive erosion up stream.</td>
</tr>
</tbody>
</table>
| Performance Indicator: | • Is working in accordance with licensed/permitted area and relevant conditions?  
• Is regular monitoring of the river channel undertaken and if any erosion or incision is apparent are steps taken to remedy the situation?  
• If the problem is persistent, has any review of the license/permission conditions or quarry plan been undertaken to remedy situation and prevent recurrence? |
| Activity or Location: | Extraction or Closure |
| Impact Group:    | Physical |
| Issue Description: | The erosion of the river channel cause by uncontrolled river mining, leading to the undermining of its channel, pipelines, roads and bridges. |
| Intervention Level: | Technical |
| Best Practice Guidance: | Maintain natural continuity of sediment transport through the river system by implementation of best practice river mining |
Environmental and Social Impacts of River Mining in Jamaica

Issue Number: 12

Objective: **Bank erosion** – to prevent the erosion of the river bank and channel, change in river course or the progressive migration of the nick point up stream.

Performance Indicator:
- Is working in accordance with licensed/permitted area and relevant conditions?
- Is regular monitoring of the river channel undertaken and if any erosion or incision is apparent are steps taken to remedy the situation?
- If the problem is persistent, has any review of the license/permission conditions or quarry plan been undertaken to remedy situation and prevent recurrence?

Activity or Location: Extraction, Processing, Transport

Impact Group: Physical

Issue Description: Where there is damage to the riverbank, though mining of the bank or by unrestricted access and egress from the river channel by heavy vehicles, erosion and river migration can occur. The character of the river changes and the river may in some cases move its course, leading to erosion of land, roads and bridges.

Intervention Level: Technical

Minimum Acceptable Standard: Minimal impact on the riverbank and channel with no significant erosion.

Best Practice Guidance: Maintain natural continuity of sediment transport through the river system by implementation of best practice river mining. Minimise access and egress points from river. Maintain a buffer zone either side of riverbanks to maintain their integrity. Do not undermine channel by extracting from or below banks. Protect vulnerable banks and remedy erosion where apparent. Review operations if this persists.
Objective: Livestock – to ensure minimum loss of livestock during mining operations and restoration of farming areas following closure of mines.

Performance Indicator:

- Does the site include existing or former agricultural land used for livestock and if so has the farmer been recompensed for loss of land?
- Is there provision for progressive restoration of the floodplain agriculture following mining activity?
- Does the site adjoin agriculture where livestock are present and if so is the site adequately fenced to prevent ingress of livestock and their possible loss?

Activity or Location: Extraction, Processing, Transport

Impact Group: Socio-livelihoods

Issue Description: Livestock may be lost or reduced as a result of legal or illegal infringement by the mine operators on existing farm land or from mine operators killing the cattle or the cattle being involved in a mine related accident.

Intervention Level: Policy, land use, planning and technical.

Minimum Acceptable Standard: The overall balance of agricultural and mining interests, including interim compensation (income, land or animals) to maintain production and long-term restoration of the land.

Best Practice Guidance: Land loss, if unsanctioned, must be curtailed by official agencies. If sanctioned, then comparable land-in-kind or fair and clearly defined compensation mechanisms must be implemented. Loss of livestock through accidents can be mitigated through the construction and maintenance of an impenetrable boundary fence.
**Issue Number:** 14  

**Objective:** *Cultivated land (food and fuel)* – to ensure that there is no long term loss of productive farmland as a result of mining unless this is unavoidable and to ensure that impacts during mining are controlled.  

**Performance Indicator:**  
- Does the site include existing or former agricultural land and if so has the farmer been recompensed for loss of land?  
- Is there provision for progressive restoration of the floodplain agriculture following mining activity?  
- Is the quality of the land restoration sufficient to support productive agriculture?  

**Activity or Location:** Extraction, Processing, Transport  

**Impact Group:** Socio-livelihoods  

**Issue Description:** Loss of farmland to mining operations.  

**Intervention Level:** Policy, technical and land use, planning  

**Minimum Acceptable Standard:** Avoidance of permanent loss of productive farmland to mining.  

**Best Practice Guidance:** Encroachment by the mine operators on productive farmland, if unsanctioned, must be curtailed by official agencies. If sanctioned, then comparable compensation or land-in-kind should be provided (which could include payments to the farmer). Failing this, a fair and clearly defined compensation mechanism must be implemented. This compensation mechanism needs to include instruction on budgeting and investing the compensation sums to the beneficiaries/farmer. Following mine closure the land should be restored on a progressive basis to productive agriculture.
Environmental and Social Impacts of River Mining in Jamaica

**Issue Number:** 15

**Objective:** Fishing and fish stock – the avoidance of adverse impacts on fishing and river ecology by the minimisation of impacts within the river.

**Performance Indicator:**
- Has consideration been given to the incidence of fishing or related activities within the area of the mine?
- Is there any adverse impact on fishing, due to turbidity, bank erosion or other activity and if so, have measures been taken to reduce or eliminate these impacts?
- Is working in accordance with licensed/permitted area and relevant conditions?
- If the problem is persistent, has any review of the license/permission conditions or quarry plan been undertaken to remedy situation and prevent recurrence?

**Activity or Location:** Exploration, Extraction, Closure

**Impact Group:** Socio-livelihoods

**Issue Description:** Increase in the level of downstream water turbidity and effluents and changes in river flow as a result of river mining can have a significant effect on the level of fish stock and access to suitable fishing waters.

**Intervention Level:** Technical

**Minimum Acceptable Standard:** Minimisation of impact on fishing by avoidance of unacceptable levels of turbidity or other pollution.

**Best Practice Guidance:** The best solution is the elimination or reduction in water turbidity or the other factors affecting fishing. This should be undertaken by following the principles for water management and minimisation of working in the river channel. Where river mining and reliance on fishing as a means of livelihood or sustenance is particularly concentrated compensation for loss of livelihood must be considered.
<table>
<thead>
<tr>
<th><strong>Issue Number:</strong></th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td><strong>Employment displacement</strong> – avoid unnecessary displacement of economic activity and employment caused by mining activity.</td>
</tr>
</tbody>
</table>
| **Performance Indicator:** | • Has consideration been given to the presence of other economic or employment interests and the potential impacts of the mining operation on them?  
• Has this been quantified and consulted upon?  
• Is there any adverse impact that conflicts with other economic activities (e.g., on fishing, or tourism) and if so, have measures been taken to reduce or eliminate these impacts?  
• If the problem is persistent, or if there is an inherent conflict has consideration been given to refusal of the license or review of the license/permission conditions or quarry plan to remedy situation and prevent recurrence? |
<p>| <strong>Activity or Location:</strong> | Extraction, Processing, Transport, Closure |
| <strong>Impact Group:</strong> | Socio-livelihoods |
| <strong>Issue Description</strong> | There is potential for mining activity to conflict with other land uses such as tourism, agriculture or fishing and potential for consequent loss of employment in these other businesses if this is not resolved. While in most cases the issue can be avoided by careful planning, design and conditioning/control of mining operations, there may be cases where this is not adequate and consideration needs to be given over which activity should prevail. |
| <strong>Intervention Level:</strong> | Policy, Land use and planning |
| <strong>Minimum Acceptable Standard:</strong> | Consideration should be explicitly given to different economic interests and employment and any potential conflicts minimised. |
| <strong>Best Practice Guidance:</strong> | Minimise the adverse impacts arising from mining activity. Undertake an analysis of alternative economic activity and employment and the impact of displacing existing employment. Utilise available local skills and give the community (regardless of political affiliation, social grouping) priority for employment opportunities. The most likely form of employment displacement will involve agricultural or fishing activities through encroachment and water pollution. In this case, the aforementioned livelihood mitigation measures will also be relevant. For other activities e.g. tourism, avoidance, mitigation or compensation mechanisms should be considered. |</p>
<table>
<thead>
<tr>
<th>Issue Number:</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td><strong>Housing</strong> – the avoidance of adverse impacts on housing, housing land and the quality of life of communities.</td>
</tr>
</tbody>
</table>
| **Performance Indicator:** | • Has consideration been given to the presence of housing in the location, design and layout of the mine/quarry and plant site and the potential impacts of the mining operation on them?  
• Is monitoring undertaken of the operation of the site in order to avoid adverse impacts on housing and communities?  
• Is the operation of the site in accordance with the quarry plan and the relevant conditions of the license/permission?  
• If there are persistent problems, or if there is an inherent conflict has consideration been given to refusal of the license or review of the license/permission conditions or quarry plan to remedy situation and prevent recurrence? |
| **Activity or Location:** | Extraction, Processing, Transport |
| **Impact Group:** | Socio-livelihoods |
| **Issue Description:** | Encroachment by the mine operators on existing housing or housing land and the quality of life of communities. |
| **Intervention Level:** | Policy, Land use and planning, Technical |
| **Minimum Acceptable Standard:** | To ensure that there is no encroachment on housing without fair and reasonable compensation and to ensure that the right to enjoy a good quality of life by local communities is protected. |
| **Best Practice Guidance:** | The best practice would be to avoid existing established housing areas and communities and to ensure that they are safeguarded by a protective buffer zone within which no mining should take place. Further measures as detailed in this code should also be adopted (e.g. to control noise and dust). Encroachment by the mine operations on existing housing or housing land, if unsanctioned, must be curtailed by official agencies. If sanctioned, then comparable housing and land-in-kind should be provided. Failing this, a fair and clearly defined compensation mechanism must be implemented. This needs to include instruction on budgeting and investing the compensation to the beneficiaries. |
Issue Number: 18

Objective: **Sustainable Transport** – to help minimise the impact of traffic including accidents, road surface degradation, traffic congestion and the impact of slow moving traffic.

Performance Indicator:

- Are appropriate traffic routes being used which avoid sensitive areas and unsuitable roads where practicable?
- Is the mine/quarry as close as possible to potential markets?
- Has action been taken to ensure that drivers obey speed limits and behave in a reasonable manner?
- Are quarry vehicles loaded correctly and are steps in place to ensure vehicles are not over their permitted weight limits?
- Are vehicles adequately maintained, with particular checks on brakes and other essential equipment?
- Are transport vehicles maintained and equipped so as to minimise fuel consumption and exhaust emissions?
- Are vehicles loads sheeted and have effective tailgates to avoid accidental spillage?

Activity or Location: Transport

Impact Group: Socio-economic

Issue Description: The presence of heavily laden mine and quarry traffic can have a significant impact on the road system and its other users. In Jamaica, frequent broken down vehicles, many visibly over their permitted weight lead to congestion and where they use routes repeatedly, lead to break up of the surface and strain on bridges.

Intervention Level: Policy, Land use and planning, Technical

Minimum Acceptable Standard: To ensure that the effects of quarry or mine traffic are minimised.

Best Practice Guidance: Careful consideration should be given to the location of mine and quarry sites to ensure that the distances travelled by quarry traffic are minimised and use the most suitable roads. Depending on the scale of operation, existing roads may be unable to accommodate extensive and sustained truck traffic and will demand an upgrading and expansion programme. This could be co-ordinated with other land use priorities and investment to maximise benefits and likelihood of investment. Once operational, appropriately maintained, loaded and driven vehicles help to minimise adverse impacts.
Objective: Workplace accidents – to minimise worker accidents and deaths or serious injury to others arising from unsafe working practices.

Performance Indicator:

- Where the extraction area is separate from the main production area, is it securely fenced?
- Is working proceeding according to the quarry plan?
- Is the site worked in benches with appropriate width and height, to avoid high faces and ensure bench stability?
- Are material stockpiles in a stable condition and suitably located?
- Is the working proceeding in accordance with the relevant conditions of the license or permission?
- Where the working is within the river channel have steps been taken to ensure that the banks and river margins are left in tact and that the channel is protected from erosion/undercutting?
- Are silt ponds or areas of unstable ground signed and securely fenced to avoid accidents?
- If the access road to the excavation is adjacent to the quarry edge, have safety bunds been provided in accordance with safety regulations?
- Have quarry faces been left in a safe condition?
- Are all protective guards on quarry/mine equipment in good condition and securely fixed in place?
- Are working areas well lit (when in dark or evening conditions), tidy and free of obstruction?
- Are there notices warning of the presence of the quarry, the danger and how to avoid it and such signs clean and give clear instruction to staff and visitors?
- Are all staff trained to use equipment safely at all times including maintenance work?
- Are plant and vehicles adequately maintained and checked?
- Are the Company Policy and any Manager’s Rules on Health and Safety displayed, followed and monitored?
- Have all risks to be the public and visitors been identified and controlled?
- Are all site staff aware of the relevant health and safety information and are they working in the spirit of the regulations?

Activity or Location: Exploration, Extraction, Processing, Transport, Closure

Impact Group: Socio-health

Issue Description: Deaths and serious injury in the workplace, through uncontrolled access of people and animals to mine and quarry sites and through unsafe practices leading to off site injury (e.g. land instability or road accidents).

Intervention Level: Technical

Minimum Acceptable Standard: Compliance with relevant health and safety controls.

Best Practice: There is well-established existing technical guidance on mineworker health and
Guidance: Safety both within Jamaica and internationally. These guidelines concern such issues as using hard-hats, operating machinery, sounding warnings, traffic speed, worker age and experience, training etc. The problem in Jamaica, as in many other developing countries, is that such guidelines are often ignored or regarded as a hindrance to core operations. Implementation, monitoring and enforcement of these guidelines remain the overriding challenge.
<table>
<thead>
<tr>
<th>Issue Number:</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective:</td>
<td><strong>Plant and Buildings</strong> - to ensure that the plant and stock area are tidy, the plant and buildings are well maintained, dust and noise are being controlled, and that the plant is operated in accordance with restrictions imposed by the planning conditions.</td>
</tr>
</tbody>
</table>
| Performance Indicator: | • Are all site staff aware of the relevant health and safety information and are they working within the regulations?  
• Have the plant and buildings been maintained and has any necessary repair and repainting work been carried out?  
• Is the plant noisy, poorly silenced or producing excessive fumes and if so are measures in hand to remedy such problems?  
• Have damaged conveyor, plant or building panels and broken windows been removed and replaced?  
• Is the plant and stockyard area tidy?  
• Is dust from mobile or fixed plant and equipment effectively controlled?  
• Is the general external appearance of the site office good?  
• Are the buildings clean and cared for internally?  
• Are the toilet facilities clean and adequate for visitors?  
• Is there adequate parking for staff and visitors and is it clearly signposted and safely located?  
• Are site records such as operational plans, planning permissions, site licenses and safety procedures available at the site office? |
| Relevant Activity or Location: | Exploration, extraction, processing, waste disposal, transport |
| Impact Group: | Physical, human health, quality of life, economic |
| Issue Description: | Poorly maintained plant sites are both inefficient and a cause of danger and nuisance to people working at the site or living nearby. Breakdowns, accidents, inefficient production and general disturbance through noise, dust and other impacts arise where equipment is old and poorly maintained. Maintenance is therefore, central to the control of many of these impacts and helps ensure operations are acceptable. A well-maintained site, with adequate facilities for employees and visitors is likely to engender more respect and care for the working and external environment, benefiting the workforce and community. |
| Intervention Level: | Technical |
| Minimum acceptable standard: | To maintain all plant and buildings in good condition with appropriate silencing. |
| Best Practice Guidance: | To choose items of plant and machinery and quarrying techniques that minimise adverse environmental impacts and maintain this to high standards according to manufacturer’s specifications. |
Issue Number: 21

Objective: *External Appearance* - To ensure that the entrance to the site and its environs are clean and tidy, well sign-posted and fenced. Measures should be taken as far as possible to ensure that site operations are screened to minimise their visual and landscape impact. The overall objective is to ensure that the site blends with its immediate surroundings.

Performance Indicator:

- Is dust from mobile or fixed plant and equipment effectively controlled?
- Does the site boundary fencing, entrance and general external appearance blend with the surrounding countryside?
- Have steps been taken to reduce the effect of the site visibility and noise, dust and smell beyond the site boundaries?
- Have screening bunds been placed to minimise the visual impact of the access road, plant buildings and extraction area?
- Have screening bunds been grass seeded and kept free of weeds?
- Have tree and hedge planting or the retention of forest or vegetation features been incorporated into the site design to assist in screening?
- Are the entrance gates and boundary fences in a good condition?
- Has a site entrance sign been erected and is it visible, clean and well maintained?
- Has any shrub or tree planting been undertaken to enhance the entrance?
- Have any screening, planting or grassed areas at the site entrance and/or boundaries been maintained?

Relevant Activity or Location: Extraction, processing, waste disposal, transport and closure

Impact Group: Quality of life, livelihoods, economic

Issue Description: Visual impact of river mining and the associated plant, equipment, physical disturbance and quarry areas can be significant and degrade the landscape or visual quality of significant areas, an issue important to quality of life and tourism. This often combines with noise or dust to create a significant overall impact.

Intervention Level: All - reactive technical, proactive technical, planning & land use and policy.

Minimum acceptable standard: Provision of minimum level of screening to avoid obtrusive operations.

Best Practice Guidance: Consult the community on those aspects of the project that they find most aesthetically intrusive or unsightly. Avoid particularly sensitive landscapes (i.e. important for tourism). Effective screening of all boundaries to conceal plant, buildings and working areas from public view (planting several rows of fast-growing trees or use of grassed earth mounds or fences at Policy locations where mining activity is to occur). Design of quarry layout to minimise views into the site. Excavated riverbeds and surrounding land/plant sites should be restored following mine activity so as not to permanently scar the terrain.
<table>
<thead>
<tr>
<th>Issue Number:</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td><strong>Restoration and After-use</strong> – to ensure that the land is restored to an appropriate condition that enables its beneficial after-use.</td>
</tr>
<tr>
<td><strong>Performance Indicator:</strong></td>
<td>Is restoration proceeding according of the operational plan and the requirements of the planning permission?</td>
</tr>
<tr>
<td></td>
<td>Has an after care scheme been prepared and submitted to the government where appropriate?</td>
</tr>
<tr>
<td></td>
<td>Where appropriate, is the restoration phased with the mineral extraction?</td>
</tr>
<tr>
<td></td>
<td>Are topsoils, subsoils and overburden stored separately?</td>
</tr>
<tr>
<td></td>
<td>Have soils been handled only when in a dry and friable condition?</td>
</tr>
<tr>
<td></td>
<td>Have recommended machinery and soil handling methods to minimise solid compaction been followed in solid stripping, storage and placement operations?</td>
</tr>
<tr>
<td></td>
<td>Do the restored area appear cared for and well managed?</td>
</tr>
<tr>
<td></td>
<td>Has action been taken to deal with problems of discolouration, dieback, wasteloggng or settlement in the restored areas?</td>
</tr>
<tr>
<td></td>
<td>Are detailed restoration and farming management records being maintained?</td>
</tr>
<tr>
<td></td>
<td>Has land drainage been installed where appropriate?</td>
</tr>
<tr>
<td></td>
<td>Has tree and hedge planting been undertaken?</td>
</tr>
<tr>
<td></td>
<td>Have conservation areas been developed?</td>
</tr>
<tr>
<td></td>
<td>Does restoration blend with the surrounding landscape and land uses?</td>
</tr>
<tr>
<td></td>
<td>Have the banks of any restored lakes and/or of the river channel been designed and protected against water erosion?</td>
</tr>
<tr>
<td><strong>Relevant Activity or Location</strong></td>
<td>Extraction and closure</td>
</tr>
<tr>
<td><strong>Impact Group:</strong></td>
<td>Physical, quality of life, livelihoods, economic</td>
</tr>
<tr>
<td><strong>Issue Description:</strong></td>
<td>Visual impact of river mining and the associated plant, equipment, physical disturbance and quarry areas can be significant and degrade the landscape or visual quality of significant areas, an issue important to quality of life and tourism. This often combines with noise or dust to create a significant overall impact.</td>
</tr>
<tr>
<td><strong>Intervention Level:</strong></td>
<td>Policy, Planning &amp; land use and Technical.</td>
</tr>
<tr>
<td><strong>Minimum acceptable standard:</strong></td>
<td>Provision of land restoration to beneficial after-use.</td>
</tr>
<tr>
<td><strong>Best Practice Guidance:</strong></td>
<td>Operations should be planned with restoration and after-use in mind. This can be to ensure the continued integrity of the river and its channel or where working involves the floodplain for the plant site or for mining or quarrying can be for agriculture, tourism, lakes, fishing or nature conservation/wildlife. Where working is of the river terrace, operations should follow the quarry plan and be in phases so that progressive restoration of worked out areas can take place. Where working the floodplain, soils should be removed carefully before sand and gravel is extracted and the soil should be stored in earth bunds or mounds for reuse in restoration. Soils can form useful screen bunds to help visually screen mining operations. As part of restoration soils should be replaced where restoration is dry (i.e. above the groundwater level) or can form gently graded margins to lakes where extraction is below the water level. The aim should be to provide an ongoing use for the land or for the long term integrity of the river, once mining has ceased.</td>
</tr>
<tr>
<td>Issue Number:</td>
<td>23</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Objective:</strong></td>
<td><strong>Community Liaison</strong> – To promote effective dialogue between mining companies and the local communities in which they operate.</td>
</tr>
</tbody>
</table>
| **Performance Indicator:** | • Are there any links with the community?
• Has any contact been made with the local community to discuss proposals or ongoing operations?
• Are the relevant company managers or site owner identified on signs at the site to allow local people to contact him/her?
• Is there any regular meeting between representatives of the community and the company to resolve problems or issues without delay or antagonism?
• Have copies of the relevant permissions/licenses and quarry plans been made available to local organisations or people and are they available for inspection at the site?
• Do staff have an understanding of the environmental aspects of their activities and how the can assist in reducing their impact? |
| **Relevant Activity or Location** | Extraction and closure |
| **Impact Group:** | Quality of life, livelihoods, economic |
| **Issue Description:** | Many of the potential impacts arising from river mining or quarrying in the floodplain on the local community, on agriculture and other local economic interests, such as tourism. These issues can be resolved through effective dialogue so that both the interests of the mining company and those of the local community can be protected. Discussion often helps people understand mining operations and the need for them and helps companies understand what local people feel is important to them. Through discussion and a flexible approach, mining can be an accepted part of community life. |
| **Intervention Level:** | Planning & land use and Technical. |
| **Minimum acceptable standard:** | Provision of key information and some effective consultation/dialogue. |
| **Best Practice Guidance:** | Details of the site manager/owner (name, telephone number, work address) should be displayed at the site entrance so that people can make contact. Copies of the quarry plan and relevant permissions/licenses should be displayed at the site office and access should be made available to them either there or at another place in the local area (library or council office). Consideration should be given to forming local liaison groups where members of the community and the mining company meet at regular intervals (quarterly or six monthly) to review the operations and any issues arising. |
Environmental and Social Impacts of River Mining in Jamaica

Issue Number: 24

Objective: **Quarry Plans** – to ensure that all river mining and quarry sites in floodplains have quarry plans and that these provide an effective guide for day to day operations, the overall planning of mine and quarry development and as a basis for effective control.

Performance Indicator:

- Is there a Quarry Plan that shows in plan form and in written text how the mine or quarry is proposed to be developed and operate?
- Does this show the overall layout of the site and all key elements of infrastructure (e.g. extraction areas, location of plant sites, buffer zones and areas to be retained where no working is to take place) and nearby sensitive features?
- Is the Quarry Plan kept under review and are any amendments notified to government and regulating agencies and to local community?
- Are employees aware of the Quarry Plan and familiar with its contents so far as it affects their areas of responsibility?
- Outside of their direct areas of responsibility, are employees familiar with the overall approach that is intended and who to contact should problems or issues arise?
- Is the Quarry Plan discussed on a regular basis and monitored against operations with the regulating agencies?

Relevant Activity or Location: Extraction, Processing, Traffic and Closure

Impact Group: Physical, Health, Quality of life, Livelihoods, Economic

Issue Description: Many of the issues arising from mining or quarrying activity can be predicted and measures planned to ensure that the risk of problems arising is minimised. This is best undertaken through the preparation of a Quarry Plan which can then form the basis of successful license/permit applications, conditions and ongoing employee training and operation.

Intervention Level: Planning & land use and Technical.

Minimum acceptable standard: Provision of key information on quarry design, layout and operation.

Best Practice Guidance: It is usual in Jamaica for Quarry Plans to set out the geology and basic information on the operations proposed, but in order to address fully the overall impact of quarrying/mining further information is required. The preparation of a Quarry Plan should start from the pre development state and address all relevant site constraints and opportunities, including all of the key environmental impacts and how they are proposed to be addressed during operation. The Quarry Plan should detail how the site is to be developed initially, the mining process and ongoing phasing of operations. The Quarry Plan should contain a site location plan, an overall site layout plan (showing all relevant infrastructure and features and the maximum extent/limit of working), a restoration plan (showing how and when each phase is to be restored to a beneficial after-use) and cross sections showing the depth of working and nature of any bank treatment where working is within the river channel. The Quarry Plan should also detail the health and safety and environmental monitoring and controls to be adopted.
**Issue Number:** 25

**Objective:** License/Permission – To ensure that effective and up to date licenses and permits exist for all sites and that operations comply with the requirements of those licenses/permits.

**Performance Indicator:**

- Does the site have a valid copy of all of the necessary licenses/permits?
- Are copies of the licenses/permits kept on site for inspection?
- Are employees familiar with the contents so far as relevant to their work?
- Is there a clear line of responsibility for site employees to ensure that they are aware of the need for compliance and any remedial steps that may need to be taken where any conditions are breached?
- Are the conditions up to date and relevant to the operation of the mine/quarry or do they need to be reviewed?
- Are the conditions consistent with the Quarry Plan?

**Relevant Activity or Location**

Extraction, Processing, Traffic and closure

**Impact Group:** Physical, Health, Quality of life, livelihoods, economic

**Issue Description:** Compliance with conditions of any license or permit is essential to the minimisation of adverse environmental impacts.

**Intervention Level:** Planning & land use and Technical.

**Minimum acceptable standard:** Full compliance.

**Best Practice Guidance:** Regular and frequent audits by an appropriate site manager is the best way of ensuring compliance with conditions. A good working knowledge by site employees helps day-to-day compliance.
7.0 CONCLUSIONS AND RECOMMENDATIONS

Ultimately, the ability of mine operators and government agencies to identify, generate, implement and enforce appropriate technical and strategic mitigation and enhancement measures in Jamaica will be affected by a number of factors. The critical factors observed during the course of this research include; the legal status of the mine operators; regulatory development and synthesis; government agency co-ordination; agency funding and corruption. These interrelated factors are in no way unique to the Jamaican context and are typical of the mining sector and regulatory environments of many developing and even developed countries around the world.

The legal status of the mine operators themselves will clearly affect the ability of government agencies and the will of mine operators to mitigate environmental and social impacts. However, while by definition any unlicensed operator will be running an illegal operation, Table 8 (above) also demonstrates that licensed operators may undertake illegal operations, although the potential for this diminishes from small/medium-scale to large-scale. This should not be taken to imply that large-scale operations will be in compliance with environmental and social regulations, but rather that the potential risk of them operating outside their licensed area is low (i.e. Table 8 is not a measure of the potential for environmental and social impacts).

It was earlier stated that regulated (licensed) operations have, in theory if not reality, lower environmental and social impacts than unlicensed operations, even when the operations are large-scale. However, this theoretical position relies on an assumption of appropriate existing regulation, the effective enforcement of that regulation, and consistent and regular monitoring undertaken by well-resourced government agencies with comprehensively trained staff. This assumption does not appear particularly robust in the Jamaican context for a number of reasons. The first, though probably least significant, reason relates to the existence of appropriate regulation.

Despite the enactment of a substantial raft of regulation, there are still some regulatory gaps in the Jamaican legal framework etc. (see report by Fidgett, 2003). However, Jamaica’s present legislative framework is relatively comprehensive overall and it is weaknesses with regard to monitoring and enforcement that remain the overriding concerns.

Monitoring and enforcement are undermined by regulatory inconsistencies and a lack of clarity regarding responsibilities and strategic priorities among and between government departments. As a result, responsibility for the monitoring of social and environmental impacts and the enforcement of mitigation and enhancement measures are falling between the various governmental departments. For instance, dust monitoring is the responsibility of Mines and Geology, NEPA and Department of Health and yet there is no co-ordinated monitoring programme between them. Legislative inconsistencies compound the problem of agency co-ordination. While NEPA has the legal right to demand an environmental impact assessment, there are conflicts and gaps between the NRC Act, Mining Act and Quarries Control Act.

There is, therefore, a need to synthesise the legislation and develop a memorandum of understanding between departments regarding monitoring and enforcement.
responsibilities. In this, the collaborative efforts of the NRCA, the Environmental Warden Services of the Ministry of Environment and Housing, the National Security Force and the Judicial System will be critical. However, equally critical is clarifying and streamlining the process. One measure would be to ensure that agencies charged with monitoring have the enforcement authority. In this respect, NEPA should be given greater enforcement rights and capacity. Moreover, enforcement should not be the responsibility of departments like Mines and Geology who have an economic stake in mining as this places them in the position of ‘poacher and gamekeeper’.

A lack of funding and resources, corruption at all levels and intimidation of police and field environmental officers compound these contextual challenges. Amidst this, however, there are innovative medium term solutions such as the idea employed in some countries to ensure that post-closure commitments are met is that of mine bonding. This refers to the depositing of a sum of money (the posting of a bond) with a consent authority (government agency) by the mining company before operations begin. The deposit is intended to guarantee the reclamation and rehabilitation of the area to be mined. If the mining company goes bankrupt or fails to comply with the conditions imposed, they forfeit the bond to the consent authority, which then becomes responsible for the rehabilitation of the mine site (Gilpin 1995).

In the interim period between the adoption of technical solutions detailed in this report and more comprehensive, and ultimately precursory, institutional, legal and political changes necessitated at the strategic level, innovative medium term solutions such as those suggested above can be employed and should be further encouraged.
8.0 REFERENCES


Avotri, T. 1997 Health Impacts in Wassa West district in Relation to the Mining Industry: A Report to TWN. Tarkwa: Tarkwa General Hospital. 7/7/97.


Durkheim, E. 1933 La Sociologie. La Science Francais 1, 27-35.


Emerson-Bain, A. 1994 Sustainable Development or Malignant Growth?: Marama Publications.


9.0 GLOSSARY

**Biodiversity**: Biological diversity – the variety of life forms including micro-organisms, plants, animals and their genes, and the ecosystems that they form.

**Certainty**: Refers to the likelihood or probability of occurrence of impact.

**Cohesion**: maintenance of a particular or special unit of character, the boundaries of which may be physical or conceptual, through functional and effective ties.

**Contaminant**: Any substance present at a concentration above that found naturally that may or may not cause harm.

**Cumulativity**: Refers to the degree to which the impact will lead to other impacts.

**Demography**: Human populations and their changing patterns in terms of their growth, distribution and decline, due to factors like migration, fertility and mortality.

**Environmental Impact Assessment (EIA)**: A formal process to identify, estimate and evaluate the environmental consequences of current or proposed actions.

**Frequency**: Refers to how often the impact will occur.

**Household**: A group of persons sharing a home or living space, who aggregate and share their incomes, as evidenced by the fact that they regularly take meals together.

**Impact – direct**: Impacts arising as a direct result of an activity (i.e. with a clear cause-and-effect relationship).

**Impact – indirect**: Impacts arising as a result of an activity, but not directly linked (i.e. an impact caused by an activity but delivered via a sequence of connected events not by the activity itself).

**Locality**: Refers to the area of impact.

**Mitigability**: Refers to the potential of the impact to be mitigated.

**NGO**: Non-government Organisation (NGO) is an organisation, which is neither a business or represents a government. In this way both the International Chamber of Commerce and Greenpeace are NGOs.

**Primary Data**: data collected by study / research and which was not already available.

**Significance**: Relates to the incidence and distribution of impacts and results from estimating the magnitude and severity of the impact and the response that is evoked.

**Social Impact**: the direct, indirect and cumulative social consequences of actions, including change to norms, beliefs, perceptions and values.

**Social Impact Assessment**: the assessment, in advance, of the positive and negative social impacts of a given proposed project or policy development.
Social Pathology: Organic metaphor to suggest that parts of societies, like body parts, could suffer breakdown and disease.

Social Profile: a comprehensive and systematic summary of the key characteristics of a community or region. Typically prepared by means of a desk study of the available literature, plus interviews and key informants.

Stakeholder: groups or individuals either directly or indirectly affected by the project or who have a significant interest in operational decisions.

Survey: the systematic collection of facts, usually by means of a questionnaire, about a defined social group.

Sustainable Development: Development meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.
For more information contact:

Corporate Citizenship Unit,
Warwick Business School,
The University of Warwick,
Coventry CV4 7AL
United Kingdom