JUST COMPENSATION VALUE AND SUSTAINABLE DEVELOPMENT FOR LARGE SCALE MINERAL PROJECTS IN DEVELOPING ECONOMIES

By

Barry Daniel Green

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Chair

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Abstract:

by Barry Daniel Green, Ph.D.
Washington State University
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Chair: Philip Wandschneider

This research intends to develop a framework for assessing just compensation values for mining projects, where they might contribute toward a responsible, profitable, and sustainable path to economic growth and development. More specifically, it will deal with methods to determine a "sustainable" rate of mineral extraction, putting a dollar value on the environmental impacts from various levels of mineral extraction, and how a collaborative group including mining concerns, governmental agencies, and concerned citizenry, might function collectively to invest available monies into the region's economy. The project focuses on an emerging (society) political economy (Chile) and uses an interdisciplinary approach. **(a) Objectives:** The approach rests on the assumption that the policy objectives of environmental protection and sustainable economic development can be subsumed into the "Hartwick rule" goal of investing (financial and in-kind) mining rents in natural, social, and infrastructure capital. **Specific research tasks include:** Compilation of data on the initial (ex ante) cost estimates for environmental compliance; analysis of environmental monitoring/remediation; analysis of the opportunity for alternative compensation/remediation packages; analysis of third party environmental groups; and determination of the circumstances under which the minerals industry would make monies available for investment into a country with a developing economy's infrastructure projects. **(b)**

Approach: Minerals industry (company, regional and national) review of copper related reserves, production, methods of production, production costs, and profits. Determination of environmental costs on a per unit basis related to copper production, by review of U.S. EPA regulations, methodology, and models. Assessment of collaborative feasibility, by determination of the existence of web sites facilitating electronic information exchange at the company, governmental, regional and NGO level. **(c) Expected results:** The expected results of a study of this nature -- which uses information gleaned from the private and government sectors, and incorporates environmental standards (minimum to maximum) -- is to aid in policy decisions relating to benefit transfer to local/regional infrastructure investment. Results from this study potentially can be used by both the mining industry, government and regional groups in setting fee/tax/compensation schedule and negotiation frameworks to further "sustainable development."

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CHAPTER ONE

INTRODUCTION

In practice and theory, mineral development triggers two concerns: one over the environmental effects of mining operations, the other over sustainable economic benefits from the use of a non-renewable asset. In the current international climate, environmental effects can attract particular attention. In industrialized countries, regulations generally require mining concerns to mitigate, remediate/reclaim, or prevent any potential environmental harm. In emerging economies, regulations are quite variable, and national needs for a clean environment compete with infrastructure and health needs more so than in industrialized countries. In these circumstances it can be useful to look at the overall assets of the mining enterprise to explore how the financial, technical and capital assets of the mining concern might best contribute to a host country's goals. Whereas in richer countries the discussion over sustainability and non-renewable resources and the environmental impacts of mining are often separated, (involving different conversations between different actors, and different policies and laws;) in developing countries the goals of maintaining environmental quality and expanding economic development are intertwined.

At the present time sustainable development studies have occurred, and are occurring in many transitional economies. One of theses transitional economies is Chile, a country that has been diversifying its economy in recent years but is still mining dependent. Since Chile has a long history of dependence on mining (see history and institutional chapters, three and four), the problem of dependence on a nonrenewable resource has been apparent in a practical way for a period of years. In Region III, Chilean mining has accounted for anywhere between 38.4 to 46.1

percent of the regional GDP between the years of 1996 and 2003. (A more detailed breakdown of the Region III's economy appears in Chapter Eight.) Several studies examine the role of mining and its current and potential relationship to sustainable development. A recent United Nations/United Nations Environmental Programme (UN/UNEP) study in Chile (*Implementation of Policy Response Packages to Promote Sustainable Management of Natural Resources – Confronting Sustainability in the Mining Sector Role for a Sustainability Fund)* examines mining and sustainability based upon two premises. One premise being that production is based on a finite resource, at least on a local scale, and the other stating that there is normally a strong degree of interdependence between mining exploitation and the local or regional community.

These concerns over sustainability and environmental impact motivate this study. The study's ultimate goal is to advance discussion on a methodology toward a responsible, profitable, and sustainable path for mining to be a part of regional economic growth and development. The study will focus more specifically on the interrelated questions of how one can determine "sustainable" rate and manner of mineral extraction while showing that the returns to mining are appropriately allocated to maintaining sustainable regional development and a healthy mining industry. In addition, the process of operationally defining sustainable development should be collaborative, with participation from mining concerns, governmental agencies and the affected citizenry. Hence one is concerned with four levels of sustainability – sustainability of the asset, sustainable growth and development for the well-being of the regional population, sustainable basic quality of the environment, and sustainable economic life of the industry. These four levels of sustainability are interrelated but they are unlikely to be completely complementary – some trade-offs and compromises among them will certainly be required. The major contribution of this study will be to develop a conceptual and practical approach that will help obtain a workable model for incorporating and balancing all these aspects of sustainability.

Major themes of this study are illustrated by the conclusions of the Organization for Economic Co-operation and Development (OECD) in their "Environmental Performance Review – Chile" of 2005. Included in the category of *Towards Sustainable Development*, are the recommendations in Table 1-1.

TABLE 1-1.

Recommendations Towards Sustainable Development

1. *Develop economic analyses of environment-related policies, expanding both economic information on the environment (e.g. on environmental expenditure, environment-related taxes, health risk assessment, water and energy prices) and cost-benefit analysis of projects and legislation relating to the environment.*
2. *Review ways and means of integrating environmental concerns in fiscal instruments and policies.*
3. *Formalize institutional integration mechanisms relating to sustainable development.*
4. *Increase the financial contribution of the mining sector to support long-term investment in human and social capital and to apply the polluter pays principle according to the General Environmental Framework Law; consider a mechanism for proper capture of resource rents associated with mineral exploitation.*
5. *Continue to develop public participation in processes such as project-based environmental impact assessments and strategic environmental assessments of public policies, plans and programs*.

Source: OECD (1996)

This approach is meant to address the intertwined goals of protecting environmental quality while expanding economic development with incorporating greater public participation that drives this study. In this section, I will initially state the basic concepts used. That will be followed by a discussion of the need and significance for a study of this type, while expressing my assumptions and limitations to addressing the research questions. Finally, I will point out the potential benefits of the approach developed here and briefly outline the rest of the dissertation.

A. Basic Concepts

This work centers around three basic premises -- one that monetary calculations for the removal of a non-renewable resource can be made, that these financial calculations can be used as a basis to estimate a dollar quantity and that the identified amounts should be injected into the economy to substitute for the removal of that non-renewable resource. For the purpose of this work, the non-renewable resource is copper and the location is Region III of Chile. In this research paper, different schools of thought will be discussed concerning compensation for the removal of copper (resource depletion), and this will be reflected in the methods of calculation. Principal thoughts on this topic will arise in discussion of Hotelling, Hartwick, Repetto, El Serafy and World Bank methods of resource depletion and compensation.

Secondly, the need to protect the environment at some level that is agreed upon by all is taken as an essential starting point. I assume that protection of the environment and protection of human health are fundamentally interrelated. With the Chilean environmental laws based on the framework of the U.S. Environmental Protection Agency, I employed information and models that are used for that purpose in the United States.

Another part of this dissertation deals with what might be considered by some to be a side issue, but which is here considered fundamental. I consider participation by the local community in decisions affecting their well-being to be an essential part of the definition of well-being itself. Hence, a full treatment of sustainable development must address participation. Therefore, a section of this study will address participation through the idea of social capital. In this case, the application will be to the availability of electronic information exchange – an increasingly important mode of networking and participation.

B. Purpose and Significance of the Study

The purpose of this dissertation is to develop a framework for assessing the incorporation of infrastructure development in environmental remediation programs for mineral utilization in developing and emerging economies. These environmental reclamation/remediation programs would comprise a negotiated agreement between the mining industry and appropriate state and community entities and emphasize economic incentives. By combining tools from economics and environmental science, the study will illustrate the feasibility of taking a measurement tool (resource depletion) at the national level, incorporating environmental standards, and with the addition of potentially greater social capital in the form of availability of electronic information that facilitates greater networking, illustrate a realistic approach to a framework that will address these concerns at a regional level. This research project allows for mining companies to achieve profitability goals, while maintaining environmental remediation/reclamation standards, and assist in the avoidance/dampening of a cyclical economy through identifying monies available for infrastructure development in the affected communities. By determining tradeoffs and needs between high-tech remediation methods and low-tech remediation methods, a more stable estimate of remediation costs can be ascertained for the mining concern. Reducing uncertainty encourages mining firm investment in the community through the continuance of their existing projects, as well as the development of new projects. The investigator worked with mining concerns, universities and appropriate governmental agencies in Chile for the development of this model. The study follows the work of Bowles and Picket, *Footprints in the Jungle – Natural*

Resources Industries and Biodiversity Conservation, through the investigation of the potential of the minerals industry in regards to their contribution to economic sustainability. It also follows *Sustainable Development in Mineral Economics* by Autry and Mikesell, *The Global Possible-Resources, Development, and the New Century* by Robert Repetto, and *Population, Technology, and Lifestyle* by Goodland, Daly and El Serafy, by critiquing the areas of resource depletion, and environmental compensation brought about by the very act of resource consumption.

At the local level, mineral projects may have minimal interaction with the rest of the host country economy resulting in little, if any positive gain in infrastructure or standard of living for the project area. Historically a very sizeable proportion of the expansion and operation of multinational companies to developing countries or emerging economies has been concentrated in the extraction and processing of natural resources (Gillis, Perkins, Roemer and Snodgrass). In addition, mining operations worldwide are normally large in scale resulting in long-term regional effects on the environment and local population. The economic intentions of both the mining industry and local/regional are usually compatible – both hope for mutually beneficial mining operations. Unfortunately, sometimes the results are mixed for the long-term economic and infrastructure development of the affected region. This may lead to one of several results after the mining operation has ceased or slowed -- an overall economic gain, a stratified economy, or the region being worse off economically than it was prior to the mining operation.

In consideration of these factors, Auty and Mikesell state that …*"A benefit to all parties concerned would be a methodology that would increase the likelihood of a post mining operation infrastructure that aids in the region's long-term economic gain. Balanced growth models in mineral rich countries advocate congruent expansion of the various sectors of the economy, such as infrastructure, manufacturing, agriculture, and other natural resource industries"* (Auty and

Mikesell - 1998). Achieving these goals would require that some portion of the resources (in economic terms, the mining rents per the Hartwick rule) generated during a mine's operation would go to mining dependent communities as an investment in the community. With this in mind the project will evaluate the possibility to assist development in countries with emerging economies, through the design of cost-effective combinations of monies available for infrastructure development, and environmental remediation on projects being conducted by the minerals industry. This will aid in sustainable development, at both a community and regional level.

This study uses relevant information gleaned from the private and government sectors, incorporated with environmental standards (minimum to maximum). Its purpose is to aid in policy decisions relating to local/regional infrastructure investment. Results from this study potentially can be used by both the mining industry and governments in setting a fee/tax/compensation schedule that may prove beneficial in creating "sustainable" development while maintaining profit incentive in private industry.

C. Operational Criteria

Numerous policy approaches towards mining have been tried in the past, and various options will be explored in the future. The general lofty goals discussed above need to be formulated as more practical criteria. The methods and procedures developed in this study will seek to meet the following criteria:

- Does the method take into account an essential value for environmental damage of a mining operation through a $/unit cost, plus long-term monitoring costs.

- Does the method involve all relevant decision making parties in the policy process (mining concerns, governments, and regional/national NGOs).
- Does it provide resources (dollars) to sustain the region's economy (sustainable development).
- Does it protect human health.
- Does it leave the decision making in the region/country of the mining activity.
- Does it provide the mining concern a transparent guideline of what is expected, (no hidden costs or environmental creep).

Finally, as development lags behind in developing countries, and the world's demand for mineral resources continues to grow, policy options that are working to be fair, equitable and inclusive should be explored.

D. Research Questions

Based upon the review of economic methods of calculating resource depletion, environmental models and frameworks to assess environmental protection of human health, and a method to enhance social capital through electronic networking, research questions below were formulated.

1. Do sufficient funds exist in the private mining sector for complete environmental remediation/reclamation (real or perceived), through the compensation for resource depletion?

2. Is it practicable to base environmental remediation costs on a standard accounting unit measure (e.g., dollars per tons mined or tons processed) for the purpose of business, and regional government income predictions?
3. Can predictions be made regarding the costs for complete environmental remediation/reclamation (real or perceived), and minimum environmental remediation (protection of human health)?
4. Can a collaborative method be developed to use a percentage of funds (if/when they exist) for development in an agreed upon fashion by a working group that includes mining companies, governmental agencies, and the private citizenry from the affected area?

E. Methods and Procedures

During the course of the dissertation the research questions, will be approached in the following fashion.

1. To determine if sufficient funds exist for remediation of environmental damages, remediation of health costs, adequate returns to mine investors, and adequate re-investment to create "sustainable development", the study will include estimates of rates of depreciation, estimates of Hotelling/scarcity rents, and estimates of damages for Region III of Chile – to the extent possible given existing data. More generally the study will develop procedures for making these estimates.
2. In the process of estimating the variables in 1 above, the study will investigate the potential for developing operational measures keyed to mining quantities.

3. The study will review literature on environmental damages in Chile and world-wide. It will examine the potential for specific estimates based on Chilean experience, and the alternative – estimation by “transferring” costs from other, generic sources.
4. The study will examine concepts of social capital and how it might be enhanced relating to mining activities and environmental concerns, through a comparison of standard of living against developed countries and other mineral producing countries, and the existing infrastructure for supporting electronic networking.

F. Outline of the Study

The remainder of this dissertation starts with development of the theoretical framework regarding calculation of resource depletion, and a working definition of sustainable development (Chapter Two). The next few chapters describe the historical, structural and institutional background of the mining industry in Chile and Region III specifically. Chapter Three addresses mining in Chile from a historical standpoint to illustrate the country and region’s long dependency on the mining industry. In addition, it shows historical changes in policies toward mining, including nationalization that lead to today’s more international/friendly business climate, thus allowing for business, government, and citizen group collaboration to be explored. Chapter Four focuses on the development of Chile’s environmental regulations, laws and sustainable development from an international perspective. Chapter Five provides data regarding copper mining and its importance to the Chilean national and Region III economy. Chapter Six contains the empirical analysis of mining assets, depletion, rent and re-investment. It contains the calculations of resource depletion by various methods, while Chapter Seven addresses environmental compensation. Chapter Eight discusses social and information indicators, social capital in several forms and networking. The information is this chapter illustrates the current conditions in Region III that make it possible for greater participation through the availability of electronic information and networking. Finally, in Chapter Nine the results are presented, followed by a discussion of the findings in Chapter Ten.

G. Conclusion

In this chapter I have provided the outline I will follow regarding the use of the basic concepts I have chosen, the significance of this study, the assumptions, limitations and potential benefits. I intentionally laid out the study in a direct manner with the hope of advancing economic tools, environmental models and regulations, and aiding in the generation of social capital into a mainstream usable fashion. The trade off between resource depletion and environmental compensation on a national scale is a cumbersome prospect at best, and does not lend itself easily for encouraging public participation. However, by combining each aspect and bringing it down to a workable (regional) scale, the potential for advancing the recommendations in Table 1-1 (Recommendations Towards Sustainable Development) has a better chance to succeed. Ideas, methods, and concepts, no matter what discipline are of more value when put to use to benefit all involved.

CHAPTER TWO

THEORETICAL FRAMEWORK – MINERAL ASSETS AND SUSTAINABILITY IN CHILE

"It is becoming increasingly clear that the quest for sustainability and sustainable development requires integrating economic, social, cultural, political, and ecological factors. It requires the constructive articulation of the top-down approaches to development with the bottom-up or grassroots initiatives. It requires the simultaneous consideration of the local and global dimensions and of the way they interact. And it requires broadening the spatial and temporal horizons to accommodate the need for intra-generational as well as inter-generational equality" (Gallopin - 2003).

A. Introduction and Overview

This dissertation concerns the paradoxical task of assuring sustainability while exploiting the non-renewable mineral assets of a region. The ultimate goal of the study is to define a sliding "sustainability fee" that could be charged to a mining entity in order to achieve some level of sustainability (in a sense to be defined) while allowing for the extraction and use of minerals and the economic health of the mining entity. In this chapter I will describe some of the basic models, theories and concepts that will be used to accomplish these goals. The principle theoretical/conceptual elements used in this study are: 1) the concept of sustainability, 2) theories of scarcity (Hotelling) rents and their re-investment in the context of requirements for (Hartwick-style) sustainability, 3) the economics concerning remedies for externalities and (concentrating on compensation), 4) concepts and theories regarding social capital. In this chapter, I shall concentrate on the first three of these. The concepts and theories regarding social capital are contained in the social capital and social indicators chapter. I start with a brief sketch of the overall problem.

Extracting and using a finite non-renewable resource is not sustainable in the long run in a literal, physical sense. Hence, some care must be taken in determining the sense in which sustainability is desired and justified, and then, in defining and ultimately measuring the rates of mineral extraction against the operational definition. This study is based on the idea that some sense of sustainability can be maintained if a sufficient amount of the returns from mineral extraction are reinvested in some recognized replacement asset. This definition of sustainability is sometimes called “weak sustainability” or, in a purely economic context, Hartwick sustainability. However, defining this exactly presents both theoretical and measurement difficulties. This study addresses resource depletion inclusive of environmental protection/remediation (with local population well-being, health and participation in the immediate background) in hopes of providing a more realistic component of overall sustainability calculations.

The ultimate policy and applied goal of this work is to establish parameters for a sliding fee schedule related to the depletion of resources (specifically copper) and the related environmental damage caused in the mining of this resource. Hence, calculating the fees that are derived from the mining of copper and its external effects by the key mining companies in Region III, Chile will be a major empirical contribution of this study (see chapters six and seven).

In this chapter, I will be addressing various schools of thought regarding mineral, and sustainability, a working definition of sustainable development, and how this can be reconciled when it comes to the use of nonrenewable resources. Next, is the topic of what are the primary measureable components related to sustainable development for mining? Theoretical approaches to calculating these components are discussed (with details of the methods provided in the methods chapter). A final section discusses the theory of externalities and compensation as a basis for supporting policies to address the potential mining losses of environmental damages, health effects, and reduced assets (depleted mining stock).

B. The Problem – Practical Issues

At the center of the ongoing international debate about sustainable development in the mining industry, one of the main topics concerns the use of the concept of "weak sustainability". This theory puts forth the belief that it is possible to convert natural capital, the resources, into other forms of capital. With this in mind the question of establishing Sustainability Funds arose in Chile (and elsewhere). In the Chilean mining sector, the potential for Sustainability Funds are being explored, with the primary source of revenue coming from an additional tax on mining production. Some of the topics in relationship to a Sustainability Fund that are currently debated include:

1. How should the collected funds be earmarked? It is unclear whether the aim is to pay "compensation" to the state, or if the motivation is linked to sustainability at the mining area/regional level.
2. Is an additional tax on mining production justified or could there be other forms of financing?
3. Who should administer the funds?
4. How should the funds be distributed?

However, in some sense these practical questions are ahead of the curve. Basic questions about what is at stake should be addressed if the amount of such funds and their uses are to be adequately considered. Often, implementation depends on the execution of the detailed and thorny questions listed above, but realistically the basic questions on this approach have yet to be answered. More basic questions concern how to characterize the continuing conversion of capital – in the form of contributions by the mining sector to infrastructure, to the community, or to the formation of human or social capital. (UN/UNEP – 2003)

<u>C. Sustainable Development</u>

Sustainable development at the present time is a topic of continued debate. The term itself, "sustainable development" is used in many different ways in many different areas of development leading to differing degrees of understanding. The term "sustainable development" is used in numerous fields such as environmental science, economics, community development and others.

- General definition
    - Includes social and cultural components as well as economic and environmental factors *"Development that meets the needs of the present without compromising the ability of future generations to meet their own need"*(Brundtland - UN)
- In environmental-economic domain – narrow to broad
    - Strict preservation – "*"A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community."* (Aldo Leopold -- "land ethic")
    - Strict sustainability- asset preservation – interest only, use asset only at a rate that will insure long-term (multi-generational) availability

- Allow for equitable resource use (consumption, standards of living) over time, and for future generations – leading to the Hartwick definition

Given the broad range of definitions, the stance that one takes on sustainable development is very much a personal decision at one level, and, for society, an open policy decision which is arguably best left to the affected local population. Regardless, I believe that sustainability must deal with the reality of current conditions – increasing population and the material requirements of those populations. Increasing populations put greater and greater demands on natural resources. Moreover, sustainability must recognize the goals of maintaining a high standard of living in the developed countries, while striving to raise the standard of living in emerging economies and developing countries. Consequently, in this undertaking based on a principle of sustainable development it is appropriate to remove as much ambiguity from the term as possible.

1. Working Definition of Sustainable Development

In this paper, the basic definition of sustainability will be taken from Richard M. Auty's and Raymond F. Mikesell's definition in their book *Sustainable Development in Mineral Economies.*

"The concept of sustainable development requires that the contribution to economic development be maintained, both during periods of temporary reduction in mineral exports and over the long run when mineral producing capacity declines relative to the size of the overall economy. ***What is required is not the sustainability of the mineral production that initially generates growth, but the maintenance of economic and social conditions for sustaining that growth****."*

Auty's and Mikesell's definition corresponds closely to the Hartwick Rule for sustainability. John Hartwick showed that that, so long as the stock of aggregate capital did not decline over time, non-declining consumption was possible. This was possible by having the stock of capital held constant by investing Hotelling (scarcity) rents into substitutes, particularly, man-made capital. Hotelling rents (also called scarcity rent, user costs or resource royalty in the economics literature) are derived from the theory of the dynamic optimization of non-renewable resource use pioneered by Harold Hotelling. The Hotelling theory is now the general theory of non-renewable resources in economics. This Hotelling theory states that, for non-renewable resources to be used "efficiently," the operation of appropriate markets must reduce the output of a mineral as it becomes scarce, so that the reserves of any mineral will deplete slowly and never be completely exhausted where there are increasing costs and diminishing qualities of ores (Hotelling 1931). Whether markets will or will not achieve this ideal rate of depletion depends on factors that are beyond the current study. The basic point here is that the Hotelling theory predicts a kind of sustainability that emerges automatically in an appropriate market structure (and if it does not emerge, the path of depletion will not be efficient). However this concept of sustainability is relatively narrow. It includes the "stretching out" of the resource use over time and a final amount that is never used where it is too expensive to mine. Non-use is not a satisfying definition of sustainability, and gradually declining consumption also seems to leave something to be desired. The Hartwick idea of re-investing some or all of the Hotelling rents creates a concept of sustainability closer to those discussed above.

D. On Mineral Extraction, Costs, Resource Depletion (RD) and Rent

Resource depletion is the value by which the mineral asset has been reduce or depleted per unit of time – usually in one year. One might think that determining annual resource depletion is a straightforward procedure and that resource depletion is simply equal to current extraction multiplied by price. Yet the literature contains several methods for calculating the current depletion. Why is this? The reasons turn out to be rather complex and interrelated. The basic reason is that depletion is really the difference in the value of the asset at the end of the year compared to its value at the beginning of the year. Hence, depletion has more to do with the value of the remaining asset than how much has been extracted this year. That is, depletion concerns the reduction in value of the asset left in the ground versus extraction which simply measures physical quantity of stock reduced.

There are several factors that affect the future value of the asset besides the raw figure of current extraction. An obvious factor is whether new discoveries have added to the mineral stock. While this factor is obvious, how it might be accounted for in several different ways is not.

The more complex problem is to determine how the current extraction affects the future value of the remaining stock. With most assets one can separate out an "interest" and a "principle." One calculates the current interest in a simply way, and this is roughly equivalent to the current extraction for a mineral asset. However, for most non-mineral assets the value of the "principal" is a different problem. For perspective, consider first financial assets. For these assets, interest is literally the payment received for "use" of the money and the nominal value of the financial asset does not decline. However, note that the value of the asset can be different at the end of the year than it was at the beginning of the year. This is because the real value of the asset is the present value of the expected future interest payments on that asset. Applying this perspective to the mineral asset situation, we see that mineral assets decline in nominal amounts depending on the quantity extracted (and the quantity added by new discoveries) from the total stock. In the extreme, one can extract the whole mineral body in one year, and then there would be NO asset remaining.

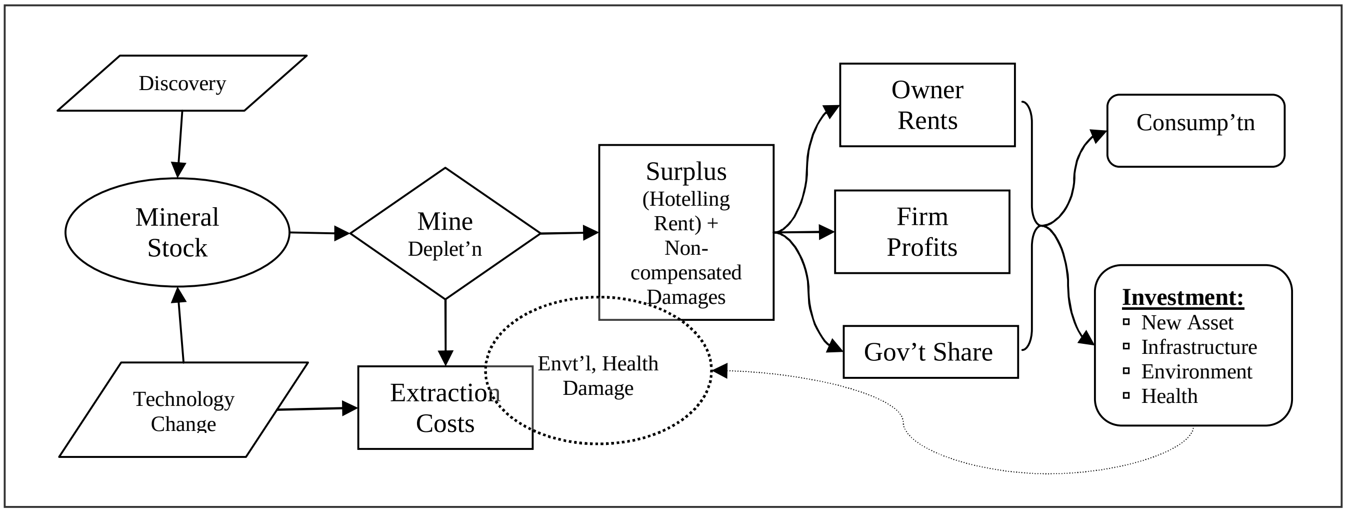
As another analogy, consider physical capital like buildings and machinery. Here, the "interest" is the physical stream of services that were provided for during the year. The asset is not literally "eaten up" in the way that mineral assets are, but the asset does *depreciate* in value due to obsolescence and wear and tear. The nominal body of the asset is not the same at the end of the year as at the beginning, but the decline in nominal amount is not a simple direct proportion of the rate of use. However, it is also true that the value of the asset at the end of the year depends on its ability to generate future "interest" from the services it provides. Here we see that the value of the asset at the end of the year is related to both the use of the asset (through wear and tear and obsolescence) and to its ability to generate future revenue streams.

Compared to financial and physical capital, mineral stock has a direct reduction in value due to the consumption of part of the "principal." Where all parameters that affect future value are unchanged, it should be that reduction in the value of the principal is a straightforward function of the amount extracted/consumed. However, one first must note that various factors can affect the value of the asset at the end of the year versus at the beginning of the year. To some extent these are the same kind of factors that can affect the value of financial assets and physical assets – essentially factors that affect the demand and supply for the asset. The biggest difference with mineral assets is that current extraction is interdependent with future value. This is because extraction of x amount in the current year means the mineral is more scarce at the end of the year than at the beginning. Hence, the rate of extraction affects the future value of the resource rather directly.

This phenomenon was first rigorously formulated by Hotelling. Based on a dynamic optimization framework that related current consumption and future values, Hotelling calculated that the price of the mineral should rise at the rate of interest (other things equal) so that the mineral asset would have a similar rate of return as other assets in the economy. Hence, a holder of a mineral asset could expect to see the same stream of revenues as a holder of a financial asset or an owner of a factory (Khanna).

For my purposes the discussion of asset depletion must now be integrated with sustainability. In application, we must also reconcile the depletion measurement with accounting concerns which require that the "books" balance for all the flows and stocks of the economy. What the latter amounts to is the concern of how to adjust annual income (GDP) for changes in (depreciation of) assets to arrive at Net Income. The sustainability issue which is at the heart of my concern has to do with the idea that to use a mineral resource (weakly) sustainably, one must invest in other forms of capital to offset this depreciation in the mineral asset's value. Operationally dealing with the accounting and the sustainability issue turns out to be complicated and to depend on various assumptions. The result is that there are multiple reasonable ways to account for mineral depletion and the associated measures of net national income. I start with the income obtained from extracting and selling the mineral. Essentially one can divide this income into a part that covers operational costs and a scarcity or "Hotelling rent" as shown in Figure 2-1. Rent is the income flow from a natural resource. Contract rent is the accounting rent that the owner of the land or resource actually receives. In Figure 2-1, the Hotelling rent is distributed among owners of the land or mine, profits to the mining firm and a "state share" usually in the form of taxes. (In economic theory "normal profits" to the mining firm are included as part of the extraction costs, and only "super-normal" profits are derived from the Hotelling rent.)

FIGURE 2-1. Rent Distribution



Hotelling rent is a variety of *economic rent,* where economic rent is defined as the amount of revenue that exceeds true economic extraction costs. In economics, extraction costs should include all economic opportunity costs such as "normal profits" as well as external social costs in the from of environmental and health damages. I show this in figure 2-1 by the overlapping circle of health and environmental damages with extraction costs. These externality costs are separated out because they often do not appear as "costs" to the unregulated mining firm. Hence, for practical reasons we usually see the environmental and health damages as requiring payments from the profits, rents or taxes.

The economic rent of a mineral or land asset is analogous to the interest on a financial asset. In the economic theory of non-renewable resources, mineral assets should receive a "Hotelling" or scarcity rent or "marginal user cost" that is equal to the value lost to future generations of using the mineral today instead of conserving it for tomorrow (hence the term, "user cost" – the cost of using the resource now instead of preserving it for the future). According to the Hartwick and the Auty and Mikesell notions of sustainable use of a mineral asset, much of this Hotelling or scarcity rent should be re-invested in replacement assets.

So, how does one simultaneously account for the following factors – the value of the quantity extracted, the amount to be reinvested in replacement assets, the amount that can be used for current consumption, and the change in the value of the asset from the beginning to the end of the year? Essentially one starts with the gross revenue, subtracts the operating expenditures to get a nominal rent or surplus (see figure 2-1). Then one must adjust the rent for changed asset value due to appreciation and other changes in asset values. Finally one divides the resulting adjusted rent into a reinvestment fund and a consumption fund. In figure 2-1, I show that the nominal surplus "passes through" the hands of the owners, the firms and the government who each distribute parts of their returns into consumption or (re-)investment. The "proper" reinvestment fund is defined relative to the amount by which the asset is depreciated. I define and discuss the operational methods commonly found in the literature for calculating these factors in Chapter Six – methods and data.

1. Types of Compensation for Mining Activity

Suppose the extraction costs, the externality costs and the Hotelling rent for a resource have all been calculated. Then a policy for paying for the externality costs and for re-investing parts of the Hotelling rent into replacement assets must be determined to meet the requirements for sustainable development described earlier. "*Direct regulation has been the most popular way of approaching environmental problems in the world, with quality and emissions or* *discharge standards being the most frequently used instruments. The main reasons why it is used is the importance of having objective values to guide environmental management and the capacity for direct control by the authorities over the conduct of economic actors" (United Nations – Economic Commission for Latin America and the Caribbean-2003).*

During the last decade, an option that has found favor in developed countries is that of using economic instruments in environmental management to complement traditional direct regulation schemes. These instruments provide greater flexibility, through price/cost incentives, as well as the possibility of obtaining income to finance environmental management and investment through specifically dedicated funds. One new development in this respect is the use of environmental taxes as an integral part of the fiscal reform plans of most highly developed countries.

Ultimately, after providing the economic affects of mining in Region III, and discussing types of compensation, I believe the best way to approach environmental compensation for Region III mining activities is by a direct payment through the calculation of sustainable income, or environmental domestic product (EDP).

E. Economic Compensation

From an economic viewpoint, in a mining operation (or any other project with environmental effects), there exists an efficient level of development of a natural resource to be traded off against a percentage of environmental damage. One factor in determining the efficient level of remediation is that, as the percentage of remediation approaches 100%, the associated costs rise considerably. Another part of the cost of remediation is the value forgone of any activity that may have to be restricted to reduce the environmental damages. These are the opportunity costs of environmental restrictions - benefits forgone. On the damage side, the nature of damages and their valuation by the affected stakeholders affect the efficient level of remediation/reclamation. In other words, 100% physical remediation/reclamation is rarely economically efficient.

There are several factors to consider in accounting for environmental damages. Remediation/reclamation of environmental damages is only one possible approach to accounting for such damages. Economists often suggest financial compensation as an alternative. More precisely a party responsible for environmental damage might account for those damages in one or more of the following ways:

- ex ante prevention or reduction of the damage
- ex post remediation or clean-up of the damage
- payment of compensating cash amounts
- payment of compensating in-kind activities or “products”

Past priorities and policies have included tax expenditures, subsidies and quotas to work towards economic sustainability. Tax expenditures are usually defined as an exemption, (or some other type of exception), from general tax rules, that is intended to benefit a particular industry, economic activity or agent. Some forms of tax expenditures practiced by host country governments in relationship to the mining industry, since the 1960s are:

- Exemption from the tax base.
- Special deductions or allowances in the definition of taxable income.
- Delayed tax payment.
- Credits that are deducted from total tax liability.
- Special rates for certain economic activities or agents.

- Subsidies and quotas
- Green tax

The negatives associated with tax expenditures are that it is detrimental towards either environmental remediation/reclamation, or the ability of a government to impose a “green” tax. Whereas, studies have indicated that “green” taxes are fairly attractive towards addressing environmental problems (i.e., air emissions, wastewater discharges, ...), as well as natural resource usage, it is known that either “green” taxes do not exist, or exist at a very low level in countries with developing economies. The first step towards implementation of a “green” tax, or a system that includes true environmental costs, is the elimination of tax expenditures that do not address environmental problems (OECD Subsidies).

In this chapter I’ve touched on the mining dependence of the Region III economy, varying schools of thought relating to resource depletion and sustainability, and measureable components of sustainability related to resource depletion and mining. Finally, I provided a brief overview of resource depletion related to rent, types of compensation and economic compensation.

CHAPTER THREE

HISTORY OF MINING IN CHILE

This chapter will give a thumbnail sketch of how mining is woven into the historical and present day economy of Region III Chile. It will highlight activities from the colonial period through the nitrate era, nationalization and finally the introduction of Decree Law 600, the mining operating standard of today.

A. Colonial

"*Despite frequent contentions to the contrary, mining neither excluded nor aborted the development of other activities such as agriculture, trade and industry. Rather, the mining industry constituted a stimulus and support for these other activities, and within the technical limitations of the time, it made possible a network of roads from Upper California and Texas to Tierra del Fuego and over the mountains from the Pacific to the Atlantic*" (Prieto - 1973).

Mining in Latin America has a long and storied history starting shortly after Magellan's ship, Vittoria, completed an east-west circumnavigation of the globe during the years of 1519 – 1522. In October and November of 1520 Ferdinand Magellan, his men, and three of his ships made their way through the southern tip of Chile via the strait that now bears his name (Collier and Sater). In 1524, tin and copper mines were opened and operated complete with smelting facilities in Tasco, Mexico. By 1550 Pedro de Valdivia had founded the cities of La Concepción and Valdivia, Chile, and gold mines were being established in nearby Confines and Quilacoya. With the continuing advent of mining in Latin America, Philip II enacted the *Ordenanzas del Nuevo Cuaderno*, a summary of mining laws and regulations for America (Prieto).

Mining continued to grow during the remainder of the sixteenth and seventeenth centuries, but it was not until the mid eighteenth century, with the construction of a mint, that the activity of mining increased and began to heavily influence the Chilean economy. *"Chilean production of metals in the colonial period did not compare in value with that of Peru and Bolivia, but nevertheless the mining industry was important enough to influence Chile's economy. By the end of the eighteenth century, her mining activities were expanding.*

A mint was established in Santiago de Chile in 1749 and began to function early in 1750 coining both gold and silver. …The lack of specie, which had been felt before, was remedied, and Chilean commerce was carried on with the new currency. Silver and gold mining received a stimulus since miners now had a market for their precious metal without having to send it to Peru.

The increase of population, trade, and wealth of Chile was due in large part to the advantages of the mint and mining" (Diffie quoted in Prieto - 1973).

Until midway through the eighteenth century the area known as "Norte Chico" (little north), an area that encompasses modern day Region III in the north of Chile, was sparsely populated. The first sign that the area was gaining in importance was when Copiapo, a small staging post on the overland route to Peru, was given city status in 1744. A doubling of the area's population from 30,000 to 60,000 was seen during the years from 1763 to 1813 (Collier and Sater).

Norte Chico was blessed with high grade ores, so that little capital was required to conduct the mining, and few technical advances were required to carryout the processing of the mined ores. During this timeframe (mid-eighteenth to mid-nineteenth century), the mines were normally small, shallow and short lived, with sunken/shaft mines being the rare exception. Usually mines were clustered together, with these groups being known as *minerales*. In Norte

Chico there were about eighty such *minerales*, with the usual arrangement being several of the *minerales* located around a designated district headquarter, of which Copiapó is a textbook example. Following is a listing of the significant mining laws that guided the industry from the Colonial period to the present day (Collier and Sater).

TABLE 3-1. Significant Mining Laws/Regulations/Treaties

1584 *Ordenanzas del Nuevo Cuaderno*, a summary of mining laws and regulations for America

1854 Law originating *sociedades anónimas*, joint stock companies

1881 Nitrate Decree. Any individual could obtain possession of an *oficina* by depositing with the Chilean treasury three quarters of the certificate issued for the establishment and paying the balance of its sale price in cash (O'Brien).

1970-71 Nationalization of Kennecott and Anaconda Mining Companies.

1974 Foreign Investment Statute, known as DL (Decree Law) 600.

1992 The so-called Codelco, (Chilean National Copper Corporation) Law authorized Codelco for the first time to form joint ventures with the private sector to work unexploited deposits.

B. Independence

During the time period after Chile first proclaimed its independence in 1810, and Spain's recognition of Chile's independence in 1818, mining flourished and actually grew quite dramatically in Norte Chico. In large part, this was due to the majority of battles being waged by the royalists to the south of this district, allowing for development in the mining sector to progress basically without interruption. Silver production probably doubled between 1810 and 1830, and copper for which there was growing international demand, was being mined on a much larger scale (Collier and Sater).

A major change in mining occurred when a law passed in 1854 saw the initiation of *sociedades anonima*, or joint stock companies opening up the industry to outside investment. The first *sociedades anónimas* were in the railroads, but by the 1870s their presence in mining was felt due to the speculative nature of the industry (Collier and Sater).

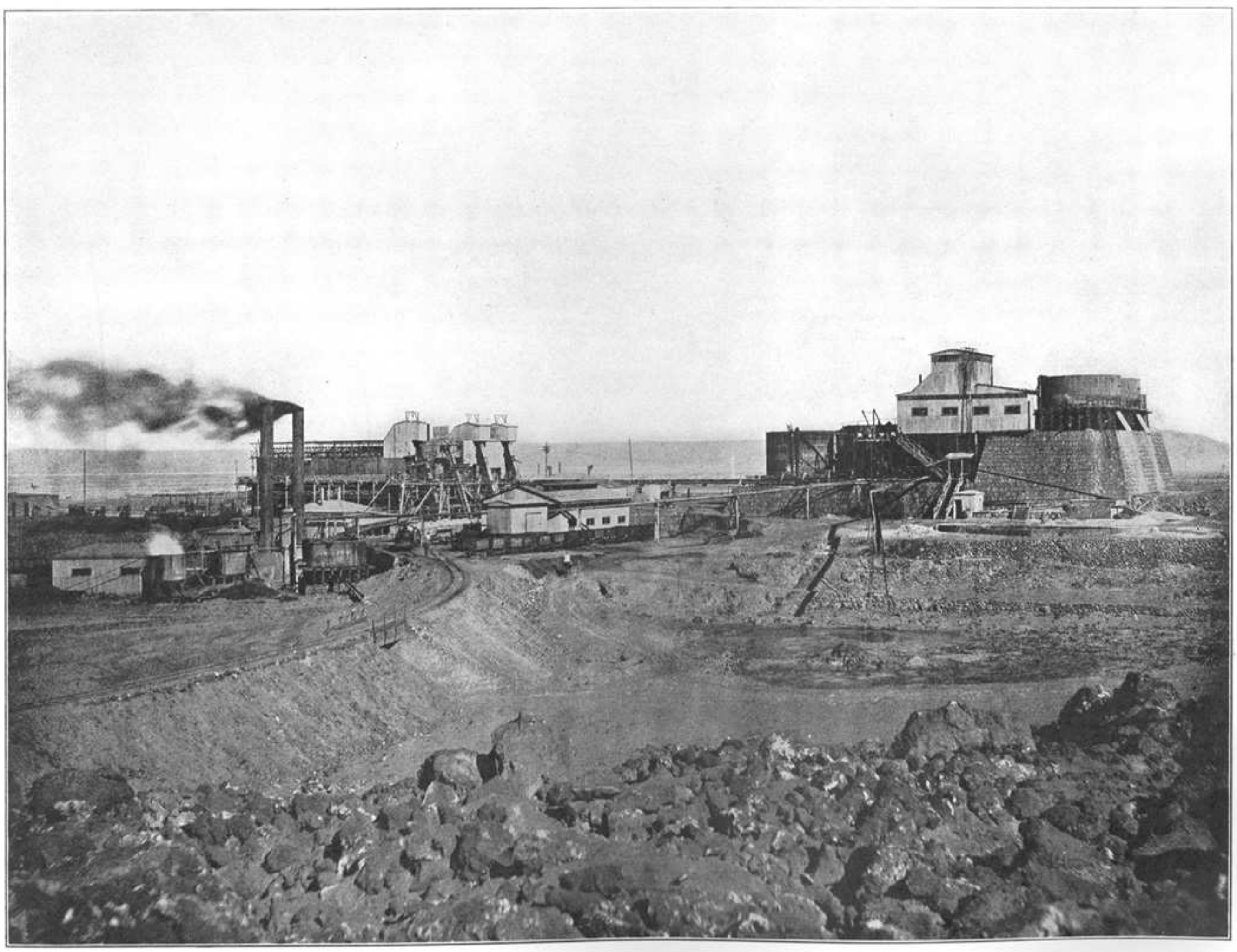
C. Nitrate era 1870s – 1930s

In the 1870s a new mining business arose that would have a strong influence on Chile and its history. This was the business of mining nitrate, in large part driven by demand in Europe as a fertilizer. Initially, it was mined further north in the deserts of Peru and Bolivia. This along with additional discoveries of silver in the Atacama Desert and mining activities by Chileans in Bolivia caused pressure to mount concerning the geographical boundaries of the three countries. After an uneasy peace in the 1870s, and despite a secret boundary agreement with Bolivia, Chile declared war on Peru and Bolivia on April 5, 1879.

Although a number of factors led up to the war, a major consideration by the Chilean government was the recent decline of the mining sector, which in turn led to a decline in the economy. Warfare with Peru and Bolivia and capture of their nitrate riches were viewed as a possible solution to Chile's economic problems.

During the time of the war, Chile found itself in a somewhat precarious situation in that the majority of bondholders for the Peruvian nitrate works were Europeans. Although Peru had defaulted on the bonds in 1876, Chile still had to deal with the claims of ownership of the nitrate works because of their dependency on Europe for war materials. Ultimately, this led to the Nitrate Decree of 1881, that stated, “Any individual could obtain possession of an *oficina* by depositing with the Chilean treasury three quarters of the certificate issued for the establishment and paying the balance of its sale price in cash” (O’Brien - 1982).

FIGURE 3-1. View of Nitrate and Iodine Plant



39. General view of nitrate and Iodine plant.

Source: *Views of the Chilian Nitrate Works and Ports* (not dated). The Nitrate Association of Propaganda of Chili, South America. New York City, New York, William S. Myers.

As the following table displays, nitrate was an economic windfall for the Chilean government, but concern was voiced over the amount of foreign ownership in the nitrate industry. By 1895, British companies alone accounted for 60% of nitrate exported. Even though by 1920 ownership of the nitrate *oficinas* had reversed with Chileans now possessing ownership nearing 60%, the boom was nearing an end and subsequent benefits were relatively short lived. This left Chileans pondering the question if Chile would have been better off with a nationalized nitrate industry? But, this was speculative and the choice made by the Chilean government in 1881 seemed rational for that time (Collier and Sater).

TABLE 3-2. Nitrate Industry, 1880 – 1920

Year	***Oficinas***	**Workers**	**Production(a)**	**Export(a)**	**Price(b)**
1880		2,800	224,000	224,000	47.05
1885		4,600	436,000	436,000	33.68
1890		13,000	1,075,000	1,063,000	23.88
1895	53	22,500	1,308,000	1,238,000	25.92
1900	51	19,700	1,508,000	1,454,000	25.05
1905	90	30,600	1,755,000	1,650,000	36.40
1910	102	43,500	2,465,000	2,336,000	32.93
1915	116	45,500	1,755,000	2,023,000	33.12
1920	101	46,200	2,523,000	2,794,000	49.66

(a) 1,000 of metric tons, (b) US $

Source: Coller and Sater

D. 1930 – 1969

In an era of industrial advances worldwide, Chile was the norm when it came to the mining industry. Internal concerns were mounting, however, in regards to mining, and this was brought about by the amount of international involvement/ownership of the industry. Even though the taxation rate of foreign owned mining companies was already at 33% by 1939, there were some political leaders in Chile speaking out on the issue of nationalization of the industry. As early as 1940, Jorge González von Marees, the *nacista* leader stated the case for nationalization in order "to liberate ourselves from the Yankee tutelage we endure today, and to adopt more decidedly nationalistic attitudes in the area of economics" (Collier and Sater - 2004). While the government in power at that time had no interest in acting on the nationalization issue, it did reveal a level of animosity against American interest in Chile's mining industry.

The case for nationalization and the animosity against American interests in the Chilean mining industry died down for sometime when the European market was reduced at the onset of World War II. Whereas, there was a brief period when the United States did not take up the slack in the copper market caused by the war, this was short lived with the attack on Pearl Harbor and the entrance into war by the United States. With a few minor downturns, the American market was to remain strong, and by the 1950s copper had replaced nitrate as the main revenue earner for the Chilean government.

A problem that arose during this timeframe was the government's use of the tax revenue generated from the mining industry through taxation. The nitrate mining period had been quite labor intensive, and consequently, many of the benefits circulated throughout the economy in the form of additional job creation for Chileans. However, as copper replaced nitrate as the main revenue earner for the government, an unanticipated trend developed. Due to the heavily mechanized nature of the copper industry, especially with the advancement of technologies during the 1950s and 60s, there was in actuality a decrease in employment from 18,390 in 1940 to 12,548 in 1960 in the mining industry. This coupled with the fact that over two thirds of the revenue generated by mining was used to subsidize imports, left a declining amount of revenue being invested in Chilean infrastructure. The end result was fewer jobs and development opportunities for Chilean nationals (Collier and Sater).

E. Chilean Nationalization of Copper 1969 – 1973

In 1970 and approved by Congress in 1971, Salvador Allende nationalized the Chilean copper industry. This was accomplished by the Chilean government purchasing the holdings of Kennecott and Anaconda mines by way of 30 year bonds. Part of the equation to the forced buyout of Kennecott and Anaconda, was the calculation of excess profits made by the two companies since 1955. The line of excess profits was set at 12%, and based upon this the Allende government's calculations left Kennecott owing Chile $310 million U.S., and Anaconda owing the sum of $78 million U.S.

Chile's nationalization was set back and did not achieve the desired results with the action of Kennecott and Anaconda in international courts, the difficulty of obtaining foreign loans, the drain of technical support, the replacement of machinery, spare parts and the fall of copper prices by 35 cents per pound. The experiment ended with the Allende government in 1973 (Collier and Sater).

F. 1974 – Present Day

In 1992 the Chilean Foreign Investment Committee (FIC) designed mining law to enable foreign capital and technology transfer on a large-scale basis. The FIC has taken great strides to provide investors with both constitutional guarantees regarding private property rights as well as specific investment agreements on a per-project basic for the life of the mine. The investment contract, passed into law in 1974 by the congress and known as the DL 600, provides foreign investors with financial protection, allowing them to compete with national firms, in addition to laying out tax rules far in advance (CIA - Fact Book).

The Decree Law 600 (DL 600) is the main law that regulates all the Foreign Investment including mining operations in Chile. This law provides all the information about the mining business and all the legal procedures.

TABLE 3-3 Main Points of Decree Law 600

1. *"The law specifically guarantees non-discriminatory treatment to foreign investors, access to foreign exchange for repatriation of capital and profits, the ability to hold assets indefinitely, and the option to receive national tax treatment.*

2. *Investors are allowed to own up to 100% of a Chilean Based-company and there is no time limit.*

3. *A maximum of 15% of the labor force can be formed by foreigners but there is an exception for specialized technical employees that can't be found in Chile.*

4. *D.L. 600 guarantees investors the right to repatriate capital one year after its entry and to remit profits at any time. In practice, the one-year capital lock-in has not represented a* *restraint since most productive projects --in areas such as mining, forestry, fishing and infrastructure-- require more than a one-year start-up period.*

5. *Foreign investors may request a maximum time-limit of three years to materialize their contributions. In the case of mining projects, the time-limit is eight years, but if previous explorations are required, the FIC is empowered to extend it to up to twelve years (Foreign Direct Investment).*

Once the decision to invest is made, the investor has to submit an application to the executive vice-president of the FIC, along with pertinent project information and all technical specifications. The proposed project information is sent to the Chilean Commission of Copper (Cochilco), which issues a report on the project. In addition, the investor is required to send project information to the National Environment Commission (Conama), which evaluates the project for environmental effects and sends a report to the FIC. If and when the project is approved, the investing party then has permission to conduct business (Foreign Direct Investment).

In April of 1992, the so-called Codelco (Chilean National Copper Corporation) Law, authorized Codelco for the first time to form joint ventures with the private sector to work unexploited deposits. In 1992, after enactment of this law, Codelco invited domestic and foreign mining firms to participate in four joint explorations in northern Chile. The importance of foreign private firms in large-scale copper mining also resulted from the international business community's improved perception of Chile, and from a mining law enacted during the Pinochet regime that clearly established compensation rules in the case of nationalization, and otherwise encouraged investment in this sector. Given this more favorable context, Phelps Dodge, a United

States mining company, and the Sumitomo Metal Mining Company, a Japanese firm, signed a US$1.5 billion contract in 1992 with the Chilean government to develop La Candelaria, a copper and gold mine south of Copiapó. The mine's potential production of refined copper was equivalent to about 10 percent of Codelco's entire production. (CIA – Fact Book).

In this chapter I have traced, albeit briefly, the progression of mining in Region III and the laws that govern it.

CHAPTER FOUR

DEVELOPMENT OF ENVIRONMENTAL INSTITUITONS IN CHILEAN MINING

This chapter contains a brief outline of the (limited) development of environmental institutions in Chile. It discusses how the institutions that do exist have been overshadowed by economic pressure. The later part of the chapter presents a concise look at the current status of environmental agencies brought about by the 1994 law and the pressure that they are subjected to today The chapter concludes with a discussion of the status of international mining laws and the pressure they bring to bear on a national level.

A. 1970-1980

After a brief period of success (1970-71), Allende's economic reforms stagnated, and with a struggling economy and foreign investment on the decline, the environment was not given much thought. After Pinochet came to power in 1973 economic reforms were centered around privatization and liberalization of trade. During this time environmental protection was seen as a deterrent to economic growth, was excluded from the political decision-making process and was limited to small private initiatives. In 1979, environmental considerations were initiated by a small number of Chilean and foreign firms, when they established a fund for scientists to produce an ecological history of Chile to help balance environmental needs with economic development (Commanding Heights).

B. 1981 – 1990

The Chilean Political Constitution of 1980 recognized the right to live in a pollution free environment (Article 19, No. 8, of the Constitucion Politica de Chile de 1980 – in Detzner and

Aylwin), although in actuality nothing changed. Chile continued to depend on exports from the mining, forestry, and fishing industries. Native forests were clear-cut; rivers dammed while the mining process continued to emit arsenic and carbon monoxide into the air and water. During this time, Santiago became one of the world's smoggiest cities. No national policies or institutions existed to regulate the use of natural resources. During this timeframe, it became apparent to the Chilean government that they needed to consolidate and streamline their environmental policies, due to having over 800 conflicting legal and mandatory requirements, involving over 70 different government ministries and agencies (Detzner and Aylwin).

C. 1991- Present

At the start of the 1990s, the Patricio Aylwin administration (1990-1994) considered it inappropriate to create an environmental ministry, as other Latin American countries were doing. The Aylwin government's argument was that ecological matters were "transversal", cutting across the mandates of all ministries. Therefore, there existed no need for the Chilean government to have an environmental ministry. But by 1994, the government’s environmental policy under President Eduardo Frei shifted, resulting in the adoption of the Chilean Environmental Framework Law (Law 19,300) in March of that year, with the framework being based upon the United States’ Environmental Protection Agency’s regulations. This action was inspired by mainly two things; the 1992 Earth Summit, and the need to have environmental policy in place for the purpose of trade negotiations. Law 19,300 established the criteria for the country’s environmental policy, and aided in the procurement of trade treaties. The most important feature of Law 19,300 was the creation of the Environmental Impact Assessment (EIA) System. Its intended purpose was to balance environmental protection with economic growth, and it was placed under the authority of the National Commission for the Environment

(CONAMA). But the government failed to provide the means to implement the law. Environmental regulation remained disorganized and not until a Chilean Supreme Court decision of 1997 did compliance with its key provisions, including the Environmental Impact Assessment System, become more than voluntary (Sagaris).

The environmental law that has been in effect in Chile since Mar. 9, 1994 has aged very quickly due to increased population, and the accompanying demands to raise the standard of living through continued exports of Chilean resources, to fund national programs and infrastructure development. With the emphasis on infrastructure development, environmental concerns have not been adequately funded. In looking at recent history one can see the problems that exist due to these economic trends and resulting environmental pressures (Table 4-1). In the future, health issues and the export-oriented segment of the economy will have even a larger determination on environmental progress. The main thrust should be in the area of expanding and strengthening environmental institutions. *"In particular, stronger actions are needed concerning EIAs; quality and emission standards for air, water, waste and nature management; the use of economic instruments; territorial management policies; and national as well as regional plans and strategies"* (OECD - 1996).

TABLE 4-1. Economic Trends and Environmental Pressures, 1990 – 2003 (%) Selected economic trends

	Percent of Change
GDP [a]	103
Population	20
Agricultural production	43
Mining production (index)	265
Forest harvest [b]	180
Aquaculture harvest [c]	824
Industrial production	161
Total primary energy supply [d]	81
Total final energy consumption [d]	79
Road vehicles	197

a) at 1995 prices and purchasing power parities.

b) Plantation forest harvest

c) 17% growth per year on average over 1999-2003, including a doubling over 1999-2001.

d) To 2002

Source: OECD

D. International Mining Laws (environment)

Although international mining laws relating to the environment have been around in some limited fashion for sometime (roughly 1970), the real push for environmental awareness in mining in developing countries and countries with emerging economies came about due to the

Brundtland Commission's report on sustainable development. The 1987 United Nations World Commission on Environment and Development (Brundtland Commission), featured sustainable development as the driving force behind this commission, and consequently it has been adopted as the main international environmental law by the nations at the Rio Earth Summit in 1992, through the Rio Declaration and Agenda 21.

"However defined, the core concept of sustainable development is to direct global economic efforts toward increasing the present generation's quality of life while recognizing two essential principles: the Earth's finite capacity to accommodate people and industrial development, and a moral imperative not to deprive future generations of natural resources essential to well-being and quality of environment" (S. Smith quoted in Pring - 2006).

In the international community, sustainable development for the mining sector in the context of Agenda 21 has come to mean poverty alleviation, meeting of basic human needs, environmental impact assessment, pollution abatement, minimization of environmental impact, resource conservation, adequate worker health and safety standards, community betterment, and protection and restoration of the environment (Pring).

A further clarification regarding the normal "hands off" treatment regarding individual countries and the management of their natural resources is needed. It is a generally accepted fact that nation-states have sovereignty, that is, supreme, independent, political and legal control over their own natural resources. A clarification of this was stated in Agenda 21's Stockholm Declaration.

“States have, in accordance with the Charter of the United Nation and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or areas beyond the limits of national jurisdiction” (Principle 21 of the Stockholm Declaration quoted in Pring – 2006).

But recently States have either knowingly or unknowingly given up portions of their sovereign powers, through developing principals of a legal nature, judicial decisions, and long-term treaties and other binding legal agreements. Because of this individual state sovereignty over natural resources is no longer an absolute. Limitations or constraints on the mining industry are developing in three ways: *(1) the bedrock international environmental law principle that States are responsible for preventing transboundary environmental harm to other States, (2) the undertakings and agreements of specific treaties, and (3) the emerging principles of sustainable development*” (Pring - 2006).

Because of recent developments, there is a boom on international environmental laws, and with these developments there are currently over 1,000 international treaties, and other legal authorities focused on the environment on record. But as of yet, there does not exist a comprehensive international mining law. The proliferation of entities that are now involved in environmental concerns in the mining industry is an impressive list and it continues to grow. With a large number of laws and treaties for example; The Biodiversity Treaty, The Law of the Sea Convention, implementation of environmental impact assessments limiting mining access control, treaties on access, water quality, and air quality effecting process control, and finally with mining product control being limited by the banning of some products, the World Trade

Organization and trade measures, international mining concerns have no choice but to deal with the environment in a competent manner. After all, it is the firms that realize that these regulations are here to stay and their need to bring their resources to deal with these problems in professional and innovative ways, who will be involved with mining for the long run.

This chapter has illustrated the need for strengthening of environmental institutions due to economic and international pressure, and the need for the mining industry to be part of the solution.

CHAPTER FIVE

ECONOMIC ACTIVITY – MINING

A. Introduction

This chapter will provide an overview of the mining industry and its contributions to the economy in Region III. Initially, I will show how the mining industry is divided by size, followed by national and Region III copper production data, and then pointing out mining's contribution to Region III GDP. Following this is a breakdown of production costs and the value of copper at a company level.

B. Company Data for Region III

Chile is the world's largest producer of copper and at the present time holds roughly 30 percent of the known copper reserves. In 2003, Chile accounted for 40 percent of the world copper production and copper accounted for 45 percent of Chile's exports. The state owned company of Codelco is the largest producer of copper and sells roughly half of their production to China, United States, France and South Korea (MBendi).

The Chilean mining system has companies, national and international, structured by a size classification for ongoing mining activity. The existing structure has large scale mining operations designated as category "A" operations. During the time period of 2001 – 2005 category "A" concerns have produced from 90 to 94 percent of the country's total copper output. Category "B" or medium size mining operations have accounted for 5 to 9 percent of Chile's copper output during the same time period, and the small or category "C" mines have produced the remaining amount of copper during this time (SERNAGEOMIN). Following is a breakdown of the size of mining activities, types of operations, production and costs for copper producers to illustrate the current activity in Chile's Region III.

TABLE 5-1. Active Copper Mining Facilities in Region III, Chile (2005):

Category "A"(Company)	**Mine Type**	**Total # of mines/ projects/plants**
CODELCO – El Salvador	Underground	1
C. C. M. Candelaria	Open Pit	1
CEMIN Ltda.	Open Pit	1
CODELCO – El Salvador	Open Pit	1
CODELCO – El Salvador	Plant – Heap Leaching	1
CODELCO – El Salvador	Plant - Concentrator	1
CODELCO – El Salvador	Plant – Smelter	1
CODELCO – El Salvador	Plant - Refining	1
C. C. M. Candelaria	Plant – Shipping (port)	1
C. C. M. Candelaria	Plant - Concentrator	1
Empresa Nacional de Mineria	Plant – Smelter	1
Empresa Nacional de Mineria	Plant – Smelter	1
Category "B" (Company)	**Mine Type**	**Total # of mines/ projects/plants**
Mra. COBREX Ltda.	Underground	1
Sociedad Punta del Cobre SA	Underground	3
S. C. M. Carola	Underground	1
C. M. Maricunga	Open Pit	1
CEMIN Ltda.	Open Pit	1
E. M. Mantos Blancos – MV	Open Pit	1
Placer Dome – Latin America	Project	1
E. M. Mantos Blancos – MV	Plant - Electric	1
E. M. Mantos Blancos – MV	Plant - Electric	1

Empresa de Nacional de Mineria	Plant – Heap Leaching	1
Sociedad Punta del Cobre SA	Plant – Leaching	1
Sociedad Punta del Cobre SA	Plant	1
C. M. San Estaban 1a SA	Plant	1
COEMIN Ltda.	Plant	1
C. M. Maricunga	Plant – Smelter	1
CEMIN Ltda.	Plant	1

Category "C"	**Mine Type**	**Total # of mines/ projects/plants**
	Underground	147
	Open Pit	4
	Projects	2
	Plants	8

SOURCE: Minerals Guide of Chile - 2005

In 2004, mine production of copper accounted for 12% of Chile's GDP (Anderson). Table 5-2 shows the significance of Region III copper production nationally.

TABLE 5-2. Chile – Country and Region III – Copper Production

YEAR	Chile Copper Production (metric tons – fine)	Region III Production (metric tons – fine)	Reg. III % of nat. prod.
1992	1,942,700	164,109	8.4
1993	2,055,400	154,245	7.5
1994	2,219,900	182,777	8.2
1995	2,486,600	314,354	12.6
Source: Cochilco			
1996	3,144,163	360,318	11.5

1997	**3,438,103**	**378,617**	**11.0**
1998	**3,763,994**	**433,308**	**11.5**
1999	**4,421,785**	**452,592**	**10.2**
2000	**4,646,335**	**407,637**	**8.8**
2001	**4,766,062**	**429,044**	**9.0**
2002	**4,619,787**	**412,949**	**8.9**
2003	**4,909,178**	**442,782**	**9.0**
2004	**5,418,800**	**441,092**	**8.1**
2005	**5,330,414**	**432,924**	**8.1**

Source: SERNAGEOMIN

In Table 5-3 (below) one can see the importance of copper, and its contribution to Region III's GDP.

TABLE 5-3. Region III Economy – Breakdown by Sector (%)

Sector	**Year and percentage of Region III GDP sector contributions**							
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Ag & Forestry	**4.4**	**4.2**	**4.0**	**4.4**	**4.4**	**4.2**	**4.4**	**4.7**
Fishing	**1.0**	**1.7**	**1.3**	**1.4**	**1.5**	**1.5**	**1.8**	**2.8**
Mining	**42.3**	**43.0**	**43.8**	**46.1**	**44.8**	**43.6**	**38.4**	**39.4**
Manufacturing	**3.1**	**3.1**	**2.4**	**2.1**	**2.3**	**2.4**	**2.5**	**2.7**
Elec., Gas & Water	**5.9**	**6.5**	**7.4**	**7.4**	**6.4**	**6.2**	**6.8**	**7.4**
Construction	**8.1**	**7.9**	**9.6**	**6.9**	**7.4**	**9.2**	**11.1**	**8.2**
Business, Restaurants & Hotels	**8.0**	**7.8**	**6.8**	**6.6**	**7.1**	**7.1**	**7.5**	**7.3**
Trans. &Communications	**4.5**	**4.5**	**4.0**	**3.7**	**4.0**	**3.9**	**4.3**	**4.3**
Financial Services	**4.6**	**4.6**	**4.5**	**4.4**	**4.6**	**4.5**	**4.7**	**4.6**
Private Housing	**6.6**	**6.7**	**6.5**	**6.8**	**7.1**	**7.0**	**7.4**	**7.5**
Personal Services	**7.2**	**7.2**	**6.9**	**7.1**	**7.3**	**7.4**	**7.9**	**8.0**
Public Admin.	**3.2**	**3.0**	**2.8**	**2.9**	**3.0**	**3.0**	**3.1**	**3.1**

Source: Banco Central

Below in Tables 5-4, and 5-5 is a summary of costs per metric ton of copper produced, followed by the total value of copper for different mining concerns during a period of years.

TABLE 5-4. Production Costs for Copper Producers in Region III – US Dollars/Metric Ton

YEAR	A-001	A-002	A-003
1992	1,825		
1993	1,839		
1994	1,764		1,098
1995	1,424	1,093	1,032
1996	1,657	990	1,226
1997	1,739	1,025	1,208
1998	1,702	959	1,190
1999	1,508	937	1,140
2000	1,691	1.003	1,113
2001	1,640	930	1,078
2002	1,649	1,023	1,129
2005	2,837	1,709	1,980

Source: Farrell (Further breakdown in Mining Appendix)

TABLE 5-5. Product Price and Net Copper Value for Producers in Region III

YEAR	Product Price (selling) (USD/met ton)	A-001 (copper value) mil. USD	A-002 (copper value) mil. USD	A-003 (copper val.) mil. USD
1992	2,283	143.1		
1993	1,917	112.0		
1994	2,313	148.1		45.1
1995	2,936	186.6	27.7	327.9
1996	2,290	127.6	41.3	209.5
1997	2,276	121.1	44.5	244.3
1998	1,653	80.3	32.1	223.0
1999	1,574	89.0	30.5	218.8
2000	1,814	89.9	35.3	261.8
2001	1,578	75.9	30.6	237.2
2002	1,558	70.6	21.1	211.8
2005	3,684	161.7	90.7	451.4

Sources: Farrell and Cochilco (Further breakdown in Mining Appendix)

C. Conclusion

The tables in this chapter have given a brief but concise look at the makeup, production, production costs, product price and value, and contributions of the mining industry in Region III Chile.

CHAPTER SIX

Methods And Data for Analysis of Resource Depletion Rents and Sustainable Investment

A. Introduction

This chapter details the methods and data used for key empirical parts of this study. In particular it will discuss the major alternative methods for calculating resource depletion, the associated rents, and the amount which can and should be reinvested to fulfill “Hartwick sustainability. Relevant terms can be found in the glossary and the concepts are discussed in the theory chapter. This chapter will also provide an overview of data sources for the mining analysis.

Resource depletion might be calculated in several different ways. Normally when dealing with resource depletion and sustainability the calculations are made for the economy of a country, although here we will focus on one region – Chile’s region III. Following is a brief overview of five principle methods found in the literature. Three of these methods were chosen for use in the study and they will be detailed later.

1. U. S. Department of Commerce

1. Calculate gross rent as total annual revenue produced by the mine less current operation expenditures.
2. Resource rent is obtained by subtracting from gross rent annual depreciation of man made capital and a normal rent return to the capital invested in the mine.
3. Per unit rent of the resource equals resource rent divided by the physically quantity extracted.

4. Depletion is resource rent per unit times the quantity of the resource extracted during the year. If there are additions to reserves, they are valued at rent-per-unit times the physical quantity, and subtracted from depletion.

The U. S. Department of Commerce method was not chosen because it greatly overstates the value of depletion. The reason being that the value of the mineral being produced includes labor, capital, and materials in the extraction costs (Auty and Mikesell).

2. Present-Value Method

An alternative method for calculating the value of annual depletion is to determine the reduction in the present value of the expected net revenue between two periods. This method requires selecting an appropriate discount rate, and making assumptions regarding future mineral prices and extraction costs to arrive at the expected present value for each period. It is also necessary to determine the optimum path of exploitation since the optimum path is usually not constant annual production (Hartwick and Hageman – 1993 in Auty and Mikesell).

This method was not chosen due to the inability to know with a degree of certainty the optimum path of exploration compared to annual production.

Of the approaches to calculating resource depletion for the determination of a potential income stream to be invested in the non-mining economy, the following three were used. It is not my intent to ascertain the “best” or “more correct” method, but to provide a contribution that may be used in future comparison of these models at a smaller geographical and political area.

3. World Bank Method

The World Bank method does not consider new discoveries that are added to national/regional reserves. In addition the resource depletion the World Bank assigns an environmental damage of $20 (US $)/metric ton or CO_2 to the emitting country/region (Neumayer).

(P-AC) · R

P = resource price

AC = average cost

R = depletion

4. Net Price Approach (Repetto)

The net price approach is similar to Hotelling, except that resource rent or net price is defined as current market price minus average extraction costs, including normal profit on the capital investment. Resource depletion is the net reduction in the stock of the natural resource times the net price (Repetto et al (1998) in Auty and Mikesell).

(P-AC) · (R-D)

D = resource discoveries

Normally, the World Bank and the Net Price (Repetto) methods will account for a wider and higher range of estimates due to a greater adjustment of GDP.

5. User Cost (El Serafy – United Nations) Method

This method rejects Hotelling, and Rapetto and divides the net receipts from mineral extraction into capital consumption representing the amount earned at the expense of eroding the value of the asset, and net receipts available for consumption. The latter represents true income and is based on the Hicksian notion that true income is a level of consumption that can be sustained indefinitely. The attractiveness of this method is twofold in that it is the accepted method to calculate resource depletion used by the United Nations, and it conforms with the conventional definition of sustainable income by requiring that the natural capital asset be replaced only to the extent needed to maintain the income stream indefinitely (Auty and Mikesell). This method usually provides a more narrow range and lower estimates due to less severe adjustments in the GDP.

$$(P\text{-}AC) \cdot R \cdot \left[\frac{1}{(1+r)n+1} \right]$$

P = resource price

AC = average cost

R = depletion

r = discount rate

n = is the number of remaining years of the resource stock if production was the same in the future as in the base year (Neumayer)

By using these methods of calculations for resource depletion, in conjunction with environmental remediation figures, it will provide a range of estimates of the income that should be reinvested into the economy from copper production.

B. Treatment of Depletion, Rents, and Compensation

In this study I will essentially take health costs as non-negotiable social costs. I view them as part of the costs of mining, though in national accounts these are "externalities," and are not explicitly counted. Hence, health costs will have to be met by direct payments from the rents to the resource. The position taken here is that, in principle health costs should be part of the "cost of business" and should be paid.

Likewise, environmental damages are externalities which are not directly counted as costs in national accounts except to the extent environmental measures are required in the course of doing business. Here we take the perspective that compensation for environmental damages need not be some form of direct remediation of the damages. Compensation for environmental damages can range from literal return to the pre-existing state (rarely possible) to cash, in lieu, payments. We approach environmental compensation for Region III mining activities by assuming direct payment through the calculation of sustainable income, which is categorized as environment domestic product (EDP – Table 6-1). While mining company, and agency information from Region III will be used initially, any gaps in information will be taken from the next higher level available (national, appropriate models,…) and this data will be adjusted to a regional basis and used accordingly.

The estimate of sustainable income (EDP) will use the calculations based upon data availability for each category, and by the three methods of resource depletion (RD) stated previously. For the World Bank method there will be two calculations, one including their built in environmental cost (CO_2), and the other without the built in environmental cost (CO_2). The figures derived from the resource depletion (RD) calculations will be used in accordance with environmental and resource accounting (EARA) methods that recognize the specific contribution of natural resources to the national output which is shown in GDP measurements (Table 6-1 Terms, Definitions/Derivations). In general, I will focus on the World Bank, Net Price (Repetto), and User Cost (El Serafy – UN) measures. Two calculations will be undertaken for restoration of environmental damage (PR). PR1 (high value) encompasses maximum (100% perceived or real) environmental protection/remediation, and PR2 (low value) the minimum environmental expenditures to safeguard human health. The difference between the PR1 and PR2 values will comprise the available capital to be reinvested in Region III, Chile.

With the calculation of an estimated sustainable income derived from the mining industry, one must keep in mind that, for true sustainability in the region, reinvestment of this capital must be diversified. Investments must take place in productive projects or in private enterprise that yield a sizeable economic return. Social projects that yield low economic returns should be kept to a manageable percentage of the sustainable income stream.

In the determination of the economic compensation values one must remember the role of economic analysis, it is not to be used to justify normative values. It is instead a method by which different courses of action can be delineated. In its relationship to sustainable development it is best to remember:

- *"Economic analysis is not a tool to develop values, as it is not suited to the task;*
- *the role of economic analysis is to provide information relevant to a decision, not to provide the decision; and*
- *values used in economic analysis are best determined by preferences, although rights can also shape values* (Lesser, et al. - 1997)."

In moving from a national to a regional calculation some tradeoffs have to be made. A good percentage of Region III specific data exists for reserves, production, processing, GDP, GDP by sector, and this allowed for some Region III specific calculations. Other items such as product price, and consumption of fixed assets, discount rate, and exchange rates were calculated using national data, and then adjusting this data to a regional level. After meetings with the Chilean National Commission for the Environment (CONAMA) and a review of their national and regional environmental data, I chose to deal with the deterioration of environmental quality (DQR) by setting the damage initially at zero (starting at the time of negotiations) and accounting for it in the future by the high environmental calculation (PR-1). I believe this to be a readily acceptable approach due to the fact that mining has been ongoing in this area for more that a century and to try and identify specific companies or projects responsible for generic environmental deterioration is all but impossible. Also, in the environmental damages (PR) category of calculations a credit for company specific environmental projects proved to be impossible, due to lack of site specific environmental expenditures. Realistically, I feel that under any circumstances, the best approach is when dealing with a company/agency or consortium on a mining project to have the controlling interest to provide their financial records showing environmental expenditures. Dependent upon negotiations these expenditures can be subtracted from the high environmental calculations (PR-1) along with a long-term agreed upon accounting approach to environmental deductions.

The table below presents a brief definition of the terms being used and a note on their derivation with respect to the project's calculation of sustainable development.

TABLE 6-1.	**Terms**	**Definition/Derivation**
Acronym	**Meaning**	**Derivation, definition**
GDP	(gross domestic product)	the sum of personal consumption expenditures, gross private domestic investment, government expenditures and net exports
CFA	consumption of fixed assets produced in the economy	the depreciation of fixed assets
NDP	net domestic product	= GDP – CFA + minor adjustments
CE	Current Extraction	Mineral extracted in year (t)
RD	natural resource depletion	Resource depletion is the value by which the mineral asset has been reduced or depleted (per year)
DQR	the deterioration to the quality of natural resources	CO_2 – World Bank Set to zero for other methods
PR	expenditures for protecting or restoring natural resources from damage by human activity	Includes PR1 and PR2
PR1	Environmental damage	(high value - 100% perceived or real environmental remediation.)
PR2	Environmental damage	(low value - the minimum environmental expenditures to safeguard human health)
EDP	environmental domestic product, general category for estimate of sustainable income	Includes EDP1 and EDP2
EDP1	environmental domestic product, or estimate of sustainable income using limited/no data from DQR and PR due to lack of data in those categories	= GDP – CFA – RD – minor adjustments
EDP2	environmental domestic product, or estimate of sustainable income using greater data from DQR and PR	= GDP – CFA – RD – DQR – PR – minor adjustments
From Auty and Mikesell		

.

C. Calculation Procedures and Data Sources for Measurable Components of Sustainable Development

Data sources for the measureable components were initially identified during an extended visit to Chile in the fall of 2005. During this time, I met with governmental representatives from the Chilean national mining concern (CODELCO), the Chilean Copper Commission (Cochilco), the National Institute of Statistics (INE), the Ministry of Mines, the Central Bank of Chile (Banco Central de Chile), the National Business for Mining in Chile (ENAMI), the National Commission for the Environment (CONAMA – national and Region III), and the National Service for Geology and Mining (SERNAGEOMIN – national and Region III). In addition to this, I had meetings with faculty members from the University of Austral – Valdivia, Catholic University of Chile – Santiago, University of Chile – Santiago (Agriculture, and Mining campuses), and the University of Atacama – Copiapo, at their Technical Information Center. Upon my return, during the continuation of this work additional information was obtained either by e-mail or phone contact with the U.S. Environmental Protection Agency (EPA), the United States Geological Survey (USGS), Mine Cost Ltd., Western Mine Cost, and Phelps Dodge.

Calculations were based on the formula stated in the 1997 work of Auty and Mikesell, *Sustainable Development in Mineral Economics*, but outcomes were determined for a particular region (Region III, Chile), rather than on a national level.

I firmly believe that I have exhausted all available information for the copper mining industry in Region III Chile, and to improve upon the data would require time and resources beyond the scope and financial limitations (self-financed) of this work. Following is a breakdown where ultimately I gathered the majority of my information.

TABLE 6-2.	**Data Sources**
Variable	**Source**
GDP	Central Bank – Chile (Banco Central - Chile) and INE (National Statistics – Chile)
CFA	Central Bank – Chile = Working Paper #233 (Banco Central - Chile)
NDP	Central Bank – Chile (Banco Central - Chile) or calculation
RD_1 - RD_4	Cochiclo, CODELCO, SERNAGEOMIN, ENAMI, Phelps Dodge, USGS, Western Mine, and INE - Four methods for calculations, see narrative
DQR –	National Commission of the Environment – Chile (CONAMA)
PR	– actual mining company reports and CONAMA reports – includes PR1 and PR2
PR1	– Resource Strategies, Incorporated, Mineral Policy Center, EPA, GAO and production data from $RD_{1-}RD_4$
PR2	– Resource Strategies, Incorporated, Mineral Policy Center, EPA, GAO and production data from $RD_{1-}RD_4$
EDP	Environmental Domestic Product – includes EDP1 and EDP2
EDP1	– Calculations based upon available information
EDP2	– Calculations based upon available information

CHAPTER SEVEN

ENVIRONMENTAL ACTIVITY – MINING

In this chapter, I outline the overall importance, and the need for sustainable mining practices that take into account the environmental ramifications of a mining activity. Other issues that are addressed are environmental regulatory frameworks that share common features, related technology and method of payment. Although the main thrust is the justification for using the U. S. Environmental Protection Agency (U.S. EPA) framework for Chile, and associated models and studies based upon this framework with a breakdown of scenarios that result in environmental cost estimates associated with mining in Region III Chile. Finally, several options are considered that could be explored in another work.

A. Introduction

At present, countries with emerging economies are facing increased growth in the mining industry. Mining operations and processing create a number of environmental and human health problems at local, regional, and location dependent (national/international) levels. "Exploration and mine development may result in land degradation, forest clearance, and ecosystem disruption. Mining dumps and tailings are frequently a principal source of solid waste pollution. Mining and concentration and smelting processes may contribute toxic chemicals and metals to groundwater and rivers, while roasting and smelting generate several of the planet's major air pollutants" (OECD-Development Centre Doc. 1994). To what extent the mining operation does environmental damage depends on how it much it disturbs the environment. Where in actuality the environment may be affected through deterioration of water or air quality, it does not necessarily have a deleterious effect on the population due to the activity being conducted in a remote area. But the environment is affected nonetheless, and the damages should be taken into account.

Most countries already have environmental standards for air emissions, and wastewater discharge to prevent groundwater contamination, as well as hazardous, and toxic waste management guidelines to insure adequate remediation of mining activity. Nevertheless, forced compliance on the mining industry is weak due to lack of law enforcement, lack of monitoring capability and skilled human resources to carry out these activities. The rule (real or perceived) that mining companies must restore a mined area to exactly the way it was before extraction might not be physically feasible, nor be in agreement with the principle of maximizing the difference between social benefits and social costs (Auty & Mikesell). This is illustrated by the findings of the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, where the participants recognized the economic and social importance of minerals and mining to the development of a country. In the WSSD report in paragraph 44 it alludes to the importance of mining, stating that "enhancing the contribution of mining, minerals and metals to sustainable development includes actions to address the environmental, economic, health and social impacts and benefits of mining, minerals and metals throughout their life cycle; to enhance the participation of stakeholders; and to foster sustainable mining practices through the provision of financial, technical and capacity building support"(UNEP-Class of 2006)**.** These recommendations made by the WSSD leads one to incorporate alternative approaches to environmental compliance, remediation, and reclamation related to the mining industry that recognize the benefits as well as the costs to the geographical area affected by mining.

B. Environmental Compensation

Examples that emphasize an integrated approach to meet the needs of society from an economic and social aspect related to mining and the minerals industry are readily available in wide array of publications. While there exist various methods for addressing the approaches to reach this end, they are piecemeal at best. Of the approaches to environmental management of the minerals industry, particularly in the industrialized countries, regulatory frameworks have increasingly become more comprehensive and sophisticated. While in recent times in the United States, Canada and Western Europe, industry specific (mining) regulations have become more commonplace. Although, relatively new this has the possibility of becoming more and more prevalent as time goes on. In conjunction with industry specific regulations, other compliance methods being employed to a certain extent and being given additional consideration are those of market based initiatives, such as emission trading and environmental bonds (Warhusrt – OECD). While regulatory frameworks vary from region to region, some general themes can be identified that apply to the United States, Canada, Australia, Japan and Europe. With those being:

- Shift the cost of the pollution onto the polluters.
- Use of Best Available Technology (BAT). Hard to enforce and comply with due to change in manufacturing technology, raw material supply, and changing market and environmental conditions over time.
- Adverse effects of BAT. Due to ever changing technology manufacturing facilities result in upgrading by adding proven "end of pipe" solutions (additional water treatment, scrubbers, bag houses, cyclones, electrostatic precipitators,…), this results in little incentive for research and development (R&D) to come up with creative ways to deal with pollution. The end result being increasing added expenses to add pollution control

equipment with a declining return in regards to its effectiveness in pollution abatement (Warhusrt – OECD).

A drawback to BAT is that it is designed to meet overall environmental criteria and may not take into account site specific conditions. Site specific conditions may afford the opportunity to individualized "sinks" through evaporation/precipitation patterns, and soil/geologic conditions that may not be considered on a larger scale.

A point that expands on the 'polluter pay' theory and has relevance to this paper is expounded on by a recommendation under the category of sustainable development in an OECD - UN ECLAC environmental performance review for Chile that states; "increase the financial contributions of the mining sector to support long-term investment in human and social capital and to apply the polluter pay principle according to General Environmental Framework Law; consider a mechanism for proper capture of resource rents associated with mineral exploitation" (OECD-UN ECLAC).

C. Justification to use the United States Environmental Protection Agency Framework/Standards for the Chilean Study

Recently there has been a movement by the governments of developing countries to adopt environmental regulatory frameworks from industrialized countries. This has proceeded to the point where the Chilean government's environmental protection framework is loosely modeled after the United States Environmental Protection Agency (EPA) (Warhusrt – OECD). Although, the use of an environmentally well developed framework may be a good and logical first step, the implementation and enforcement portions of such a framework are not as easily transferrable. As put forth in the findings of the *Environmental Performance Review on Chile by the Organisation for Economic Co-operation and Development*, it will be necessary for Chile to: " i) thoroughly and efficiently implement its environmental policies; ii) further integrate environmental concerns into economic, social and sectoral decisions; and iii) strengthen its international environmental co-operation" (OECD-UN ECLAC - 2005). So in time this may prove to be the way to proceed, but for now the comparisons are somewhat limited and enforcement of these environmental standards is unobtainable.

At the present time whatever method/approach ultimately proves to be the most efficient and effective (i.e., polluter pays), one has to start with a realistic baseline and proceed from that point. The baseline that I have chosen should be accepted without reservation is that of protecting human health in the mining project area. Without an accepted baseline the need to negotiate does not exist. One logical method for establishing this baseline, or starting point is the environmental regulations of the EPA due to their history and the parallel to Chile's environmental regulations.

The United States along with Canada is among the leaders in the development and implementation of environmental regulations in the mining industry. In the United States the history of environmental/land use regulations started in the 19th century with the General Mining Law (1872), and was followed early in the 20th century with the passing of the National Park Service Act (1916), and the Leasing Act (1920). These first laws dealt primarily with land access, and really did not address environmental concerns. The first acts with the environment as the driving force were the Wilderness Act (1964), and the National Environmental Protection Act (1969), which empowered the EPA and a National Environmental Quality Control Council (NEQC) to advise the President on environmental matters, laying the need and groundwork for environmental regulations. In relatively quick succession legislation that affected mining directly was passed. This included requirements for Environmental Impact Statements (EIS), the Clean Air Act (1970), Clean Water Act (1972), regulations to control mining and reclamation (1977), the Resource Conservation and Recovery Act (RCRA - 1976), and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA – 1980), commonly known as Superfund (Warhusrt – OECD).

Whereas CERCLA/Superfund affects the clean-up of closed or abandoned mining operations it illustrates what prior lack of regulations have lead to in long-term environmental costs. American taxpayers today are potentially liable for anywhere from $1 billion (USD) to more than $ 12 billion (USD) in clean-up costs from inadequately insured and abandoned mining sites developed and operated to extract metals. This is the minimum and maximum clean-up costs that the public will have to bear after exhausting the companies reclamation bonds that were intended to guarantee "that if a mining company is unable or unwilling to clean-up after a mine closes, funds would be available to remedy and prevent pollution at the site" (Kuipers). As of 2003 in the western United States (Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, South Dakota, Utah and Washington), the total dollar amount (USD) in place by all companies and agencies operating current and past mining operations was $1,402,282,404, or an average of $5,164/acre on a total of 271,544 acres for environmental clean-up. This left the American public with a minimum estimated clean-up cost of $701,141,202, but when considering the estimated maximum dollar amount for clean-up ($50,000/acre) there exists an estimated shortfall of $12,174,917,596 (Kuipers).

While it is apparent that the taxpayers in the United States, either at the federal or state level will end up with a clean-up bill for past mining and current mining that is underfunded, it is a situation that does not have to happen in the future, or at least the results can be better anticipated. Assuming that the decision is made by regulatory forces that the polluter pay principle is the option to be pursued, there still exists an array of choices. At what level of remediation does the polluter pay? And if paying at a level of 100% remediation does that necessarily indicate that 100% remediation will be carried out? If human health is protected during the mining operation, and after mine closure does that free up resources ($) to be used elsewhere in the economy? If so, and those resources are reinvested into the economy in the region affected by mining activities what are the potential gains? Potentially the growth of the economy, albeit peripherally, will possess the resources in the form of a greater tax base to address clean-up issues. No one can argue that mining is an integral part of the economy, especially in mineral dependent economies, and no one can argue that environmental protection for the sake of ensuring human health is also integral. So the question is, how does the government reconcile mining growth with environmental protection while securing a more diversified and stable economy for the region's future?

D. Use of Resource Strategies Incorporated's EPA Model for Generation of Environmental Compensation

Previously discussed methods of calculating resource depletion have taken place in the economic section. The World Bank method, in conjunction with the Net Price method and the User Cost method all display varying ways of calculating resource depletion, but that is only part of the overall picture as environmental quality has to be given its consideration. Previous calculations have been conducted at a national level and either included some form of environmental remediation in their calculations, a generic figure such as US dollars/ per ton

CO_2/person, or did not address environmental degradation. Whereas a paucity of environmental models exist to deal with the mining industry, and more specifically the copper industry, Resource Strategies Incorporated (RSI), a specialist in world mining and metals production, (under a contract with the United States Bureau of Mines, Branch of Procurement) developed a model to assign economic impacts to the managing of copper mines and their associated waste, non-hazardous (EPA Subtitle D) and hazardous (EPA Subtitle C). This model assigned four different levels of active and long-term monitoring for various environmental indicators under the framework of EPA regulations, in addition to a scenario for abandonment. The scenarios include:

- Scenario 1: Groundwater monitoring and permitting are required for existing waste units but no great change from current waste management practices would be expected. This program is less stringent than the current Subtitle D program. For example, it does not require run-on/run-off controls, calls for a less sophisticated closure cover, and requires a shorter post-closure period and a less stringent groundwater monitoring configuration. It represents the lower bound, in terms of compliance cost, that is likely under a “minimal” regulatory approach.

- Scenario 2: Stringent groundwater monitoring, run-on/run-off controls, a vegetative cover over waste dumps and post-closure cover maintenance would be required. This scenario more closely resembles the current subtitle D program. However, it has been modified in order to calculate compliance costs. For example, Scenario No. 2 does not consider location standards or performance goals on a case by case basis when estimating the cost of compliance.

- Scenario 3: Requires closure of all existing waste management units and construction of new units. Single synthetic liner systems would be mandated. Existing units would be closed with the waste in place and covered with a synthetic cap. This represents a less stringent version of the current Subtitle C program. For example, it allows for a less sophisticated liner system and groundwater monitoring configuration. This scenario was developed to provide an estimate of the cost of compliance under a less rigorous Subtitle C regulatory approach.

- Scenario 4: This scenario represents a Subtitle C approach to the regulation of mining wastes. It is the most stringent and most costly of the four scenarios. Double liner systems with leachate detection and collection, and more elaborate capping of closed units is required.

- Abandonment: Implementation of abandonment is a common criteria under Subtitle D for landfill waste units. On the basis of this legislative precedence, the inclusion of abandonment as a feasible option under Scenarios 3 and 4 was analyzed for copper beneficiation and processing waste units (RSI).

A complete breakdown of monitoring scenarios appears in Appendix #4

The mining industry worldwide is responsible for enormous quantities of solid waste every year, and the copper industry is the single largest contributor to mining waste**.** The reasons for the quantities of waste being generated are actually quite straightforward, that being twofold: copper being a high demand metal, and copper content in the parent material is generally of a low percentage (generally between 1 and 2 percent for Chile). In the United States the EPA faced a regulatory challenge due to the quantity of waste, and classification of waste due to the waste possessing hazardous waste characteristics of corrosivity and toxicity. Ultimately, in July

1986, the EPA determined that mining and beneficiation waste should not be regulated under RCRA Subtitle C regulations as hazardous waste (RSI). This determination facilitated the split between copper mining and copper processing waste.

In the continuing phase of copper production, smelting while producing considerably less waste volume wise, contributes more from a hazardous waste standpoint. A percentage of concentrate from the extracting process comes off as sulfur dioxide which goes to an acid plant or smelter slag. This waste is classified under RCRA Subtitle C regulations as hazardous waste. The hazardous waste under Subtitle C in conjunction with the large volume of non-hazardous waste (Subtitle D) being produced in the initial mining of copper ore, shows the need for adequate environmental regulations (RSI).

The RSI model has taken its information from specific companies and sites associated with the United States copper mining industry, and does include the categories of refined copper production, extraction/electrowinning, smelting and general mine production. But due to the proprietary nature of the data shared by U. S. mining concerns used for the model information, it has been generalized. In addition to the four scenarios involving environmental monitoring, RSI provides cost estimates for the categories of mining, smelting, refining, copper solvent extraction/electrowinning, and corrective action. This information along with complementary smelter costs and the United Nations \$20/ton CO_2 expense in some cases is the basis for additional costs. I believe that dealing with general/combined information from the United States copper industry provides a better indicator of environmental expenses in Chile Region III, than the limited data from that region. This is especially relevant due to the fact that Chilean environmental regulations are based off of the United States EPA framework, allowing for like category comparisons. Estimates for complete environmental remediation of a mine site do not exist. Although limited RSI and several other studies do provide an opportunity to gauge a dollar value on varying degrees of environmental management and waste handling from copper mining and processing. The cost estimates have been updated to reflect the price for compliance in 2000 US dollars to be consistent with other values related to production costs and values.

E. Environmental Cost Estimates

Using cost estimation data from the RSI model, and production data from large scale mines, and their production facilities, in conjunction with Chilean government estimates of production, and the government owned processing facilities, I calculated environmental calculations for production and processing damages. In conjunctions with these estimates, additional calculations were made for long-term environmental monitoring based upon the previously stated scenarios. Table 7-1 provides environmental cost estimates for different combinations of scenarios #1 (least stringent) and #4 (most stringent), while Table 7-2 provides estimated Region III mining profits.

TABLE 7-1. Environmental Costs for Region III, Chile in 2000 U. S. $

Environmental Costs (1) US $	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Region III #1-Least Stringent (2-total)	**5,266,361**	**4,949,818**	**5,865,429**	**10,087,817**	**11,562,831**	**12,150,056**
Region III #4 -Most Stringent w/abandonment (2-total)	**130,246,093**	**122,417,470**	**145,062,063**	**249,488,938**	**285,968,543**	**300,491,654**
Region III #4 - Most Stringent w/closure & maintenance (2-total)	**369,010,357**	**346,849,498**	**411,009,178**	**706,885,325**	**810,244,204**	**851,393,019**
Region III #1-Least Stringent (2-total) w/processing				**10,161,892**	**11,704,807**	**12,304,378**

Region III #4 -Most Stringent w/abandonment (2-total) w/processing			
Region III #4 - Most Stringent w/closure & maintenance (2-total) w/processing	**706,984,797**	**810,434,858**	**851,600,251**

SOURCES:

(1) Resource Strategies Inc.

(2) Anuario - del Cobre 1985-2005 COCHILCO

Environmental Costs (1) US $	**1998**	**1999**	**2000**	**2001**	**2002**	**2005**
Region III #1-Least Stringent (2-total)	**13,905,125**	**14,523,961**	**13,081,327**	**13,768,291**	**13,251,793**	**13,892,803**
Region III #4 -Most Stringent w/abandonment (2-total)	**343,897,494**	**359,202,356**	**323,523,551**	**340,513,345**	**327,739,452**	**343,592,730**
Region III #4 - Most Stringent w/closure & maintenance (2-total)	**974,376,233**	**1,017,740,010**	**916,650,061**	**964,787,810**	**933,092,497**	**973,512,735**
Region III #1-Least Stringent (2-total) w/processing	**14,059,447**	**14,678,283**	**13,235,649**	**13,922,613**	**13,359,818**	**14,085,706**
Region III #4 -Most Stringent w/abandonment (2-total) w/processing		**362,406,610**	**326,946,810**	**344,214,295**		
Region III #4 - Most Stringent w/closure & maintenance (2-total) w/processing	**974,583,465**	**1,027,560,003**	**927,127,069**	**976,097,893**	**933,237,560**	**973,771,776**

SOURCES:

(1) Resource Strategies Inc.

(2) Anuario - del Cobre 1985-2005 COCHILCO

A complete breakdown of monitoring scenarios appears in Appendix #4

TABLE 7-2. Estimated Mining Profits for Region III Chile

Year	Profit in US $ (mil)
1992	50.6
1993	24.8
1994	-12.0
1995	399.1
1996	174.9
1997	274.3
1998	105.0
1999	108.2
2000	162.0
2001	121.1
2002	68.0
2005	437.6

Known profits for between
53.9%-75.7%, weighted averaged for remaining %

By measuring total costs of environmental remediation associated with mining, and using that as a baseline, it provides a realistic comparison for all concerned entities. Incorporating cost estimates for environmental remediation of past and present mining activity and using previously mentioned scenarios provides one with a dollar estimate on which a course of action might be chosen. By weighing all of the options such as BAT or “best practices” low technological solutions and institutional controls for Region III, Chile, a basis for a realistic long-term economic policy for Region III, and how it relates to long-term environmental costs can be better understood. This understanding will provide information necessary for continued discussions, and subsequent evolving policy concerning mining, economic development and the environment, between mining concerns, government and interested citizenry represented by non-governmental organizations (NGOs).

The Chilean government has the option of maximizing their net benefits by entering into negotiations with the mining concern over the levels of environmental remediation to be carried out. Using 100% remediation as the upper level (scenario 4) plus associated environmental processing costs, and the protection of human health as the lowest acceptable level (scenario 1) plus some level of associated environmental processing costs, a calculated cost leaves a scale of alternative actions in between the high and low estimates. In negotiations between the mining concern, the government and NGOs representing the public's interest, various options for maximizing net benefits can be explored.

Possible options to be explored where net benefits may be increased are:

- Low technological options of environmental remediation. (Gains being lower initial cost of capital outlay, easier technological transfer, labor intensive (thus increasing assets being brought into the country – multiplier effect) greater chance of uniform remediation, and ultimately, an equal level of remediation.
- Institutional controls may in part (or totally) replace remediation if the mining area is deemed of little economic value and is sparsely populated.
- Selected areas of high-tech remediation (BAT) incorporated with low-tech efforts and institutional controls.

The dollar amount ($/unit of environmental remediation) below the initial figure of company responsibility or environmental remediation, would constitute the amount of lost net benefits for the government of the host country. This leads to the opportunity of negotiations between all interested parties (mining concern, government and NGOs) and potentially would allocate these lost profits (lost net benefits) to ideally benefit all. This may be conceivable with the mining concerns realizing an increased profit, the government having additional revenue to invest in other areas of the economy to aid in sustainability, and the NGOs possibly gaining by the addition of local employment to either work in cost saving tech (low, mid or high) remediation jobs, management of institutional control programs, or inputs into other socially relevant programs. But, it is of vital importance to realize that the mining concern is responsible for the replacement of capital (in some form) to compensate for environmental damage.

A necessity in this decision making process for the government would be the calculation (or estimate) of the environmental damage and capital required to sustain a region's economy. This environmental estimate dollar amount is part of the total compensation, in conjunction with the resource depletion calculation for economic sustainability, as defined previously.

F. Conclusion

Uncertainty: An overall compensation package would require one more element - measures to specifically address the topic of uncertainty. There are two kinds of uncertainty relevant to these circumstances. The first concerns the long time lag and uncertainty of many environmental effects. Asbestos provides a dramatic example of an entire industry built around a material that later was found to have very severe health and environmental risks. Experience with American waste and clean-up regulations shows the need to address responsibility for all levels of environmental damage, even those unanticipated at the beginning of a project. The second area of uncertainty is business uncertainty. Environmental uncertainty can lead to business uncertainty where businesses are exposed to unknown levels of future liability. Another source of business uncertainty concerns the regulatory and policy environment. Mid-stream changes in environmental responsibilities can significantly alter a firm's business activities, sales, costs, and profits. Therefore, any compensation arrangement would need to deal explicitly with overall liability for environmental damages - including both the currently calculated damages and any unexpected future damages. Both the business and the local community would benefit from knowing exactly who will be responsible for all damages including unanticipated future damages. For this reason any projects must include assessment, monitoring, enforcement and re-insurance provisions.

Increasingly, mining companies in an increasing fashion have committed resources to environmental compliance and stewardship, and these efforts must be taken into consideration. But unfortunately, a major commitment in one geographic area does not necessarily translate to an operation at a different location, or environmental remediation efforts for one particular process or mine type does not always benefit a different mine site or refining process. Environmental investments in the mining industry are normally a long-term proposition, and their investment value should be considered in a yearly fashion for the affected area, and over the accounting life of the equipment. In the same way, mining company profits tend to be cyclical, therefore this should be considered whenever long-term financial arrangements are being negotiated.

Development of a sliding tax/fee schedule based upon environmental costs/savings for the mining industry to insure sustainable development should be the thrust of an attempt to maximize social net benefit while working within the market system.

This chapter has shown the logical progression from environmental consequences, how several countries deal with these consequences, and how the U.S. EPA framework is a justifiable method to approach environmental problems associated with mining in Chile. It concludes with various scenarios to be considered, projected environmental costs and the nature of uncertainty in environmental cost and how these costs can affect a business.

CHAPTER EIGHT

SOCIAL FACTORS – INDICATORS OF WELL-BEING AND INFORMATION, AND AN INFORMATION ORIENTED EXAMINATION OF SOCIAL CAPITAL IN CHILE, REGION III

A. Introduction

Mineral wealth provides an opportunity for both the mining concern and local communities to explore meaningful long-term gains through mutually agreed upon goals of development in the mine's area of operation. Previous chapters contain explorations of the economic and environmental dimensions of the relationship between the local community and the external mining concern. This chapter will focus on the social components of this relationship. The chapter has three related sections concentrating on well-being, information, and social capital. These social factors have been chosen for their relevance to the process and outcome of a community's potential for interactions with, and possible future negotiations with a mining concern.

The first section of the chapter discusses well-being indicators. An immediate purpose of this section is to provide background information for this study as a whole. The longer run reason is that ultimately a total evaluation of the relationship between the mining enterprise and the community will require measuring changes in social, cultural and political, as well as economic well-being. Measuring such changes was limited in this study because of time, data and resource constraints. Whereas a complete study of the impact of mining would require with and without estimates of community well-being, insufficient effort has been placed on collecting the relevant kinds of data by various actors, and collecting them was beyond the scope of this work. Therefore, the empirical focus of this section will be an analysis of Chile compared to other mining nations and region III of Chile compared to national averages. This study will use classes of social indicators (education, health, and income and economic activity) that correspond to well-being indicators used by the United Nations' agencies and, consequently, by many other international and national organizations and researchers.

The second and third sections of the chapter are tied together by the common theme of information. The underlying motive for this focus on information is the goal for a collaborative method of determining mining costs and damages and of determining the appropriate methods and quantities of compensation and re-investment to promote sustainable development. Shared information is a necessary element of such collaboration, though it is, of course, only the beginning of the collaborative process.

Section two of this chapter focuses on a sub-group of social indicators concerned with information. The information indicators provide background necessary to make an assessment of electronic social capital (networking). In particular, the 2005 UNDP Human Development Report "Technology: Creation and Diffusion," discusses an important measure -- internet users per 1,000 people. This information in conjunction with additional internet information regarding Chile, forms the basis for "information indicators" to be explored later in this chapter.

The final section contains the main empirical contribution of the chapter. The section investigates social capital using Atria and Siles' definition from 2004 -- where social capital is defined as "a resource formed by the social relationships existing among groups and collectives." This section begins with a general discussion of the nature of social capital and then concentrates on a specific empirical study of information-based social capital, as a tool for networking and information, related to the environment and mining in Region III of Chile.

In this chapter I will discuss social capital in the form of electronic information and how it assists in information transfer, aids in sustainable development, and furthermore, manifests itself through the measurement of generally accepted social factors. However, the first part of this chapter is focused on the issue of measuring community well-being.

B. Social Indicators-Human Well-Being

The social factors of the mining enterprise-community interaction can be framed in terms of a discussion of sustainable development (as discussed in the theory chapter earlier). In most definitions, sustainability has economic, environmental and community/social aspects. Hence, in order to examine sustainable mineral development, we need to measure the key components that contribute to the quality of life of the community. However, social factors are numerous and complex, and have both an impact on, and are impacted by the economic production system. The range of human interactions and the nature of human and social wellbeing include -- mental and physical health, family stability, religious and political status, personal safety, family security, etc. Not only are there many factors, but most are extremely difficult to measure. Practically, one must reduce the many social dimensions down to a workable number of measurable dimensions. Fortunately, there exist some readily recognized and accepted areas where the quality of life can be measured. The United Nations Development Programme (UNDP) uses a combination of inputs from three general areas; life expectancy (health), knowledge (education) and standard of living (income) to define one of the most widely accepted measures of social well-being – the Human Development Index or HDI. In this chapter I will focus on the three areas of health, education, and standard of living, though the measures will not be restricted to those used in the UN's HDI. The point of these measurements will be to establish an approach toward measuring the social impacts of a mining development. I will explore whether the broad measures we can find in national, regional and international statistics are sufficient to portray the social impact of mining in this region. I will end by discussing what the implications of these measures and how they relate to Region III, and what other possible tools may be used in future measurement. In summary then, just as it important to determine what role the mining industry has played and will continue to play in Chile in environmental quality and economic growth, it is also necessary to develop tools and statistics for measuring local community well-being.

"Indicators only indicate; they do not explain" (UNDP-RBM). Social factor indicators, encompassing socio-cultural, socioeconomic, and socio-demographic dimensions fall into the area where it is possible to show change but not necessarily why change has occurred. The use of indicators can be made very elaborate and demanding or the approach to using them can be made straightforward and realistic. The key to good social indicators is credibility. In measuring development the UNDP tries to capture "results" of what is possible and substantively practical to measure and monitor.

The UNDP uses three types of indicators for their various reports on development.

- **Situational** (impact) indicators, which provide a broad picture of whether the developmental changes that matter to UNDP are actually occurring.
- **Outcome** indicators, which assess progress against specified outcomes.
- **Output** indicators, which assess progress against specific operational activities (UNDP-RBM).

For its Human Development Index (HDI) the UNDP uses situational indicators that describe the development situation on a national level. These indicators, while being a composite index are important for their ability to measure a country's basic achievements and trends in human development. The indicators are:

- A long and healthy life, as measured by life expectancy at birth.
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrollment ratio (with one-third weight).
- A decent standard of living, as measured by GDP per capita (purchasing power parity - PPP US$).

***** *Performance in each dimension is expressed as a value between 0 and 1, and then the HDI is calculated as a simple average of the dimension indices* (UNDP HDI – 2005).

In the 2005 Human Development Report that measures and analyzes developmental progress amongst its member countries and some selected regions, Chile has shown continuous improvement. A composite ranking lists Chile as 37th out of 177 countries in the HDI ranking. Following is an abbreviated table showing a representation of countries from the "High, Medium and Low" human development categories. Also included are the top twelve (12) copper producing countries for comparison value.

TABLE 8-1. Human Development Index - Chile and selected countries

HDI rank		**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2003**
High Human Development		**(> 0.800)**						
#1	Norway	0.868	0.888	0.898	0.912	0.936	0.956	0.963
#4	Australia (4*)	0.848	0.866	0.879	0.893	0.933	0.960	0.955
#5	Canada (5*)	0.869	0.886	0.909	0.929	0.934		0.949

#10	United States (2*)	0.867	0.887	0.901	0.916	0.929	0.938	0.944
#25	Singapore	0.725	0.761	0.784	0.822	0.861		0.907
#36	Poland (9*)				0.803	0.816	0.845	0.858
#37	**Chile (1*)**	**0.704**	**0.739**	**0.763**	**0.785**	**0.816**	**0.843**	**0.854**
#50	Bahamas		0.809	0.819	0.821	0.810		0.832
#53	Mexico (12*)	0.689	0.735	0.755	0.764	0.782	0.809	0.814
Medium Human Development (0.500 – 0.799)								
#62	Russian Fed. (6*)				0.817	0.770		0.795
#75	Venezuela	0.718	0.732	0.740	0.759	0.767	0.772	0.772
#79	Peru (3*)	0.643	0.674	0.698	0.707	0.734		0.762
#80	Kazakhstan (10*)				0.767	0.721	0.731	0.761
#85	China (7*)	0.525	0.558	0.594	0.627	0.683		0.755
#100	Georgia							0.732
#110	Indonesia (5*)	0.468	0.530	0.583	0.625	0.663	0.680	0.697
#125	Namibia					0.693	0.649	0.627
Low Human Development (< 0.500)								
#150	Djibouti					0.477	0.487	0.495
#166	Zambia (11*)	0.468	0.475	0.484	0.462	0.424	0.409	0.394
#175	Burkina Faso	0.253	0.273	0.297	0.305	0.311	0.328	0.317
#177	Niger	0.236	0.252	0.242	0.249	0.256	0.271	0.281

Source: UNDP HDI – 2005

*** World rank in copper production – (Index Mundi).**

Other HDI rankings that show that Chile is continuing an upward economic trend is the report for 103 developing countries and areas. In this report, Chile ranks 2nd, while other copper producing developing countries are ranked as follows: Mexico 13th, Peru 26th, China 27th, Indonesia 41st, and Zambia 90th.

Corresponding to the years (1975, 1980, 1985, 1990, 1995, and 2000) and the HDI ranking, one can see a steady increase in the HDI value for Chile. I would argue this is due in no small part to the stable economic base brought about by mining as illustrated by Table 8-2 below. During this timeframe the mining sector has accounted for between 9,388 (million 2000 U.S. $) and 4,909,614 (mil 2000 U.S. $). While Chile's economy has been growing as a whole at the same time, the fact that mining has maintained its percentage of the GDP indicates substantial growth within that sector, providing a dependable base to further help the diversification of the country. In addition, it can be seen that in Region III, the GDP per capita has recently passed the national average (Table 8-3), and with mining's contribution to Region III's GDP (Table 5-3), it further illustrates the importance of mining to the economy in that region. So Chile's ability to maintain its rank (37th) in the UNDP – 2005 Human Development Report has been aided by the mining industry heavily active in Region III.

TABLE 8-2. Mining Sector's Percentage of Gross Domestic Product (GDP) and Chile's GDP

Year	**% of mining contribution (1)**	**Chile – GDP current prices in National currency (in million) (2)**
1975	**7.9**	**37,891**
1980	**7.2**	**1,149,700**
1985	**11.8**	**2,930,460**
1990	**10.3**	**10,216,526**
1995	**9.3**	**28,593,362**
2000	**12.1**	**40,575,319**
2005		**66,598,991**

Source: Banco Central – Chile (1) and United Nations Statistics Division (2)

1. Regional Indicators

The previous discussion on situational indicators represents achievements/progress at a national or macro level. Region III in Chile does not comprise a national or macro picture. Where data can be broken out for Region III for comparison sake against the rest of Chile regarding life expectancy, education and income, the question is what inputs in the future will provide an opportunity for Region III along with the rest of Chile to continue an upward trend. Any policy or program change relating to the environment and mining in this region will have an effect on all of the major HDI categories.

TABLE 8-3. Region III – National Comparison GDP per capita (2000 USD)

Year	Region III	National (Chile)	Region III GDP as % of National
1996	4,473	6,065	1.9
1997	5,390	6,216	1.9
1998	5,660	5,678	1.9
1999	5,502	5,025	1.9
2000	5,346	4,879	1.8
2001	5,544	4,194	1.8
2002	5,286	3,910	1.7

Source: Banco Central – Chile

TABLE 8-4. Region III – National Comparison Life Expectancy for the period of 2000 – 2005

	Region III	National (Chile)	Region III % of pop. 2005
Total Life Expectancy	77.75	76.34	1.7
Men	75.59	71.45	1.7
Women	80.00	77.35	1.6

Source: National Institute of Statistics (INE) Population Projection

TABLE 8-5. Region III – National Comparison of Births per 1000 for the time period of 2000 – 2005 and Female Median Age Comparison for 2005

	Region III	National (Chile)
Birth Rate/1000	17.00	15.75
Female Median Age	25-29 (5 year period)	30-34 (5 year period)

Source: National Institute of Statistics (INE) Population Projection

TABLE 8-6. Region III – National Comparison of Deaths per 1000 for the time period of 2000 – 2005

	Region III	National (Chile)
Death Rate/1000	4.37	5.15

Source: National Institute of Statistics (INE) Population Projection

TABLE 8-7. Region III – National Comparison of Natural Growth (births – deaths) per 1000 for the time period of 2000 – 2005

	Region III	National (Chile)
Natural Growth/1000	12.63	10.60

Source: National Institute of Statistics (INE) Population Projection

TABLE 8-8. Comparison – percentage of graduates from Chilean school system

	Region III (1995) (1)	National (1995) (2)
Basic	80.00	85.15
Middle	80.50	54.96
Advanced	13.01	18.09

1: National Institute of Statistics (INE) Population Projection

2: Economic and Social Indicators for Chile 1960 – 2000 – Banco Central

2. Discussion

The GDP per capita data for Region III supports the hypothesis that although the Chilean economy has become more diversified, it is still dependent upon the mining industry. The GDP per capita figure as indicated in information taken for various years from the United Nations Statistics Division – National Accounts (Table 8-7) parallels the rise in profits by the mining industry during this time, either through a price increase or increased production, by the mining concerns. The taxes paid by the mining companies are based on the annual average price of copper sold on the LME (London Metal Exchange) and covered under DL 600 discussed in the History of Mining Section, and are in place until the expiration of each existing contract. At that point in time mining companies will have to pay at the rate dictated by a new mining tax or apply to pay a mining specific tax set at a flat 4 percent of the value as determined by the price on the LME annually for a period of 12 years. Nationally the government expects to generate $270 million USD in 2006 the first year of the mining specific tax (USGS).

TABLE 8-9. Estimated GDP per capita in US Dollars – various years (Chile)

Year	GDP per capita
1992	3,386
1993	3,532
1994	3,974
1995	5,006
1996	5,184
1997	5,585
1998	5,285
1999	4,795
2000	4,879
2001	4,396
2002	4,264
2003	4,638
2004	5,944
2005	7,297

Source: United Nations Statistics Division – National Accounts

The higher birth rate in Region III may be accounted for by the somewhat lower median age for women in that area. As seen in Table 8-5 the median age is in the 25 – 29 age group category, whereas the national median age for women in Chile is in the 30 – 34 age group category (INE). One hypothesis is that a better economy due to the mining attracts a younger and more male oriented workforce, resulting in generally an overall younger population. This in part is illustrated by the fact that in Region III the percentage of men (50.99) is higher than the national figure (49.50) for the year of 2005 (INE). In addition, in recent years other gains in Region III have included a better standard of living shown by recent GDP per capita figures (Table 8-3), and a longer life expectancy, where an overall gain of 1.41 years is experienced over Chile as a whole (Table 8-4). But, overall Chile nationally, and Region III demonstrate characteristics of stage three of demographic transition. This is illustrated by the fact that even though Chile in 2005 has a total fertility rate of 2.0 (U N Statistics Division - Common Database), which is slightly below the replacement level of 2.1, the population continues to grow. This is explained by Tables 8-6, and 8-7 that show a natural population increase due to a lower death rate. Furthermore, in addition to the declining birth rate which is an indicator of stage three demographic transition, is the level of education, at the national and regional level (Table 8-8), which corroborates this point.

In the category of completed levels of education Region III illustrates a greater graduation rate in the middle school category. I believe this illustrates the need for better educated workers at the mine sites, as greater technology is employed.

Region III in Chile is a region that is on an upward economic cycle, due to either direct employment in the mining industry, or being involved peripherally through a supporting business. Whereas, the economy in this region is also supported by other sectors of the economy such as agriculture, fishing, manufacturing, construction, and to lesser extent service industries, mining normally accounts for roughly 40 percent of the Region's economic activity. With this type of economy, level of education, and the existence of web-sites devoted to environmental concerns in the region, I believe that the possibility exists for the citizenry to become more involved in their environmental setting, and planning of future infrastructure development through active participation in current and future mining projects. One way this might be facilitated is by becoming actively involved in environmental remediation/monitoring at mine sites that translate to negotiations for a part of the resources required above those to protect human health, but are needed for future environmental needs. A tool to aid in these negotiations is information, with the possibility of it being obtained electronically via the Internet.

C. Information Indicators

Next we move to a different kind of social indicator, indicators describing the state of the social environment rather than the status of the people per se. This section contains a discussion of some aspects of the information infrastructure of Chile and Region III in particular. This section will set the stage for the discussion of social capital. With the early years of the 21st century upon us, greater levels of social inclusion exist through being a participant of the information society (Keeble and Loader). This social capital section will focus on aspects of social capital associated with information exchange.

In 1990, the UNDP began keeping track of the number of Internet users. Table 8-8 tracks the rise of internet use among the general population of all countries included in the Human Development Report. In conjunction with the trend listed below a recent report written in February of 2007 by Worldpress.org with the foretelling title "Chile Surpasses One Million Broadband Connections," states the fact that Chile "now boasts the highest rate of broadband connectivity and general Internet use in Latin America." Suffice it to say that more Chileans as individuals and as organizations are obtaining and exchanging information via the Internet.

TABLE 8-10. Technology in Chile and other copper producing countries

Country	**Telephone mainlines (per 1,000 people)**			**Cellular subscribers (per 1,000 people)**			**Internet users (per 1,000 people)**		
	1990	**2003**	**2005**	**1990**	**2003**	**2005**	**1990**	**2003**	**2005**
Chile	**66**	**221**	**211**	**1**	**511**	**649**	**0**	**272**	**172**
Mexico	**65**	**160**	**189**	**1**	**295**	**807**	**0**	**120**	**206**
Peru	**26**	**67**	**80**	**-**	**106**	**200**	**0**	**104**	**164**
China	**6**	**209**	**269**	**-**	**215**	**302**	**0**	**63**	**85**

Indonesia	**6**	**39**	**58**	**-**	**87**	**213**	**0**	**38**	**73**
Zambia	**8**	**8**	**8**	**0**	**22**	**81**	**0**	**6**	**20**

Source: UNDP – Human Development Indexes

One form of social capital that is needed to make or aid in the decision process is related to the availability/transfer of information. In anticipation of this discussion, it is important to determine the availability of electronic information/social capital regarding the environment and mining activities that exists in Region III. For this purpose the information provided by the UNDP regarding the number of Internet users per 1,000 people is of interest, not only for the sheer numbers themselves, but for the purpose of gathering and exchanging environmental/mining information as demonstrated by the existence of environmental web-sites in Region III, and governmental agency web-sites, and mining company web-sites in Chile.

An output type indicator (see discussion above) will be used for Internet use and information exchange. "Outputs are tangible results that can be delivered within a short timeframe." This means that the output itself may be measurable and may clearly indicate how to verify that it has been produced" (UNDP-RBM). The outputs that are being produced and are measurable for Region III Chile are web-sites that provide information relating to the environment and mining in that region on a community/regional, national and international level.

Of importance in any process is the availability and exchange of information. In the past information was exchanged in many ways throughout the community, region and at the national level. Information was exchanged in the past, and still is today by way of community groups, local government, libraries, governmental offices, telephones, and any other opportunity where social interaction took place. In recent years with the advent of the Internet and the placing of technical documents and company reports on-line, communication via e-mail, and mutual interest web-sites, a greater amount of information for civic engagement is being obtained electronically.

1. Discussion

The ability to have a good understanding of current environmental conditions and future mining plans for the residents of Region III is essential if they are to give input about future plans for their region. Whereas, information could always be obtained at the mine site through observation, or through the local governmental environmental office (CONAMA) in the city of Copiapo, this information was at best incomplete and just a snapshot of the current conditions. Through web-sites on the Internet, information is available locally/regionally, through the mining company web-sites, governmental (SERNGEOMIN, CONAMA, ….), and perhaps more importantly, national and international non-governmental organization (NGOs) web-sites devoted to mining and the environment. Not only is current information available but in many cases historical documents relating to the environment and mine production is also available. The potential exists for web-sites and their associated user groups to exchange information about relevant issues.

The importance of information being available for research and basic understanding, and exchanged at the community/regional level cannot be overstated. In the establishment of a framework for a fee/tax/compensation schedule the outcome will only be satisfactory with good and informed participation from all parties, and this requires comparable information available to all parties enabling a realistic discussion, which will allow for a mutual starting point for negotiations.

D. Social Capital

Recently, scholars have argued that, though it is critical to have economic capital as an input into the region's economy, another input that has to be addressed in the region is social capital (Atria and Siles). The concept of social capital is at once simple and complicated. The general idea is that there are some dimensions of the collective capacity of a community to "get things done" that are embedded in the fabric of the social structure rather than being simply the sum of individual agents' skills and talents. While social capital is often identified with mutual trust within a community, some other aspects of the social network are also identified with social capital. One of the forms of social capital is information, in the forms of transference, and access. Two of the ways this information is made available and proves useful for the purpose of civic engagement according to the World Bank Group is:

- Government can decentralize while staying in close 'virtual' contact to facilitate coordination.
- Volunteerism can be generated by putting people in touch with the NGOs which speak to their interests and values.

Given this premise, just as it is important to understand sustainable levels of natural capital, it is important to determine the nature of social capital, and how mining development affects and is affected by it. In a publication by Michael Woolcock, *Social Capital and Economic Development: Toward a Theoretical Synthesis and Policy Framework,* Baron and Hannan "complain about the indiscriminate and metaphoric import of economic concepts into sociological literature and refer to the social capital literature as an example of a 'plethora of capitals'" (Baron and Hannan - 1994). Sociologists lament that they, "have begun referring to virtually every feature of social life as a form of capital" (Woolcock). Because of this "plethora of capitals" a clear definition and direction must be established in regards to the use of the term and measurement of social capital.

To clarify the definitions and concepts one might step back to see the origin of the idea of social capital in the related economic concepts. The classical economists identified land, labor and physical capital (i.e., assets that that generate income) as the three basic factors shaping economic growth. In the 1960s, neo-classical economists such as T. W. Schultz and Gary Becker introduced the notion of human capital, arguing that a society's endowment of educated, trained, and healthy workers determined how productively the orthodox factors could be utilized" (Woolcock). Neo-classical economists believe that if sufficient competition exists in all markets, the consequence of this pursuit of individual gain is optimum welfare for the community as a whole (Fishwick).

"To physical and human capital, sociologists and political scientists (and some economists) working within the field of the so-called "new economic sociology" have thus began to speak of social capital, a broad term encompassing the norms and networks facilitating collective action for mutual benefit" (Woolcock). By far, however, the most common function attributed to social capital is as a source of network-mediated benefits beyond the immediate family (Portes).

Social capital has emerged as a useful conceptual tool to examine the vitality of a neighborhood, a city, or country (Putnam, 1993, 1996, 2000, cited by Quan-Hase and Wellmen in "How does the Internet Affect Social Capital"). In addition, social capital allows researchers and policy makers to evaluate a number of core dimensions, such as public and private community, and civic engagement (Quan-Hase and Wellmen).

Broad definitions of social capital generally distinguish between two types, cognitive and structural. Structural social capital includes the relatively objective and externally more observable social structures, such as associations, institutions, and networks. Cognitive social capital comprises more intangible and subjective elements such as generally accepted attitudes and norms of behavior than structural social capital (World Bank). Cognitive social capital will not be examined in this paper due to the inability to measure "intangible attitudes" via the data methods available in this study. Under the heading of structural social capital an increase in associations, institutions and networks and their associated web-sites would illustrate greater civic engagement through providing and exchanging environmental/mining information via the Internet that is relevant to Region III, Chile. These sites that provide information from the international (macro) to local (micro) levels comprise the data for measurement of web site numbers and their potential to contribute to social capital. Electronic information sites, and their associated hosts, that exchange this information and play a relevant part in the decision making process relating to environmental/mining decisions, are to be considered for their contribution/interaction of information (social capital) through the amount and type of information available at the site. "When a computer network connects people or organizations, it is a social network. Just as a computer network is a set of machines connected by a set of cables, a social network is a set of people (or organizations or other social entities) connected by a set of social relations, such as co-working, or information exchange" (Jones).

Using the concept from Putnam et al. (1993) that horizontal organizations (micro) assist in the formation of social capital, and that vertical organizations (macro) inhibit social capital formation, a framework for this section can be established. In this study, I use the framework of the Social Capital Assessment Tool (SCAT) originally designed by Bain and Hicks (1998) and later adapted by Krishna and Shrader as a starting point to assign web sites (groups) into the classification system (micro to macro). Accordingly, a macro level institution is defined as having "formal relationships and structures, such as the rules of law, legal frameworks, the political regime, the level of decentralization and the level of participation in the policy formulation" (Bain and Hicks in Krishna and Shrader). Dealing with the structural category of the micro level includes local level institutions, both formal and informal where social capital is built through "horizontal organizations and networks that have collective and transparent decision making processes, accountable leaders, and practice collective action and mutual responsibility" (Bain and Hicks in Krishna and Shrader).

To these two categories, I add a third category, that being placed in the meso, or middle between the macro and micro categories. This third category or level, contains firms and agencies that provide information to vertical organizations at the macro level, and information used by horizontal groups at the micro level (Grootaert and van Bastelaer). These firms or agencies are represented by private mining companies, government owned mining concerns (mining and processing), and governmental agencies that provide information that is used in both production and environmental decisions.

1. Social Capital Divisions

This study views social capital in a structural and interdisciplinary way, with a further breakdown of categories that are applicable to my approach are:

- *Networking:* Views relationships between and within horizontal and vertical associations, and as such is centered on the meso element, in the structural category. In addition, this approach recognizes that while social capital can unite members of a community, it can also exclude nonmembers (people not having access to the Internet) of the community.

- *Institutional:* An approach, that poses that the political, legal and institutional environments are the detriments of the strength of the community networks. This category suggests that the ability of social groups to act in their collective interest is affected by the presence of formal institutions.
- *Synergy:* A view that aims to integrate the micro, meso and macro concerns of the networks and institutional approaches in a structural way. Synergy is based on the assumption that none of the development actors (community, government, and NGOs) have enough information to act on their own.

(Grootaert, and Van Bastelaer).

I focus on the *Networking* emphasis of the interdisciplinary approach. Whereas, there will exist an overlap between macro, meso and micro level institutions, there should exist a certain amount of separation between public and private sources. Although a wide scale in size should be represented in public, private, and non-governmental sources, a relatively more defined size of institutions would be expected at the Chilean governmental level. To make an assessment of the number of sources that allow for information exchange (social capital) on Region III environmental/mining data, and at what levels is the main effort of this section of the study.

E. Application of Social Capital

The interaction of micro, meso and macro environmental/mining groups and the amount of information that is available electronically (via the internet), and whether it supplements or transforms existing social capital, in reality is a fluid process. By establishing the number of active groups, (private, governmental and international) and their site's content related to environmental/mining information related to activity in Region III, one will be able to postulate the existence of electronic social capital, and at what level (micro, meso or macro).

Finally, fitting into this exercise, social capital is seen as having the possibility of affecting economic development positively in three ways. First, is by facilitating participation between individuals, and groups in social networks increases the availability of information while decreasing its' cost. Second, participation in local networks fosters attitudes of mutual trust and makes it easier for a group to reach a collective decision. And third, networks and attitudes reduce opportunistic behavior by community members (World Bank). Internet access and the establishment of web-sites with pertinent information relating to Region III environmental and mining information are intertwined with these benefits of economic gains through social capital, making the Internet an area that needs to be examined.

1. Methods

Due to the fact that the Internet leads to new forms of social capital that cannot be "easily captured with existing forms of measurement," new applications or combinations of existing applications that are complementary to standard forms of measurement will have to be used (Quan-Haase and Wellman). With this in mind the approach will be:

- An initial focus to see what web-sites exist related to community, governmental (regional and national), and NGO (national and international) based environmental/mining concerns related to Region III, Chile.
- A determination as to what category the existing web-sites should be placed (micro, meso or macro) based upon content and the ability for information exchange of material related to Region III environmental/mining activity.
- Existence of social capital, in the form of the type and content of information exchanged at the web-site. Information to be considered is:
  - ➢ Web sites
  - ➢ E-mail (ability to interact)
  - ➢ Environmental/mining related information (Region III)
  - ➢ On-line libraries (National or Regional)
  - ➢ Scheduled meetings or events
  - ➢ Organized groups (support, activist, informational, mandated) $$$
  - ➢ Links to laws, reports and other organizations

The Internet search results in a Micro, Meso, or Macro classification (below) determined by the attributes found on the individual/organization web site.

TABLE 8-11. Micro, Meso, and Macro Organization categorization criteria

MACRO:

- **Vertical organization**
- **Rule of law**
- **Legal framework**

- **Level of participation in policy process**
- **Level of decentralization**
- **Type of regime**

MESO:

- **Mix of vertical and horizontal organizations**
- **Company charter or bylaws**
- **Organization framework**
- **Participates in company or agency policy process**
- **Accountable (oversight – board, president,…)**
- **Transparent action (profit)**
- **Transparent information (production, financial,…) used by both vertical and horizontal organizations**
- **Collective action (mining or environmental consortium)**

MICRO:

- **Horizontal organization**
- **Accountability of leaders**
- **Transparent decision making**
- **Practices collective action**

SOURCE: Adapted from Krishna and Shrader

F. Results - Electronic/Physical Social Capital

In the area of information sharing (electronic social capital) and as it relates to community (Region III), Chilean and international environmental/mining organizations the main question is, does this form of electronic social capital transform (provides the means for inexpensive and convenient communication with far-flung communities of shared interest (Barlow in Quan-Haase and Wellman)), diminish (through its entertainment and information capabilities draws people away from family and friends (Nie in Quan-Haase and Wellman)), or supplement (blends into people's lives and is another means of communication to facilitate existing social relationships and follow patterns of civic engagement and socialization (Quan-Haase and Wellman)), traditional social capital. Whereas, to make the determination as to whether electronic social capital transforms, diminishes or supplements traditional social capital is beyond this scope, I believe that the internet is at least a supplement to social capital in the form of augmenting existing communication channels between groups with mutual concern about the environment and the effects of the mining industry. Another possibility may be that the internet has actually opened the door for greater communication about environmental/mining concerns by enabling individuals with like concerns to form groups and the regional level for the purpose of sharing information with governmental agencies, governmental and international NGOs.

Following is the search results for organizations and their categories (micro, meso, or macro) that relate to environmental/mining concerns in Region III Chile. Included in the results are regional environmental NGOs, private companies and government organizations that are a source of information related to mining, the environment and economic statistics required for an economic impact analysis that mining has on the region, and finally two organizations (one Latin American) that deal with environmental changes on a national and international level, and an NGO that deals with mining issues worldwide. On the regional level three of the sites (GAEDA, RENACE, and Consejo Ecologico Communal – Tierra Amarilla) had direct web sites, while the fourth (CHADENATUR) had a shared web site but provided contact information. Many national (Chilean) NGO sites exist related to the environment, but I focused on those that dealt specifically with Region III. The following table illustrates the sources, thus the possibilities for networking at all levels on environmental/mining issues, ultimately adding to social capital.

TABLE 8-12. Existence of Micro, Meso and Macro Organizations

Micro - Environmental Groups – Region III, Chile:

- Group Action for the Ecology of Atacama (GAEDA) (**http://accionecologicaenatacama.portalciudadano.cl/**)
- Red National Action for Ecology (RENACE) (**http://www.geocities.com/SouthBeach/Palms/1350/**)
- Community Council on Ecology (Consejo Ecologico Communal – Tierra Amarilla) (**http://www.olca.cl/oca/chile/region03/tierramarilla.htm**)
- Citizens of Chanaral for the Defense of Nature (CHADENATUR) (**http://www.ecoportal.net/content/view/full/49361**)

Meso – Chilean Governmental Agencies and Mining Companies:

- Chilean National Copper Company (CODELCO) (**http://www.codelco.cl/**)
- National Commission for the Environment (CONAMA) (**http://www.conama.cl/portal/1301/channel.html**)
- Business Administration of Mining Companies (ENAMI) (**http://www.enami.cl/OpenNet/asp/default.asp?boton=Hom**)
- Chilean Copper Commission (COCHILCO) (**http://www.cochilco.cl/**)
- Phelps Dodge (**http://www.fcx.com/operations/south_america.htm**)
- National Service of Geology and Mining (SERNAGEOMIN) (**http://www.sernageomin.cl/**)
- Chilean Ministry of Mines (**http://www.minmineria.cl/**)

Macro – International NGOs, and Environmental Projects

- OXFAM (**http://act.oxfamamerica.org/oxfamamerica/ourland_ourlife.html**)
- Center for Agriculture and the Environment (AGRIMED) (**http://www.uchile.cl/facultades/cs_agronomicas/agrimed/centro.html**)
- Chilean National Institute of Statistics (INE) (**http://www.ine.cl/canales/chile_estadistico/home.php**)

- Central Bank of Chile (Banco Central) (**http://www.bcentral.cl/**)

In this chapter, I've shown statistics that illustrate that Chile itself is on an upward trend, ranking exceedingly high in the area of developing countries. In addition, I've shown that technological advances in the forms of cellular and internet support a growing information exchange network in country. Finally in Region III with the existence of site specific web sites (environmental/ecological) the framework for networking and information exchange is in place leading to the possibility of an overall gain in social capital.

CHAPTER NINE

RESULTS

A. Introduction

In this chapter, results of the study are presented in terms of the research questions posed in Chapter One.

B. Research Question #1

Do sufficient funds exist in the private mining sector for complete environmental reclamation/remediation (real or perceived)?

There is some literature on two topics relevant to answering this question: environmental accounting methods as they relate to resource depletion, and the capital issue of needed to continue sustainability at the national level. In 1997 the World Bank published a study for 103 countries addressing environmental and resource accounting and their efforts to achieve saving rates to foster sustainability (World Bank 1997). While Neumayer in *Resource Accounting in Measures of Unsustainability* challenges the methodology of the World Bank, and provides his insight into other methods such as Net Price championed by Robert Repetto and the User Cost method developed by Salah El Serafy, I believe that an analysis of resource depletion and environmental conditions brought about by mining activity can better be analyzed in a smaller geographical setting. Developing and analyzing results for Region III Chile will add to the knowledge base and further development of sustainability measurement methods in resource depletion and economic sustainability, while taking into account the environment and the affected population.

1. World Bank

The results below indicate that even at the lower environmental level (EDP2 – protection of human health) there exists a shortfall between the level of sustainable income, and profits being shown by the mining industry on a regional level, as EDP2 plus regional profits does not equal the current regional GDP – at current international prices and industrial structure. Assuming this shortfall is real, there really are no excess rents on which to build an opportunity for negotiations for using excess rent for greater environmental protection (EDP). Several unknown factors with this method are the current amount of taxes being paid by the regional mining companies and the revenue that could be redirected in lieu of these taxes, the amount of spending by the mining companies currently on environmental protection. Finally this method in this form does not account for the deterioration of environmental quality (DQR).

TABLE 9-1. World Bank in 2000 US $ - Results	**1992**	**1997**	**2002**	**2005**
Regional GDP in 2000 US $ (mil)	841	1,353	1,397	1,505
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	168	210*	217*
World Bank Res. Depletion Reg III - 2000 US $	92,229,258	378,238,383	127,188,292	603,496,056
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	12,304,378	13,359,818	14,085,706
EDP (using PR2) in 2000 US $	**653,504,381**	**794,457,239**	**1,046,451,890**	**670,418,238**

Region III #4 - Most Stringent w/abandon (total-99-01 includes processing)	130,246,093	300,491,654	327,739,452	343,592,730
EDP (using PR1) in 2000 US $	**528,524,649**	**506,269,963**	**732,072,256**	**340,911,214**
Region III mining profits in 2000 US $ (mil)	50.6	274.3	68.0	437.6
#1 Region III based upon % of national CFC *based upon 1.1% annual growth				

2. World Bank plus CO_2

The advantage to the revised calculations is in the method of CO_2 being used by the World Bank as a proxy for all pollutants, and is this fashion the deterioration of environmental quality (DQR) is taken into account. However, the results are basically the same results as in the previous World Bank calculations. Once again there appears to be a shortfall of income being generated to achieve the lower level environmental protection (human health – EDP2) – at the current prices and market structure.

TABLE 9-2. World Bank + CO2 in 2000 US $ - Results	**1992**	**1997**	**2002**	**2005**
Regional GDP in 2000 US $ (mil)	841	1,353	1,397	1,505
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	168	210*	217*

World Bank Res. Depletion Reg III - 2000 US $	92,229,258	378,238,383	127,188,292	603,496,056
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	12,304,378	13,359,818	14,085,706
Carbon Dioxide Emissions @ 20 (constant) US $/met ton/capita	12,238,156	19,966,587	19,214,635	22,002,251
EDP (using PR2) in 2000 US $	**641,266,225**	**774,490,652**	**1,027,237,255**	**648,415,987**
Region III #4 - Most Stringent w/abandon (total- 99-01 includes processing)	130,246,093	300,491,654	327,739,452	343,592,730
Carbon Dioxide Emissions @ 20 (constant) US $/met ton/capita	12,238,156	19,966,587	19,214,635	22,002,251
EDP (using PR1) in 2000 US $	**516,286,493**	**486,303,376**	**712,857,621**	**318,908,963**
Region III mining profits in 2000 US $ (mil)	50.6	274.3	68.0	437.6

#1 Region III based upon % of national CFC
*based upon 1.1% annual growth
**20 US $/mt/capita

3. Net Price (Repetto)

With the addition of being able to account for new resource discoveries this method is better suited for use in a smaller geographic region. For the years shown below, there is still a deficit when using profits in the calculations for EDP using PR2 and PR1. Using the full set of years (1992-2002, and 2005) in Appendix #2 it does turn out that there are several years where the GDP could be maintained well above the current yearly GDP level, which leaves open the possibility of working with a long-term averaging scenario. In addition this does not take into account the current expenses being paid by mining concerns for taxes, and expenses paid out for environmental remediation/reclamation, which could lead to a larger financial stream from which to work. But once again deterioration of environmental quality is not addressed.

TABLE 9-3. Net Price in 2000 US $ - Results	**1992**	**1997**	**2002**	**2005**
Regional GDP in 2000 US $ (mil)	841	1,353	1,397	1,505
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	168	210*	217*
Repetto (Net Price) Resource Depletion Region III 2000 US $	139,999,258	210,406,383	127,188,292	603,496,056
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	12,304,378	13,359,818	14,085,706
EDP (using PR2) in US $	**605,734,381**	**962,289,239**	**1,046,451,890**	**670,418,238**
Region III #4 - Most Stringent w/abandon (total-99-01 includes processing)	130,246,093	300,491,654	327,739,452	343,592,730

EDP (using PR1) in US $	**480,754,649**	**674,101,963**	**732,072,256**	**340,911,214**
#12 Region III mining profits 2000 US $ (mil)	50.6	274.3	68.0	437.6
#1 Region III based upon % of national CFC *based upon 1.1% annual growth				

4. User Cost (El Serafy)

We now examine the four methods for accounting for new resource discoveries, and with the additions of calculating the remaining life of the resource being mined and the income from resource receipts that should be considered as capital depreciation. 1997 and 2005 below show the ability of mining concerns to meet the funding level of EDP2, and still possessing some resources for negotiation purposes. Once again a full set of years (1992-2002, and 2005) in Appendix #2 illustrates additional years where the GDP could be maintained above the current yearly GDP level, which leaves open the possibility of working with a long-term averaging scenario. In addition this does not take into account the current expenses being paid by mining concerns for taxes, and expenses paid out for environmental remediation/reclamation, which could lead to a larger financial stream from which to work. But once again deterioration of environmental quality is not addressed.

TABLE 9-4. User Cost in 2000 US $- Results	**1992**	**1997**	**2002**	**2005**
Regional GDP in 2000 US $ (mil)	841	1,353	1,397	1,505

#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	168	210*	217*
El Serafy (User Cost) Resource Depletion 2000 US $	3,530,694	5,965,185	27,108,110	44,072,835
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	12,304,378	13,359,818	14,085,706
EDP (using PR2) in 2000 US $	**742,202,945**	**1,166,730,437**	**1,146,532,072**	**1,229,841,459**
Region III #4 - Most Stringent w/abandon (total- 99-01 includes processing)	130,246,093	300,491,654	327,739,452	343,592,730
EDP (using PR1) in 2000 US $	**617,223,213**	**878,543,161**	**832,152,438**	**900,334,435**
#12 Region III mining profits 2000 US $ (mil)	50.6	274.3	68.0	437.6
#1 Region III based upon % of national CFC *based upon 1.1% annual growth				

5. Findings

A direct answer to Research Question #1 would be that the User Cost Method indicates that resources exist at a minimum to protect human health. Also, not being able to know the exact dollar amount currently being paid by the mining concerns would indicate additional funds for reinvestment into the Region III economy, although the dollar figure is not known.

Briefly, a few items that would provide the User Cost method with more definitive information would be:

- Environmental baseline study for the determination of the deterioration of environmental quality (DQR). It may in fact exist either through CONAMA or the AGRIMED project conducted by the University of Chile – Santiago.
- Access to mining companies expenses regarding environmental protection/remediation/monitoring/reclamation.
- Governmental information regarding the monies currently being collected in the form of taxes on mining concerns.
- Regional/area specific information on reserves.

C. Research Question #2

Is it practicable to base environmental remediation costs on a standard accounting unit measure (e.g., dollars per tons mined or tons processed) for the purpose of business, and regional government income predictions? Obviously, there could be a lot of controversy about converting "non-market" environmental costs into some kind of accounting unit. Moreover, the problem could be magnified where the environmental cost is then placed on a per output measure such as tons mined. Nonetheless, such a measure would facilitate business, government, and community discussions if it could be accepted as a reasonable, if imperfect, proxy.

The following table presented previously in Chapter Seven illustrates environmental costs at various levels of monitoring/remediation.

TABLE 9-5. Environmental Costs for Region III, Chile:

Environmental Costs (1) US $	1992	1993	1994	1995	1996	1997
Region III #1-Least Stringent (2-total)	5,266,361	4,949,818	5,865,429	10,087,817	11,562,831	12,150,056
Region III #4 -Most Stringent w/abandonment (2-total)	130,246,093	122,417,470	145,062,063	249,488,938	285,968,543	300,491,654
Region III #4 - Most Stringent w/closure & maintenance (2-total)	369,010,357	346,849,498	411,009,178	706,885,325	810,244,204	851,393,019
Region III #1-Least Stringent (2-total) w/processing				10,161,892	11,704,807	12,304,378
Region III #4 -Most Stringent w/abandonment (2-total) w/processing						
Region III #4 - Most Stringent w/closure & maintenance (2-total) w/processing				706,984,797	810,434,858	851,600,251

SOURCES:

(1) Resource Strategies Inc.

(2) Anuario - del Cobre 1985-2005 COCHILCO

Environmental Costs (1) US $	1998	1999	2000	2001	2002	2005
Region III #1-Least Stringent (2-total)	13,905,125	14,523,961	13,081,327	13,768,291	13,251,793	13,892,803
Region III #4 -Most Stringent w/abandonment (2-total)	343,897,494	359,202,356	323,523,551	340,513,345	327,739,452	343,592,730
Region III #4 - Most Stringent w/closure & maintenance (2-total)	974,376,233	1,017,740,010	916,650,061	964,787,810	933,092,497	973,512,735
Region III #1-Least Stringent (2-total) w/processing	14,059,447	14,678,283	13,235,649	13,922,613	13,359,818	14,085,706
Region III #4 -Most Stringent w/abandonment (2-total) w/processing		362,406,610	326,946,810	344,214,295		

Region III #4 - Most Stringent w/closure & maintenance (2-total) w/processing	**974,583,465**	**1,027,560,003**	**927,127,069**	**976,097,893**	**933,237,560**	**973,771,776**

SOURCES:

(1) Resource Strategies Inc.

(2) Anuario - del Cobre 1985-2005 COCHILCO

1. Findings

Due to the different types of mines and mining operations (Table 5-1) the only practical way to approach funding for the protection of human health at the regional level would be by using a unit accounting measurement, in this case U. S. $/metric ton of copper, which would insure a reliable income stream. With dollar values for monitoring/remediation having a history under the U.S. EPA framework a reasonably financed program could be implemented by using a unit measurement method. An initial environmental baseline would have to be established, and then testing at the receiving boundaries (air and water) to maintain that environmental quality would have to be implemented. Initially, the least stringent costs could be employed with the dollar amount being paid by the mining concerns used to fund the monitoring and if need be remediation activities. Logic would dictate that this amount would be raised or lowered as operational data became available over the life of the program. So from a business, regional, and governmental standpoint this method would produce a reliable known income stream for budgetary purposes to address minimum health standards related to mining activities.

D. Research Question #3

Can predictions be made regarding the costs for complete environmental reclamation/remediation (real or perceived), and minimum environmental remediation (protection of human health)?

1. Findings

Realistically for estimating complete reclamation/remediation the answer would be no at the present time. For upward reclamation/remediation costs it will be much more difficult to use this method until long-term land use plans regarding the mine sites are known. By not knowing the long-term land use it is impossible to calculate total reclamation/remediation. Once these long-term plans are known it would be possible to use a unit measurement approach. Initially, I would envision a checkerboard effect as planning would be easier for smaller sized mines, and mines nearing the end of their production life.

Predictions could be made for the protection of human health in a straightforward fashion by establishing monitoring/remediation programs to insure pollutants are not entering receiving bodies of water and or entering the air (particulate and pollutant) at an unacceptable level. The estimated costs from this paper could be used as a starting point to fund such a function.

Although, estimating upward levels of reclamation/remediation would not be viable at this point, an agreed upon estimate that would not jeopardize the financial existence of the companies could be agreed upon until future land use plans are known, at which time a unit measurement cost could be calculated. These agreed upon financial figure would be the source of the income stream for reinvestment into the regional economy.

E. Research Question #4

Can a method be developed to use a percentage of funds (if/when they exist) for development in an agreed upon fashion by a working group that includes mining companies, governmental agencies, and the private citizenry from the affected area?

1. Findings

The answer is - definitely. The structure is in place at the micro, meso, and macro level for all parties to obtain information electronically allowing them to voice their concerns and be represented. Using methods discussed in this dissertation to determine minimum and maximum dollar values (to be used as a starting point) for the protection of human health, and as a guide for obtaining additional funds for reinvestment into their economy, allows a regional group (micro) to have a place at the negotiation table. By having such data as production, production costs, price of the product and company earnings available electronically allows a regional group to deal from an informed position. Governmental agencies (meso) outside of providing information will have the advantage of additional input into knowing what is important at a regional level, both environmentally and economically. Mining companies (meso), in part from feeling increased pressure through international mining laws, should be more receptive to regional concerns, and this method affords them the opportunity to receive this input and establish on ongoing dialogue where their viewpoint can be expressed. Macro level organization such as AGRIMED will be able to provide regional environmental trends and obtain data to incorporate into their database. An international NGO such as OXFAM is a source of mining concerns to be explored at all levels by all parties.

This method provides the way to have a free exchange of information, and tools for projecting a cost onto environmental concerns (human health), and a base from which to proceed to obtain additional capital for reinvestment into a regional economy.

CHAPTER TEN

DISCUSSION

Numerous sources (OECD, Otto and Cordes, Pring, UN…) state, that what the mining community needs in order to deal with environmental degradation in a social, environmental and economic aspects setting, is fair social representation from all affected sectors, so an agreed upon solution is equitable to everyone involved. The approach offered here presents a method that covers this fair social representation in a logical and reasonable fashion, making it straightforward and usable by interested affected parties. In this chapter I shall briefly summarize the procedures developed in this study; present an example of how the method is applied and then discuss the strengths and weaknesses of the methods.

A. Summary of the Procedures Developed in this Study

1. Goals for Developing Procedures

My goal was aimed at furthering the suggestions of Table 1-1. Recommendations Towards Sustainable Development. In this fashion the procedures I developed were interdisciplinary and transparent with the intention that they could be easily reproducible, by any of the envisioned three interested factions (regional, governmental and private-mining concerns). Transparency was established throughout the paper by initially stating the problem, and then establishing the basic concepts and theoretical framework from which I would deal with the problem, in chapters one and two. Next, I showed the dependence on mining in Chile from a historical viewpoint, and how this has lead to the country lagging behind developed countries in the form of environmental management issues. Following this, I illustrated the logical progression of dependence on mining today in both Chile and Region III in chapter five. The material presented to this point was backed up by showing an explanation of the resource depletion calculation methods, the explanation and calculations for environmental concerns, and a summary of Chile's social indicators, and information indicators and how they could be used electronically to enhance social capital through information exchange. Finally, in chapter nine the procedures were tied together with the results relating to the initial research questions. Reiterating, the procedure used and developed in this paper illustrate a method to address the concerns stated in Table 1-1 in an interdisciplinary fashion.

2. Basic Assumptions/Fundamental Point of View, Concepts, and Government and Participation

For this work I assumed that the national government's role is limited to policies that effect national economic decisions, and the protection of human health, by the monitoring/remediation of environmental conditions that exist in mining areas. However, I assumed that input would be accepted at the regional level regarding priorities of environmental conditions above the protection of human health, and areas of investment within the region from negotiated capital from the mining concerns. Additionally, these levels of environmental conditions and areas of, and amount of investment would be negotiated with interested factions representing the region, government, and private-mining concerns.

3. Theoretical Base

My theoretical base was drawn from various schools of thought regarding scarcity rents, resource depletion, sustainability, and forms of economic compensation (chapter two). These topics were addressed in a fashion that was logical and consistent with the needs of a region that is mining dependent, and in need of a long-term cash flow to aid in economic diversity and development. The theory of social capital, several interpretations, and the possibility of what influences it were addressed in chapter eight.

4. Procedures and Methods

The procedure for the calculations of resource depletion (World Bank, World Bank+CO_2, Net Price – Repetto, and User Cost – El Serafy) were addressed in chapter six, with ultimately the User Cost – El Serafy being selected due to its ability to divide the net receipts from mineral extraction into capital consumption, representing the amount earned at the expense of eroding the value of the asset, and net receipts available for consumption. This resulted in a more narrow range and lower estimates due to less severe adjustments in the GDP, which were discussed and illustrated in chapter nine. The basic finding in this section is that, under all of the proposed methods of analysis, and given prices prevailing at the times, it is difficult to show that either calculated economic scarcity rents would be sufficient to fund a sustainable economy, where sustainability must include 1) replacing the value of the asset, 2) covering health damages induced by the project, and 3) covering environmental costs. A method for calculating environmental costs was addressed in chapter seven through the use and adaptation of a

Resource Strategies Incorporated model. Finally, chapter eight dealt with the possibility of enhancing social capital by identifying electronic sources of information relating to the environment and mining industry, allowing for networking at the regional, national and international level.

5. Types of Findings and Relevancy

The findings that were addressed in chapter nine show the approach is realistic in two areas; one the measurement of environmental compensation on a unit cost basis at the protection of human health level, and secondly, a framework for informed involvement relating to negotiations to all pertinent parties (regional, governmental, and mining concerns). The relevancy can best be described by reproducing Table 1-1 – "Recommendations Towards Sustainable Development," which illustrates the direction and hopeful contribution of this work.

TABLE 10-1 (TABLE 1-1 reproduced)

Recommendations Towards Sustainable Development

1. *Develop economic analyses of environment-related policies, expanding both economic information on the environment (e.g. on environmental expenditure, environment-related taxes, health risk assessment, water and energy prices) and cost-benefit analysis of projects and legislation relating to the environment*
2. *Review ways and means of integrating environmental concerns in fiscal instruments and policies*
3. *Formalize institutional integration mechanisms relating to sustainable development*
4. *Increase the financial contribution of the mining sector to support long-term investment in human and social capital and to apply the polluter pays principle according to the General Environmental Framework Law; consider a mechanism for proper capture of resource rents associated with mineral exploitation*

5. *Continue to develop public participation in processes such as project-based environmental impact assessments and strategic environmental assessments of public policies, plans and programs*

Source: OECD (1996)

B. Application of the Methods Developed in the Study

Let's consider the concrete application of the procedures and methods developed in this study. An example would be revisiting economic compensation for mining activity for Region III Chile. A logical starting point would be to initially use Table 6-1 (Terms, Definition and Derivation) to identify the information that is required. Next, one would use the information provided in Table 10-1 (Terms, Data Sources and Organization Level) to identify the correct agency, company, or regional NGO. Following this, the electronic contact information can be taken from Table 8-10 (Existence of Micro, Meso and Macro Organizations) to start a dialogue and obtain the desired information. Finally, economic and environmental calculations can be made from the methods and references presented in Chapters Six and Seven. This method has shortcomings which will be discussed below. However, it fulfills the need that has been emphasized by numerous organizations, which is for a fair social representation from an affected sector.

Table 10-1 is an illustration of the agencies that I would contact initially if I were starting this project today. It could easily differentiate itself from the current work in this paper, by establishing contact, starting a dialogue and collecting specific hard data tailored to a group's desires.

TABLE 10-2.	Terms, Data Sources and Organization Level
Terms	**Source and Level**
GDP	Central Bank – Chile (Banco Central - Chile) and INE (National Statistics – Chile) - Macro
CFA	Central Bank and INE - Macro
NDP	Calculation based upon the information from the Central Bank and INE
RD_1 - RD_4	User Cost Method with production data coming from COCHILCO, CODELCO, ENAMI, Phelps Dodge, Chilean Ministry of Mines and INE, and reserves information coming from SERNAGEOMIN - Meso
DQR –	CONAMA, GAEDA, RENACE, Community Council on Ecology, CHADENATUR, and AGRIMED - Micro, Meso and Macro
PR	includes PR1 and PR2
PR1	EPA framework, actual data from CONAMA - Meso
PR2	EPA framework, actual data from CONAMA - Meso
EDP	Environmental Domestic Product – includes EDP1 and EDP2
EDP1	– Calculations based upon available information
EDP2	– Calculations based upon available information

Items that would have to be addressed initially is the ability to obtain consumption of fixed assets for Region III from the Central Bank, specific financial records from the mining companies, regarding production costs, profits, amount of taxes paid, and environmental expenses incurred in their mining operation. From an environmental standpoint the most obvious thing that would have to be determined (or may in fact exist to some degree) is a baseline study of environmental conditions in the region. The baseline would incorporate basic air quality data (pollutant and particle), water quality data, and solid waste generation and disposal numbers. In having the National Commission for the Environment (CONAMA) based upon the EPA framework, testing procedure regarding methodology and location would be in place.

In the study I examined three methods for determining Hotelling rents, resource depletion, and re-investment requirements. Of these three, I would recommend the User Cost (El Serafy) model as it appears to be tailored for a situation where a greater amount of specific information can be obtained. Additionally, in contrast to the World Bank and the Net Price (Repetto) methods that assume that one has to account for every bit of the "lost/depleted" mineral stock, the User Cost (El Serafy) method allows for a reasonable use of the resource if the reserves exist in sufficient quantity. The possibility, framework and organizations exist for this type of information in Region III Chile. Also, as stated earlier that the ability to account for new resource discoveries with the addition of calculating the remaining life of the resource being mined, and the income from resource receipts that should be considered as capital depreciation, is key to a more accurate assessment of resource depletion, thus providing a "better" dollar estimate to be reinvested into the regional economy.

Another advantage in using the User Cost (El Serafy) method is that the system is in place to move beyond the calculations of national levels of sustainability from resource depletion (copper), to estimates of resource depletion and environmental concerns at the regional level. The main need in Region III is the willingness/cooperation of the NGOs, companies, and governmental agencies to work together at all three organizational levels. With the framework for the collection and distribution of the majority of information already in place electronically in the form of accessible web sites, the move to usable estimates of the environmental domestic product (EDP) is attainable.

Potential benefits include a greater trust between the concerned citizenry of Region III, the mining concerns that operate in that area, and the governmental institutions that exist to serve the public.

Ultimately, after more precise/accurate numbers have been gathered and analyzed it may be found out that complete economic compensation for resource depletion and its environmental effects are unrealistic, but then the decisions can be made as to how to handle leftover environmental cleanup costs that will have to be dealt with in the future. In a scenario of this nature the potential costs could well run into the billions of dollars (US) as shown in Chapter Seven (Environmental Activity – Mining). But it could also be shown that the a greater percentage or total environmental costs can be negated with a percentage of that rent between addressing the upper limit of environmental costs and the low end value of protecting human health, by reinvesting a percentage of the rent into the regional economy after weighing information from all interested participants.

C. Strengths, Benefits and Accomplishments of this Study

I am aware of the fact that the outcomes presented in this paper could be improved upon with the willing cooperation of all involved parties. I am also aware of the fact that with the willingness of involved parties, that the outcomes would continue to improve even more with each passing year, and a greater bank of historical and more accurate data.

Numerous policy approaches towards mining have been tried in the past, and various options will be explored in the future. Whereas, my approach guarantees nothing, I believe that it was worthwhile to explore because of the following reasons:

- It provides a comprehensive approach to "sustainable" development
- It provides a starting point for future dialogue
- It is a realistic method to draw the topic of sustainable development related to mining into a discussion on a regional basis.

- It provides estimates of the capital required to replace copper resource depletion by generally accepted international methods but at a workable (regional) level.
- It provides a framework for discussion on the topic of allocation of resources, in the form of capital to sustain the region's economy (sustainable development).
- It provides a framework to protect human health.
- It leaves the decision making in the region/country of the mining activity.
- It provides the mining concern a transparent guideline of what is expected, (no hidden costs or environmental creep).
- It involves all decision making parties in the policy process (mining concerns, governments, and NGOs).

A final issue to ponder in this section is the thought of "full cost pricing." This study has shown at current prices a shortfall of funds to achieve sustainable development. With these funds not being available/not existing in the current system for sustainable development, realistically, can the system be adjusted to incorporate "wages of sustainability" (depletion, environment, and health)? At the present time that is an unknown, but the User Cost (El Serafy) method is a possible starting point to look at this question in greater depth.

D. Limitations of this Study

The main limitation of this problem based study is the lack of previous comprehensive works based upon a regional economy to draw upon for comparison, and possible data bias as the majority of information is provided by in-country agencies, and the mining firms involved in the area of study.

- Accurate representation of basic health requirements provided by environmental remediation
- Accessibility of needed information
- Time and budget constraints of the initial study (The research was self-funded.)

E. Self-assessment

I would like to conclude with a brief personal assessment of this study. This was a self-financed, one person study. This topic is large and could easily have occupied numerous people over a period of years, requiring significant amounts of money. Given the limits of resources and time, I am satisfied that I have shown that the potential exists to use methods described in this paper (and elsewhere) for the calculations of resource depletion, environmental costs, and have an exchange of this information largely through internet based sources. Therefore, concerned citizenry, public service oriented companies, facilitating governmental agencies, and private companies could make significant strides toward the determination of environmental damage in the mining sector, and deal with the realistic cost of compensation. Information is the key. I have taken various methodologies from an international, and national setting and shown how it is feasible and doable to use these methodologies in a smaller geographic (regional) setting.

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APPENDIX #1 – Glossary of Terms

TABLE A-1-1. Glossary of Terms

1. Calculation terms:

- GDP = Gross domestic product.
- CFA = Consumption of fixed assets
- NDP = Net domestic product
- EDP = Environmental domestic product.
- EDP2 = Estimate of sustainable income.
- RD = Natural resource depletion.
- DQR = The deterioration to the quality of natural resources caused by production.
- PR-1 = Environmental damage (high value - 100% perceived or real environmental protection/remediation.)
- PR-2 = Environmental damage (low value - the minimum environmental expenditures to safeguard human health) (Auty and Mikesell).

2. Hartwick's Rule Invest all profits or rents from exhaustibles in reproducible capital such as machines. …. Under such a program, the current generation converts exhaustible resources into machines and lives off 'current flows' from machines and labor. …. For the case of per-capita consumption remaining constant over time, one could say that no generation was better off than another. (Brätland)

3. Hotelling Rule states that the operation of competitive markets will automatically reduce the output of a mineral as it becomes scarce, so that the reserves of any mineral will deplete slowly and never be completely exhausted (Hotelling 1931).

4. Human Capital: The skills, knowledge and health associated with an individual or labor force measured in terms of current or expected earnings.

5. Mitigation (from United States 40 Code of Federal Regulations (CFR) includes: (a) Avoiding the impact altogether by not taking a certain action or parts of a certain action. (b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation. (c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment. (d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action. (e) Compensating for the impact by replacing or providing substitute resources or environments (King).

6. Reclamation: To recover a natural resource (land area) and put it to a new or altered use.

7. Remediation: The removal of pollution or contaminants from environmental media such as soil, groundwater, sediment or surface water for the general protection of human health.

8. Restoration: Is the return of a specific geographic area to a close approximation of its condition prior to disturbance.

9. Sustainability: "The concept of sustainable development requires that the contribution to economic development be maintained, both during periods of temporary reduction in mineral exports and over the long run when mineral producing capacity declines relative to the size of the overall economy. What is required is not the sustainability of the mineral production that initially generates growth, but the maintenance of economic and social conditions for sustaining that growth" (Auty and Mikesell - 1998).
10. Social Capital: A resource formed by the social relationships existing among groups and collectives (Atria and Siles).
11. Social Indicators – a wide range of subject matter fields compiled by the United Nations Statistic Department. The areas studied include: child bearing, child and elderly populations, contraceptive use, education, health, housing, human settlements, income and economic activity, literacy, population, unemployment and water supply and sanitation (United Nations – Statistics Department).

APPENDIX #2 – Mining Activity

Table A-2-1. Copper Smelters in Chile

Location/Name	Ownership or Operating Company	Capacity (1)	Process Type
La Negra (Altonorte)	Noranda Chile S.A.	165	Noranda Continuous
Chagres	Cia Mineria-Disputada de Las Condes	150	Outokumpu Flash
Chuquicamata	Codelco Chile	500	Outokumpu/Teniente Converter
El Teniente (Caletones)	Codelco Chile	400	Reverberatory/Teniente Conv.
Paipote	Empresa Nac. De Mineria (ENAMI)	75	Reverberatory/Teniente Conv.
Las Ventanas	Empresa Nac. De Mineria (ENAMI)	115	Teniente Converter
Portrerillos (El Salvador)	Codelco Chile	150	Reverberatory

(1) Capacity in Thousand Metric Tons

SOURCE: USGS

APPENDIX #3 – Economic Activity

TABLE A-3-1. GDP Deflator

Combined Deflator	1986 Base	1996 Base		Calc. 1992 Base			Calc. 1993 Base	
1986	100		**1992**	100		**1993**	100	
1987	125.6		**1993**	110.5		**1994**	114.2	
1988	156.3		**1994**	126.2		**1995**	126.7	
1989	178.1		**1995**	140		**1996**	128.9	
1990	214.5		**1996**	142.4		**1997**	135.5	
1991	261.3		**1997**	149.6		**1998**	140.2	
1992	293.2		**1998**	154.9		**1999**	143.8	>2.6%
1993	324		**1999**	158.9	>2.6%	**2000**	150.7	>4.8%
1994	369.9		**2000**	166.5	>4.8%			
1995	410.5							
1996	417.6							
1997	438.7	>4.9%						
1998	454.2	>1.5%						
1999	*466.1	>2.6%						
2000	*488.5	>4.8%						
2001		>4.0%						
2002		>8.5%						
2003		>0.6%						
2004		>8.3%						
2005		>3.3%						

Numbers based off of 1986 and 1996 GDP deflators from Banco Central - Chile

***calc from 1996 %**

TABLE A-3-1. GDP Deflator (continued)

Combined Deflator	1986 Base	1996 Base	Calc. 1994 Base			Calc. 1995 Base		
1986	100		**1994**	100		**1995**	100	
1987	125.6		**1995**	111		**1996**	101.7	
1988	156.3		**1996**	112.9		**1997**	106.9	
1989	178.1		**1997**	118.6		**1998**	110.6	
1990	214.5		**1998**	122.8		**1999**	113.5	>2.6%
1991	261.3		**1999**	126	>2.6%	**2000**	118.9	>4.8%
1992	293.2		**2000**	132	>4.8%			
1993	324							
1994	369.9							
1995	410.5							
1996	417.6							
1997	438.7	>4.9%						
1998	454.2	>1.5%						
1999	*466.1	>2.6%						
2000	*488.5	>4.8%						
2001		>4.0%						

2002	>8.5%
2003	>0.6%
2004	>8.3%
2005	>3.3%

Numbers based off of 1986 and 1996 GDP deflators from Banco Central - Chile

***calc from 1996 %**

TABLE A-3-1. GDP Deflator (continued)

Combined Deflator	**1986 Base**	**1996 Base**	**Calc. 1996 Base**			**Calc. 1997 Base**		
1986	100		**1996**	100		**1997**	100	
1987	125.6		**1997**	105.1		**1998**	103.5	
1988	156.3		**1998**	108.8		**1999**	106.2	>2.6%
1989	178.1		**1999**	111.6	>2.6%	**2000**	111.3	>4.8%
1990	214.5		**2000**	117	>4.8%			
1991	261.3							
1992	293.2							
1993	324							
1994	369.9							
1995	410.5							

1996	417.6	
1997	438.7	>4.9%
1998	454.2	>1.5%
1999	*466.1	>2.6%
2000	*488.5	>4.8%
2001		>4.0%
2002		>8.5%
2003		>0.6%
2004		>8.3%
2005		>3.3%

Numbers based off of 1986 and 1996 GDP deflators from Banco Central - Chile

***calc from 1996 %**

TABLE A-3-1. GDP Deflator (continued)

Combined Deflator	**1986 Base**	**1996 Base**	**Calc. 1998 Base**			**Calc. 1999 Base**		
1986	100		**1998**	100		**1999**	100	
1987	125.6		**1999**	102.6	>2.6%	**2000**	104.8	>4.8%
1988	156.3		**2000**	107.5	>4.8%			
1989	178.1							

1990	214.5	
1991	261.3	
1992	293.2	
1993	324	
1994	369.9	
1995	410.5	
1996	417.6	
1997	438.7	>4.9%
1998	454.2	>1.5%
1999	*466.1	>2.6%
2000	*488.5	>4.8%
2001		>4.0%
2002		>8.5%
2003		>0.6%
2004		>8.3%
2005		>3.3%

Numbers based off of 1986 and 1996 GDP deflators from Banco Central - Chile

***calc from 1996 %**

TABLE A-3-1. GDP Deflator (continued)

Combined Deflator	1986 Base	1996 Base	Calc. 2000 Base		Calc. 2001 Base		
1986	100		**2000**	100	**2000**	95.4	<4.8%
1987	125.6				**2001**	100	
1988	156.3						
1989	178.1						
1990	214.5						
1991	261.3						
1992	293.2						
1993	324						
1994	369.9						
1995	410.5						
1996	417.6						
1997	438.7	>4.9%					
1998	454.2	>1.5%					
1999	*466.1	>2.6%					
2000	*488.5	>4.8%					
2001		>4.0%					
2002		>8.5%					
2003		>0.6%					
2004		>8.3%					
2005		>3.3%					

Numbers based off of 1986 and 1996 GDP deflators from Banco Central - Chile

***calc from 1996 %**

TABLE A-3-1. GDP Deflator (continued)

Combined Deflator	1986 Base	1996 Base	Calc. 2002 Base			Calc. 2003 Base		
1986	100		**2000**	91.7	<4.8%	**2000**	84.6	<4.8%
1987	125.6		**2001**	96.2	<4.0%	**2001**	88.6	<4.0%
1988	156.3		**2002**	100		**2002**	92.2	<8.5%
1989	178.1					**2003**	100	
1990	214.5							
1991	261.3							
1992	293.2							
1993	324							
1994	369.9							
1995	410.5							
1996	417.6							
1997	438.7	>4.9%						
1998	454.2	>1.5%						
1999	*466.1	>2.6%						
2000	*488.5	>4.8%						
2001		>4.0%						

2002	>8.5%
2003	>0.6%
2004	>8.3%
2005	>3.3%

Numbers based off of 1986 and 1996 GDP deflators from Banco Central - Chile

***calc from 1996 %**

TABLE A-3-1. GDP Deflator (continued)

Combined Deflator	**1986 Base**	**1996 Base**	**Calc. 2004 Base**			**Calc. 2005 Base**		
1986	100		**2000**	84.1	<4.8%	**2000**	77.6	<4.8%
1987	125.6		**2001**	88.1	<4.0%	**2001**	81.3	<4.0%
1988	156.3		**2002**	91.6	<8.5%	**2002**	84.6	<8.5%
1989	178.1		**2003**	99.4	<0.6%	**2003**	91.8	<0.6%
1990	214.5		**2004**	100		**2004**	92.3	<8.3%
1991	261.3					**2005**	100	
1992	293.2							
1993	324							
1994	369.9							
1995	410.5							

1996	417.6	
1997	438.7	>4.9%
1998	454.2	>1.5%
1999	*466.1	>2.6%
2000	*488.5	>4.8%
2001		>4.0%
2002		>8.5%
2003		>0.6%
2004		>8.3%
2005		>3.3%

Numbers based off of 1986 and 1996 GDP deflators from Banco Central - Chile

***calc from 1996 %**

TABLE A-3-2. Production

REGION III CHILE YEAR	COMPANY	THOUS. (1) METRIC TONS-CU CONTENT	THOUS (2)METRIC TONS -CU CONTENT	THOUS. (5) METRIC TONS-CU CONTENT	MINE PROD.	SMELTER PROD.	THOUS. TONS MET LEACH SX-EW (5)	CATHODE ELEC. REF.	FIRE REFINED	REGION III FOREIGN INVEST.
1992	A-001	85		88.5						1992
	A-002						xxx			
	A-003			xxxx						
	Total		164							
1993	A-001	84.1		86.6						1993
	A-002						xxx			
	A-003			xxxx						
	Total		154							
1994	A-001	82.6		84.3						1994
	A-002						xxx			
	A-003			28.1						
	Total		183							
1995	A-001	85.9		78						1995
	A-002						9.6			
	A-003			150.3						
	Total		314							
1996	A-001	89.9		73.2						1996
	A-002						18.4			
	A-003			136.8						
	Total		360							
1997	A-001	88.3		70.1						1997
	A-002						20			
	A-003			155.8						
	Total		379							
1998	A-001	88.1		69.9						1998
	A-002						20			
	A-003			214.9						
	Total		433							
1999	A-001	91.7		73.6						1999

	A-002				20	
	A-003			226.9		
	Total		453			
2000	A-001	80.5		62.2		2000
	A-002				20	
	A-003			203.8		
	Total		408			
2001	A-001	81.2		62.5		2001
	A-002				20	
	A-003			220.6		
	Total		429			
2002	A-001	72.8		59		2002
	A-002				14	
	A-003			199.1		
	Total		413			
2005	A-001	77.5		54.1		2005
	A-002				25	
	A-003			162.7		
	Total		433			

TABLE A-3-2. Production (continued)

REGION III CHILE YEAR	COMPANY	FOREIGN (2) INVEST. MINING MIL $ (US)	CU (5) UNIT COSTS c/lb (bef. cred)	CU (5) PRODUCT PRICES $/lb	CU (5) NET COST AFTER CREDIT c/lb	CODELCO-SALVADOR PRICE US c/lb (4)	PRICE CURRENT $ (c/lb) US REF. (a)	PRICE CURRENT $ (c/lb) US REF. (b)	PRICE (c) CURRENT $ (c/lb) US PROD-US
1992	A-001		93.9	1.04	82.8		103.573	102.721	107.423
	A-002		xxx	xxx	xxx				
	A-003		xxx	xxx	xxx				
	Total								
1993	A-001		97.5	0.87	83.4		86.713	85.283	91.555
	A-002		xxx	xxx	xxx				
	A-003		xxx	xxx	xxx				

	Total							
1994	A-001		98.9	1.05	80	104.903	107.052	111.046
	A-002		xxx	xxx	xxx			
	A-003		62.8	1.05	49.8			
	Total							
1995	A-001		91.6	1.33	64.6	133.198	134.717	138.333
	A-002		49.6	1.33	49.6			
	A-003		56.6	1.33	46.8			
	Total							
1996	A-001	240.8	90.6	1.04	71.1	103.894	105.872	109.211
	A-002		44.9	1.04	44.9			
	A-003		64.1	1.04	55.6			
	Total							
1997	A-001	777.1	94.1	1.03	78.9	103.224	103.579	106.819
	A-002		46.6	1.03	46.5			
	A-003		62.1	1.05	54.8			
	Total							
1998	A-001	708.1	94.1	0.75	77.2	74.974	75.077	78.558
	A-002		43.5	0.75	43.5			
	A-003		60.2	0.75	54			
	Total							
1999	A-001	7.8	83.1	0.71	68.4	71.38	72.111	75.909
	A-002		42.5	0.71	42.5			
	A-003		56.6	0.71	51.7			
	Total							
2000	A-001	2.7	93.9	0.82	76.7	82.294	83.971	88.163
	A-002		45.5	0.82	45.5			
	A-003		56.8	0.82	50.5			
	Total							
2001	A-001	18	88.4	0.72	74.4	71.566	72.567	76.854
	A-002		42.2	0.72	42.2			
	A-003		54.9	0.72	48.9			
	Total							
2002	A-001	91.4	91.6	0.71	74.7	70.647	71.672	75.805
	A-002		46.4	0.71	46.4			
	A-003		59.1	0.71	51.2			

	Total								
2005	A-001	2.5 (est)	208.4	1.67	128.7	112.5	167.087	168.227	173.493
	A-002		77.5	1.67	77.5				
	A-003		100.6	1.67	89.8				
	Total								

TABLE A-3-2. Production (continued)

REGION III CHILE YEAR	COMPANY	PRICE CURRENT $ (c/lb) US SCRAP (d)	PRICE 2005 $ (c/lb) US REF. (a)	PRICE 2005 $ (c/lb) US REF. (b)	PRICE (c) 2005 $ (c/lb) US PROD-US	PRICE 2005 $ (c/lb) US SCRAP (d)	CU-PLANT TREATMENT CAPACITY (daily)	FLOAT. (3) (tons of mineral)	HEAP (3) LEACHING (tons of mineral)	TOTAL (3) CAPACITY (tons of mineral)
1992	A-001	88.628	138.7	137.6	143.9	118.7	1992	16,015	33,465	49,480
	A-002									
	A-003									
	Total									
1993	A-001	70.171	114.5	112.6	120.9	92.7	1993	15,415	29,415	44,830
	A-002									
	A-003									
	Total									
1994	A-001	85.632	136.8	139.6	144.8	111.6	1994	43,476	29,635	73,102
	A-002									
	A-003									
	Total									
1995	A-001	106.254	167.7	169.6	174.2	133.8	1995	43,707	44,491	88,648
	A-002									
	A-003									
	Total									
1996	A-001	84.712	127.9	130.3	134.4	104.3	1996	45,284	72,037	117,321
	A-002									
	A-003									
	Total									

1997	A-001	83.49	127.1	127.5	131.5	102.8	1997	78,402	75,682	154,084
	A-002									
	A-003									
	Total									
1998	A-001	61.291	94.8	94.9	99.3	77.5	1998	70,806	65,582	136,388
	A-002									
	A-003									
	Total									
1999	A-001	58.139	89.4	90.3	95.1	72.8	1999	70,806	65,582	136,388
	A-002									
	A-003									
	Total									
2000	A-001	66.251	97.7	99.7	104.6	78.6	2000	124,983	97,150	222,133
	A-002									
	A-003									
	Total									
2001	A-001	41.658	84	85.1	90.2	48.9	2001	120,136	109,300	229,436
	A-002									
	A-003									
	Total									
2002	A-001	12.096	84.9	86.1	91.1	14.5	2002	57,126	118,500	175,626
	A-002									
	A-003									
	Total									
2005	A-001	17.05	167.1	168.2	173.5	17.1	2005			
	A-002									
	A-003									
	Total									

(1) Comision Chilena Del Cobre - (COCHILCO)

(2) Anuario del Cobre y Otros Minerales 1986-2005 (June 2006 - ISSN: 0716-8462)

(2) Figures are different than COCHILCO, because of COCHILCO buying from third parties for ENAMI

(a) Refined B.M.L. - London (COCHILCO)

(b) Refined Comex - New York (COCHILCO)

c- Producer cathodes - (COCHILCO)

(d) United States - (COCHILCO)

(3) Anuario de la Mineria de Chile - 2005 (GOBIERNO DE CHILE Servicio Nacional de Geologia y Mineria)
(4) CODELCO company report 2005
(5) Michael Farrell

TABLE A-3-3. Mines – 2005

REGION III - active copper facilities 2005 *

Category "C"	Mine Type	Totals	Prod.	Cathode	tms (dry)	tmf
	Underground	147				
	Open Pit	4				
	Projects	2				
	Plants	8				
Total				**0**	**16,693**	**3,964**
Category "B"						
Mra. COBREX Ltda	Underground					
Sociedad Punta del Cobre SA	Underground	3				
S.C.M. Carola	Underground					
C.M. Maricunga	Open Pit					
CEMIN Ltda	Open Pit					
E.M. Mantos Blancos - MV	Open Pit					
Placer Dome - Latin America	Project					
E.M. Mantos Blancos - MV	Plant - Electric					
E.M. Mantos Blancos - MV	Plant - Electric					
Empresa Nacional de Mineria	Plant - Heap Leaching					
Sociedad Punta del Cobre SA	Plant - Leaching					
Sociedad Punta del Cobre SA	Plant					
C.M. San Estaban 1a SA	Plant					
CEMIN Ltda	Plant					
C.M. Maricunga	Plant - Smelter					
CEMIN Ltda	Plant					
Total				**79,911**	**282,509**	**77,225**
Category "A"						
CODELCO - El Salvador	Underground					
C.C.M. Candelaria	Open Pit					

CEMIN Ltda	Open Pit				
CODELCO - El Salvador	Open Pit				
CODELCO - El Salvador	Plant - Heap Leaching				
CODELCO - El Salvador	Plant - Concentrator				
CODELCO - El Salvador	Plant - Smelter				
CODELCO - El Salvador	Plant - Refining				
C.C.M. Candelaria	Plant - Shipping (port)				
C.C.M. Candelaria	Plant - Concentrator				
Empresa Nacional de Mineria	Plant - Smelter				
Empresa Nacional de Mineria	Plant				
Total			**164,817**	**749,506**	**81,392**
Total			**244,728**	**1,048,708**	**162,581**
Total (all categories tmf)		**432,924**			

*** GUIA Mineria de Chile 2005**

TABLE A-3-4. Copper Depletion

COPPER DEPLETION	1992	1993	1994	1995	1996	1997
Know Reserves (mil tons fine content)						
National (1)	78	80	104	134	160	163
National (2-1)					88	88
National (2-2)					163	163
Regional (7)	20.3					
A-001 - (measured) (5)						
A-001 - (inferred) (5)						
A-001 - % remain. (3)						
A-003 - (measured) (5)						
A-003 - (inferred)						
A-003 - % remain (3)					0.95%	0.88%
Depletion						
National (k-met tons fine) (6)	1,993.70	2,055.40	2,219.90	2,488.60	3,115.80	3,392.00
Region III (met tons fine) (6)	164,109	154,245	182,777	314,354	360,318	378,617
A-001 (3) (met tons cu content)	88.5	86.6	84.3	78	73.2	70.1
A-002 (3) (met tons cu content)				9.6	18.4	20
A-003 (3) (met tons cu content)			28.1	150.3	136.8	155.8
A-004 *						
A-005						
Cost US$/c/lb before credit (3)						
A-001	93.9	97.5	98.9	91.6	90.6	94.1
A-002				49.6	44.9	46.6
A-003			62.8	56.6	64.1	62.1

A-004						
A-005						
Cost US$/c/lb after credit (3)						
A-001	82.8	83.4	80	64.6	71.1	78.9
A-002				49.6	44.9	46.5
A-003			49.8	46.8	55.6	54.8
A-004						
A-005						
Prod.Price c/lb US (4)	103.573	86.713	104.903	133.198	103.894	103.224
Net Copper Value mil. $ US						
A-001	143.1	112	148.1	186.6	127.6	121.1
A-002				27.7	41.3	44.5
A-003			45.1	327.9	209.5	244.3
A-004						
A-005						
Discount Rate (8)	7.02	6.9	8.71	10.28	9.71	9.81

SOURCES:
(1) Banco Central
(2-1) USGS Reserves
(2-2) USGS Reserves Base
(3) Michael Farrell
(4)Refined B.M.L. London COCHILCO

(5) Company Reports
(6) Anuario - del Cobre.. 1986-2005 COCHILCO
(7) Williams - USGS - 1992
(8) Banco Central-Chile- Ave Int rate 90-365 days US$

*** web site under construction - no data**

TABLE A-3-4. Copper Depletion (continued)

COPPER DEPLETION	1998	1999	2000	2001	2002	2005
Know Reserves (mil tons fine content)						
National (1)	166	164	162			
National (2-1)	88	88	88	88	88	140
National (2-2)	163	160	160	160	160	360
Regional (7)						
A-001 - (measured) (5)						0.4672
A-001 - (inferred) (5)						0.0756
A-001 - % remain. (3)						
A-003 - (measured) (5)						2.4747
A-003 - (inferred)						
A-003 - % remain (3)	0.85%	0.82%	0.84%	0.83%	0.70%	0.73%
Depletion						
National (k-met tons fine) (6)	3,686.90	4,391.20	4,602.00	4,739.00	4,580.60	5,320.50
Region III (met tons fine) (6)	433,308	452,592	407,637	429,044	412,949	432,924

A-001 (3) (met tons cu content)	69.9	73.6	62.2	62.5	59	54.1
A-002 (3) (met tons cu content)	20	20	20	20	14	25
A-003 (3) (met tons cu content)	214.9	226.9	203.8	220.6	199.1	162.7
A-004 *						
A-005						
Cost US$/c/lb before credit (3)						
A-001	94.1	83.1	93.9	88.4	91.6	208.4
A-002	43.5	42.5	45.5	42.4	46.4	77.5
A-003	60.2	56.6	56.8	54.9	59.1	100.6
A-004						
A-005						
Cost US$/c/lb after credit (3)						
A-001	77.2	68.4	76.7	74.4	74.7	128.7
A-002	43.5	42.5	45.5	42.2	46.4	77.5
A-003	54	51.7	50.5	48.9	51.2	89.8
A-004						
A-005						
Prod.Price c/lb US (4)	74.974	71.38	82.294	71.566	70.674	167.087
Net Copper Value mil. $ US						
A-001	80.3	89	89.9	75.9	70.6	161.7
A-002	32.1	30.5	35.3	30.6	21.1	90.7
A-003	223	218.8	261.8	237.2	211.8	451.4
A-004						
A-005						

Discount Rate (8)	8.91	7.58	8.05	5.16	3.53	4.91

SOURCES:
(1) Banco Central
(2-1) USGS Reserves
(2-2) USGS Reserves Base
(3) Michael Farrell
(4)Refined B.M.L. London COCHILCO
(5) Company Reports
(6) Anuario - del Cobre.. 1986-2005 COCHILCO
(7) Williams - USGS - 1992
(8) Banco Central-Chile- Ave Int rate 90-365 days US$

*** web site under construction - no data**

TABLE A-3-5. Copper Depletion Conversion

COPPER DEPLETION	1992	1993	1994	1995	1996	1997
Know Reserves (met tonns fine)						
National (1) - reserves	78,000,000	80,000,000	104,000,000	134,000,000	160,000,000	163,000,000
National - reserves + other resources (1-1)	212,000,000	217,000,000	235,000,000	309,000,000	344,000,000	355,000,000
National - reserves (2-1)					88,000,000	88,000,000
National- reserve base(2-2)					163,000,000	163,000,000
Region III (7)	20,300,000					
A-001 - (measured) (5)						
A-001 - (inferred) (5)						
A-001 - % remain. (3)						
A-003 - (measured) (5)						
A-003 - (measured) (10)		3,987,998				
A-003 - (inferred)						
A-003 - % remain (3)					0.95%	0.88%
A-006 - meas. (10)	172,321	130,128	195,464	164,057	158,033	235,907
A-007 - inferred (10-1)			926,850			
A-007 - meas & infer (10-2)						1,018,980
A-007 - measured (10-3)						
A-007 - inferred (10-3)						
A-008 - measured (10)						
A-008 - inferred (10)						
A-009 - inferred (10)						
Depletion						
National (met tonns fine) (6)	1,932,700	2,055,400	2,219,900	2,488,600	3,115,800	3,392,000
Region III (met tonns fine) (6)	164,109	154,245	182,777	314,354	360,318	378,617
A-001 (3) (met tons cu content)	88,500	86,600	84,300	78,000	73,200	70,100

A-002 (3) (met tonns cu content)				9,600	18,400	20,000
A-010 - Total (3)	88,500	86,600	84,300	87,600	91,600	90,100
A-010 - Total (9)	85,000	84,100	82,600	85,900	89,900	88,300
A-003 (3) (met tonns cu content)			28,100	150,300	136,800	155,800
A-003 (9)			30,900	150,300	136,800	155,700
A-006 (10)	24,295	17,046	23,410	20,270	21,450	21,668
A-004 *						
A-005						
Cost US$/c/lb before credit (3)						
A-001	93.9	97.5	98.9	91.6	90.6	94.1
A-002				49.6	44.9	46.6
A-003			62.8	56.6	64.1	62.1
A-004 *						
A-005						
Cost US$/c/lb after credit (3)						
A-001	82.8	83.4	80	64.6	71.1	78.9
A-002				49.6	44.9	46.5
A-003			49.8	46.8	55.6	54.8
A-004 *						
A-005						
Prod.Price c/lb US (4)	103.573	86.713	104.903	133.198	103.894	103.224
Net Copper Value mil. $ US						
A-001 (3)	143.1	112	148.1	186.6	127.6	121.1
A-002 (3)				27.7	41.3	44.5
A-003 - (3)			45.1	327.9	209.5	244.3
A-004 - (3) *						

A-005						
Discount Rate (8)	7.02*	6.9	8.71	10.28	9.71	9.81
Discount Rate (8-1)	8.19	9.26	9.29	8.59	9.33	8.78

TABLE A-3-5. Copper Depletion Conversion (continued)

COPPER DEPLETION	**1998**	**1999**	**2000**	**2001**	**2002**	**2005**
Know Reserves (met tons fine)						
National (1) - reserves	166,000,000	164,000,000	162,000,000			
National - reserves + other resources (1-1)	365,000,000	365,000,000	369,000,000			
National - reserves (2-1)	88,000,000	88,000,000	88,000,000	88,000,000	88,000,000	140,000,000
National- reserve base(2-2)	163,000,000	160,000,000	160,000,000	160,000,000	160,000,000	360,000,000
Region III (7)						
A-001 - (measured) (5)						467,200
A-001 - (inferred) (5)						75,600
A-001 - % remain. (3)						
A-003 - (measured) (5)						2,474,700
A-003 - (measured) (10)						
A-003 - (inferred)						
A-003 - % remain (3)	0.85%	0.82%	0.84%	0.83%	0.70%	0.73%
A-006 - meas. (10)	223,932	223,932	223,932	223,932	223,932	182,192

A-007 - inferred (10-1)						
A-007 - meas & infer (10-2)						
A-007 - measured (10-3)						14,646,221
A-007 - inferred (10-3)						2,877,630
A-008 - measured (10)					1,542,683	
A-008 - inferred (10)					288,123	
A-009 - inferred (10)					8,424,600	
Depletion						
National (met tons fine) (6)	3,686,900	4,391,200	4,602,000	4,739,000	4,580,600	5,320,500
Region III (met tons fine) (6)	433,308	452,592	407,637	429,044	412,949	432,924
A-001 (3) (met tons cu content)	69,900	73,600	62,200	62,500	59,000	54,100
A-002 (3) (met tons cu content)	20,000	20,000	20,000	20,000	14,000	25,000
A-010 - Total (3)	89,900	93,600	82,200	82,500	73,000	79,100
A-010 - Total (9)	88,100	91,700	80,500	81,200	72,800	77,500
A-003 (3) (met tons cu content)	214,900	226,900	203,800	220,600	199,100	162,700
A-003 (9)	215,000	226,900	203,900	220,600	199,100	162,700
A-006 (10)	17,220					
A-004 *						
A-005						
Cost US$/c/lb before credit (3)						
A-001	94.1	83.1	93.9	88.4	91.6	208.4
A-002	43.5	42.5	45.5	42.4	46.4	77.5
A-003	60.2	56.6	56.8	54.9	59.1	100.6
A-004 *						
A-005						
Cost US$/c/lb after credit (3)						
A-001	77.2	68.4	76.7	74.4	74.7	128.7

A-002	43.5	42.5	45.5	42.2	46.4	77.5
A-003	54	51.7	50.5	48.9	51.2	89.8
A-004 *						
A-005						
Prod.Price c/lb US (4)	74.974	71.38	82.294	71.566	70.674	167.087
Net Copper Value mil. $ US						
A-001 (3)	80.3	89	89.9	75.9	70.6	161.7
A-002 (3)	32.1	30.5	35.3	30.6	21.1	90.7
A-003 - (3)	223	218.8	261.8	237.2	211.8	451.4
A-004 - (3) *						
A-005						
Discount Rate (8)	8.91	7.58	8.05	5.16	3.53	4.91
Discount Rate (8-1)	12.05	8.1	7.49	6.14	4.44	3.9

SOURCES:
(1) Banco Central- Reserves
(1-1)BancoCentral- Reserves +Other Resources
(2-1) USGS Reserves
(2-2) USGS Reserves Base
(3) Michael Farrell
(4)Refined B.M.L. London COCHILCO
(5) Company Reports
(6) Anuario - del Cobre.. 1986-2005 COCHILCO
(7) Williams - USGS - 1992

(8) Banco Central-Chile-
TIP (average int. rate)
90-365 day loans in US $
*** five month average**
(8-1)Banco Central, Chile,
Standard rate of interest
for the financial system -
UF
(indexed unit of account)
90-365 days
(9) Cochilco
(10) K. Long - USGS
(10-1) Long-USGS-BHP-94
(10-2) Long-USGS-BHP-97
(10-3)Long-USGS-
Eggleston

*** web site under**
construction - no data

TABLE A-3-6. National and Region III GDP

GDP - CHILE	1992	1993	1994	1995	1996	1997
National (Pesos) 2000 US$ & Pesos						
#1						
#12						
#13-2000 US$ (mil)						
#3	5,435,881	5,815,646	6,147,610	6,800,952	7,305,141	7,845,132
#12	26,554,279	28,409,431	30,031,075	33,222,651	35,685,614	38,323,470
#13-2000 US$ (mil)	49,221	52,660	55,666	61,582	66,147	71,036
#3*						
#12						
#13 - 2000 US$						
#5					40,813,311	43,544,262
#12					34,512,593	36,821,942
#13-2000 US$ (mil)					63,973	68,253
National (US $)						
#8 US current mil $	46,281	49,145	56,267	72,065	75,770	82,812
#12 (US $ 2000)	77,058	74,062	74,272	85,685	88,651	92,170
#9 GDP per capita current US $	3,386	3,532	3,974	5,006	5,184	5,585
#12 (US $ 2000)	5,638	5,323	5,246	5,952	6,065	6,216
#10 Est. growth of GDP (in percent)	12.3	7.0	5.7	10.6	7.4	6.6

Region III						
#2	92,902	102,720	117,375	134,000	153,177	
#12	453,826	501,787	573,377	654,590	748,270	
#13-2000 US$ (mil)	841	930	1,063	1,213	1,387	
#2*						162,847
#12						795,508
#13-2000 US$ (mil)						1,475
#1						
#12						
#13-2000 US$ (mil)						
#4					586,020	624,214
#12					685,643	730,330
#13-2000 US$ (mil)					1,271	1,353
#6	92,902	102,720	117,375	134,000	152,758	
#12	453,826	501,787	573,377	654,590	756,223	
#13-2000 US$ (mil)	841	930	1,063	1,213	1,402	
#6*						160,465
#12						783,872
#13-2000 US$ (mil)						1,453
Region III % of national GDP						
#7 (in percent)	1.7	1.8	1.9	2.0	2.1	
#7* (in percent)						2.0
#11Gross Capital Stock 1996 MM de peso (billion)	79,661	84,242	88,855	94,586	100,956	108,104
#11 Consumption of Fixed Capital	2,451,219	2,633,909	2,839,121	3,081,325	3,365,067	3,681,270

mil pesos 1996

#12	2,867,926	3,081,674	3,321,772	3,605,150	3,937,128	4,307,086
#13-2000 US$ (mil)	5,316	5,712	6,157	6,683	7,298	7,984

TABLE A-3-6. National and Region III GDP (continued)

GDP - CHILE	1998	1999	2000	2001	2002	2005
National (Pesos)						
2000 US$ & Pesos						
#1						57,315,532
#12						48,467,204
#13-2000 US$ (mil)						89,840
#3	8,153,011					
#12	39,827,459					
#13-2000 US$ (mil)	73,824					
#3*		8,059,767	8,493,402			
#12		39,371,962	41,490,269			
#13 - 2000 US$		72,980	76,906			
#5	44,949,409	44,605,581	46,634,995	48,233,736	49,250,882	57,256,693
#12	38,010,164	37,719,416	39,435,531	40,787,460	41,647,580	48,417,462
#13-2000 US$ (mil)	70,456	69,917	73,098	75,604	77,198	89,746
National (US $)						
#8 US curent mil $	79,374	72,996	75,197	68,568	67,266	118,908
#12 (US $ 2000)	85,327	76,500	75,197	65,414	61,683	92,273

#9 GDP per capita current US $	5,282	4,795	4,879	4,396	4,264	7,297
#12 (US $ 2000)	5,678	5,025	4,879	4,194	3,910	5,662
#10 Est. growth of GDP (in percent)	3.2	-0.8	4.5	3.4	2.2	5.7
Region III						
#2						
#12						
#13-2000 US$ (mil)						
#2*						
#12						
#13-2000 US$ (mil)						
#1						959,872
#12						812,052
#13-2000 US$ (mil)						1,505
#4	663,349	652,511	641,406	670,345	644,260	
#12	776,118	764,437	750,445	784,304	753,784	
#13-2000 US$ (mil)	1,439	1,417	1,391	1,454	1,397	
#6						
#12						
#13-2000 US$ (mil)						
#6*	172,207					
#12	841,231					
#13-2000 US$ (mil)	1,559					
Region III % of national GDP						

#7 (in percent)				
#7* (in percent)	2.1			
#11Gross Capital Stock 1996 MM de peso (billion)	115,305	120,663	126,425	132,177
#11 Consumption of Fixed Capital mil pesos 1996	4,014,402	4,293,002	4,540,939	4,803,836
#12	4,696,850	5,022,812	5,312,899	5,620,488
#13-2000 US$ (mil)	8,706	9,310	9,848	10,418

Sources from Banco Central
#1=2003 mil. pesos
#2=1986 mil pesos
#3=1986 mil pesos
#4=1996 mil pesos
#5=2003 mil pesos
Arima X-12 model
* provisional
#6=1986 mil pesos
#7 constant prices

#8 United Nations (current prices)

#9 United Nations (current prices)
#10 United Nations
#11Cent Bank of Chile - (includes-housing-rest of const-machinery & equip. 1996 & depreciation)
#12-2000 Mil.Pesos - Banco Central GDP deflators - 1986 & 1996

Banco Central Nom ex rate 2000 (539.49)

TABLE A-3-7. Total Calculations

Total Calculations in 2000 US $	1992	1993	1994	1995	1996	1997
#1 National GDP in 2000 US $ (mil)	49,221	52,660	55,666	61,582	61,249	65,137
#1 Regional GDP in 2000 US $ (mil)	841	930	1,063	1,213	1,271	1,353
% of Region III of National GDP	1.7	1.8	1.9	2	2.1	2.1
#2 Consumption of Fixed Capital - National 2000 US $ (mil)	5,316	5,712	6,157	6,683	7,298	7,984
#3 Consumption of Fixed Capital Regional 2000 US $ (mil)	90	103	117	134	153	168
#4 Product Price US $/metric ton 2000 US $	2,802	2,284	2,688	3,317	2,513	2,442
#5 Ave. Product Cost US $/met ton 2000 US $	2,240	2,192	1,839	1,314	1,444	1,443
#6 RESERVES COMBINED NATIONAL#s metric tons	78,000,000	80,000,000	104,000,000	134,000,000	161,500,000	163,000,000
#7 Region III reserves	6,630,000	6,000,000	8,528,000	16,884,000	18,734,000	18,256,000
#8 PRODUCTION National (met tonnes fine)	1,932,700	2,055,400	2,219,900	2,488,600	3,115,800	3,392,000
#8 PRODUCTION Region III (met tonnes fine)	164,109	154,245	182,777	314,354	360,318	378,617
Region III % of national	8.5%	7.5%	8.2%	12.6%	11.6%	11.2%
World Bank Resource Depletion Region III - 2000 US $	92,229,258	14,190,540	155,177,673	629,651,062	385,179,942	378,238,383
Change in Region III reserves from previous year- metric tons	-85,000	150,000	1,968,000	3,780,000	3,190,000	168,000

Repetto (Net Price) Resource Depletion Region III 2000 US $	139,999,258	390,540	- 1,515,654,327	- 6,941,688,938	- 3,024,930,058	210,406,383
Years remaining of reserves at mining rate of current year	40.4	38.9	46.7	53.7	52.0	48.2
El Serafy (User Cost) Resource Depletion 2000 US $	3,530,694	408,371	2,292,100	6,905,713	3,457,762	5,965,185
#9 Carbon Dioxide emissions metric tons/capita	2.6027	2.5987	2.9492	3.1118	3.5073	3.9747
#10 Region III population for corresponding year	235,105	238,456	241,801	245,155	248,154	251,171
Carbon Dioxide Emissions @ 20 (constant) US $/mt/capita	12,238,156	12,393,512	14,262,390	15,257,467	17,407,010	19,966,587
#11Region III #1-Least Stringent (total)	5,266,361	4,949,818	5,865,429	10,087,817	11,562,831	12,150,056
#11 Region III #1-Least Stringent (total) w/processing				10,161,892	11,704,807	12,304,378
#11 Region III #4 -Most Stringent w/abandonment (total)	130,246,093	122,417,470	145,062,063	249,488,938	285,968,543	300,491,654
#11 Region III #4 -Most Stringent w/aband. (total) w/processing						
#12 Region III mining profits 2000 US $ (mil)	50.6	24.8	-12.0	399.1	174.9	274.3

TABLE A-3-7. Total Calculations (continued)

Total Calculations in 2000 US $	1998	1999	2000	2001	2002	2005
#1 National GDP in 2000 US $ (mil)	67,084	66,814	69,646	72,024	73,606	89,840
#1 Regional GDP in 2000 US $ (mil)	1,439	1,417	1,391	1,454	1,397	1,505

% of Region III of National GDP	2.1	2.1	2	2	1.9	1.7
#2 Consumption of Fixed Capital - National 2000 US $ (mil)	8,706	9,310	9,848	10,418	10,533*	10,884*
#3 Consumption of Fixed Capital Regional 2000 US $ (mil)	183	196	197	208	210*	217*
#4 Product Price US $/metric ton 2000 US $	1,746	1,627	1,814	1,534	1,491	3,248
#5 Ave. Product Cost US $/met ton 2000 US $	1,365	1,253	1,231	1,151	1,183	1,890
#6 RESERVES COMBINED NATIONAL#s metric tons	164,500,000	162,000,000	161,000,000	160,000,000	160,000,000	360,000,000
#7 Region III reserves	19,411,000	16,686,000	14,329,000	14,400,000	14,400,000	29,160,000
#8 PRODUCTION National (met tonnes fine)	3,686,900	4,391,200	4,602,000	4,739,000	4,580,600	5,320,500
#8 PRODUCTION Region III (met tonnes fine)	433,308	452,592	407,637	429,044	412,949	432,924
Region III % of national	11.8%	10.3%	8.9%	9.0%	9.0%	8.1%
World Bank Resource Depletion Region III - 2000 US $	165,090,348	169,269,408	237,652,371	198,793,852	127,188,292	603,496,056
Change in Region III reserves from previous year- metric tons	177,000	-257,500	-89,000	-90,000	0	0
Repetto (Net Price) Resource Depletion Region III 2000 US $	97,653,348	265,574,408	289,539,371	198,793,852	127,188,292	603,496,056
Years remaining of reserves at mining rate of current year	44.8	36.9	35.2	33.6	34.9	67.4
El Serafy (User Cost) Resource Depletion 2000 US $	882,642	8,842,754	17,336,273	25,624,221	27,108,110	44,072,835
#9 Carbon Dioxide emissions metric tons/capita	3.8869	4.1627	3.8683	3.5475	3.6355	4.0689

#10 Region III population for corresponding year	254,184	257,190	260,190	262,239	264,264	270,371
Carbon Dioxide Emissions @ 20 (constant) US $/mt/capita	19,759,756	21,412,096	20,129,860	18,605,857	19,214,635	22,002,251
#11Region III #1-Least Stringent (total)	13,905,125	14,523,961	13,081,327	13,768,291	13,251,793	13,892,803
#11 Region III #1-Least Stringent (total) w/processing	14,059,447	14,678,283	13,235,649	13,922,613	13,359,818	14,085,706
#11 Region III #4 -Most Stringent w/abandonment (total)	343,897,494	359,202,356	323,523,551	340,513,345	327,739,452	343,592,730
#11 Region III #4 -Most Stringent w/aband. (total) w/processing		362,406,610	326,946,810	344,214,295		
#12 Region III mining profits 2000 US $ (mil)	105.0	108.2	162.0	121.1	68.0	437.6

SOURCES:

#1 Banco Central converted to 2000 US $

#2 Cent Bank of Chile - (includes-housing-rest of const-machinery & equip. 1996 & depreciation)

#3 % based off of GDP

#4 Refined B.M.L. London COCHILCO

#5 1992,93 CODELCO costs, 94 % prod. & applied to Region III from Codelco & Candelaria. Remaining years used % production & applied to Region III from CODELCO, CODELCO-SX-EW, & Candalaria (weighted)

#6 - Combined projections from
Banco Central and the USGS
#7 - Region III reserves based off
of % of Region III production
#8 Annuario - del Cobre, 1986-2005 COCHILCO
#9 United Nations Statistics Div.
#10 Instituto Nacional de Estadisticas "Chile Hacia el 2050"
#11 Resource Strategies In.
#12 Known profits for between 53.9%-75.7% ave. for remaining %

TABLE A-3-8. World Bank Calculations

World Bank in 2000 US $	1992	1993	1994	1995	1996	1997
Regional GDP in 2000 US $ (mil)	841	930	1,063	1,213	1,271	1,353
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	103	117	134	153	168
World Bank Res. Depletion Reg III - 2000 US $	92,229,258	14,190,540	155,177,673	629,651,062	385,179,942	378,238,383
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	4,949,818	5,865,429	10,161,892	11,704,807	12,304,378
EDP (using PR2) in 2000 US $	**653,504,381**	**807,859,642**	**784,956,898**	**439,187,046**	**721,115,251**	**794,457,239**
Region III #4 - Most Stringent w/abandon (total- 99-01 includes processing)	130,246,093	122,417,470	145,062,063	249,488,938	285,968,543	300,491,654
EDP (using) PR1 in 2000 US $	**528,524,649**	**690,391,990**	**645,760,264**	**199,860,000**	**446,851,515**	**506,269,963**
Region III mining profits in 2000 US $ (mil)	50.6	24.8	-12.0	399.1	174.9	274.3

TABLE A-3-8. World Bank Calculations (continued)

World Bank in 2000 US $	1998	1999	2000	2001	2002	2005
Regional GDP in 2000 US $ (mil)	1,439	1,417	1,391	1,454	1,397	1,505
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	183	196	197	208	210*	217*
World Bank Res. Depletion Reg III - 2000 US $	165,090,348	169,269,408	237,652,371	198,793,852	127,188,292	603,496,056
Region III #1- Least Stringent (total - 95-05 incl. processing)	14,059,447	14,678,283	13,235,649	13,922,613	13,359,818	14,085,706
EDP (using PR2) in 2000 US $	**1,076,850,205**	**1,037,052,309**	**943,111,980**	**1,033,283,545**	**1,046,451,890**	**670,418,238**
Region III #4 - Most Stringent w/abandon (total- 99-01 includes processing)	343,897,494	362,406,610	326,946,810	344,214,295	327,739,452	343,592,730
EDP (using) PR1 in 2000 US $	**747,012,158**	**689,323,982**	**629,400,819**	**702,991,853**	**732,072,256**	**340,911,214**

Region III mining profits in 2000 US $ (mil)	105.0	108.2	162.0	121.1	68.0	437.6
#1 Region III based upon % of national CFC *based upon 1.1% annual growth						

TABLE A-3-9. World Bank + CO_2 Calculations

World Bank + CO2 in 2000 US $	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Regional GDP in 2000 US $ (mil)	841	930	1,063	1,213	1,271	1,353
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	103	117	134	153	168
World Bank Res. Depletion Reg III - 2000 US $	92,229,258	14,190,540	155,177,673	629,651,062	385,179,942	378,238,383
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	4,949,818	5,865,429	10,161,892	11,704,807	12,304,378
Carbon Dioxide Emissions @ 20 (constant) US $/met ton/capita	12,238,156	12,393,512	14,262,390	15,257,467	17,407,010	19,966,587
EDP (using PR2) in 2000 US $	**641,266,225**	**795,466,130**	**770,694,508**	**423,929,579**	**703,708,241**	**774,490,652**
Region III #4 - Most Stringent w/abandon (total-99-01 includes processing)	130,246,093	122,417,470	145,062,063	249,488,938	285,968,543	300,491,654

Carbon Dioxide Emissions @ 20 (constant) US $/met ton/capita	12,238,156	12,393,512	14,262,390	15,257,467	17,407,010	19,966,587
EDP (using) PR1 in 2000 US $	**516,286,493**	**677,998,478**	**631,497,874**	**184,602,533**	**429,444,505**	**486,303,376**
Region III mining profits in 2000 US $ (mil)	50.6	24.8	-12.0	399.1	174.9	274.3

TABLE A-3-9. World Bank + CO_2 Calculations (continued)

World Bank + CO2 in 2000 US $	**1998**	**1999**	**2000**	**2001**	**2002**	**2005**
Regional GDP in 2000 US $ (mil)	1,439	1,417	1,391	1,454	1,397	1,505
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	183	196	197	208	210*	217*
World Bank Res. Depletion Reg III - 2000 US $	165,090,348	169,269,408	237,652,371	198,793,852	127,188,292	603,496,056
Region III #1- Least Stringent (total - 95-05 incl. processing)	14,059,447	14,678,283	13,235,649	13,922,613	13,359,818	14,085,706

Carbon Dioxide Emissions @ 20 (constant) US $/met ton/capita	19,759,756	21,412,096	20,129,860	18,605,857	19,214,635	22,002,251
EDP (using PR2) in 2000 US $	**1,057,090,449**	**1,015,640,213**	**922,982,120**	**1,014,677,688**	**1,027,237,255**	**648,415,987**
Region III #4 - Most Stringent w/abandon (total-99-01 includes processing)	343,897,494	362,406,610	326,946,810	344,214,295	327,739,452	343,592,730
Carbon Dioxide Emissions @ 20 (constant) US $/met ton/capita	19,759,756	21,412,096	20,129,860	18,605,857	19,214,635	22,002,251
EDP (using) PR1 in 2000 US $	**727,252,402**	**667,911,886**	**609,270,959**	**684,385,996**	**712,857,621**	**318,908,963**
Region III mining profits in 2000 US $ (mil)	105.0	108.2	162.0	121.1	68.0	437.6

#1 Region III based upon % of national CFC
*based upon 1.1% annual growth
**20 US $/mt/capita

TABLE A-3-10. Net Price (Repetto) Calculations

Net Price in 2000 US $	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Regional GDP in 2000 US $ (mil)	841	930	1,063	1,213	1,271	1,353
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	103	117	134	153	168
Repetto (Net Price) Resource Depletion Region III 2000 US $	139,999,258	390,540	- 1,515,654,327	- 6,941,688,938	- 3,024,930,058	210,406,383
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	4,949,818	5,865,429	10,161,892	11,704,807	12,304,378
EDP (using PR2) in US $	**605,734,381**	**821,659,642**	**2,455,788,898**	**8,010,527,046**	**4,131,225,251**	**962,289,239**
Region III #4 - Most Stringent w/abandon (tota- 99-01 includes processing)	130,246,093	122,417,470	145,062,063	249,488,938	285,968,543	300,491,654
EDP (using) PR1 in US $	**480,754,649**	**704,191,990**	**2,316,592,264**	**7,771,200,000**	**3,856,961,515**	**674,101,963**
#12 Region III mining profits 2000 US $ (mil)	50.6	24.8	-12.0	399.1	174.9	274.3

TABLE A-3-10. Net Price Calculations (continued)

Net Price in 2000 US $	**1998**	**1999**	**2000**	**2001**	**2002**	**2005**
Regional GDP in 2000 US $ (mil)	1,439	1,417	1,391	1,454	1,397	1,505
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	183	196	197	208	210*	217*
Repetto (Net Price) Resource Depletion Region III 2000 US $	97,653,348	265,574,408	289,539,371	198,793,852	127,188,292	603,496,056
Region III #1- Least Stringent (total - 95-05 incl. processing)	14,059,447	14,678,283	13,235,649	13,922,613	13,359,818	14,085,706
EDP (using PR2) in US $	**1,144,287,205**	**940,747,309**	**891,224,980**	**1,033,283,535**	**1,046,451,890**	**670,418,238**
Region III #4 - Most Stringent w/abandon (tota- 99-01 includes processing)	343,897,494	362,406,610	326,946,810	344,214,295	327,739,452	343,592,730
EDP (using) PR1 in US $	**814,449,158**	**593,018,982**	**577,513,819**	**702,991,853**	**732,072,256**	**340,911,214**
#12 Region III mining profits 2000 US $ (mil)	105.0	108.2	162.0	121.1	68.0	437.6

#1 Region III based upon % of national CFC
***based upon 1.1% annual growth**

TABLE A-3-11. User Cost (El Serafy) Calculations

User Cost in 2000 US $	1992	1993	1994	1995	1996	1997
Regional GDP in 2000 US $ (mil)	841	930	1,063	1,213	1,271	1,353
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	90	103	117	134	153	168
El Serafy (User Cost) Resource Depletion 2000 US $	3,530,694	408,371	2,292,100	6,905,713	3,457,762	5,965,185
Region III #1- Least Stringent (total - 95-05 incl. processing)	5,266,361	4,949,818	5,865,429	10,161,892	11,704,807	12,304,378
EDP (using PR2) in 2000 US $	**742,202,945**	**821,641,811**	**937,842,471**	**1,061,932,395**	**1,102,837,431**	**1,166,730,437**
Region III #4 - Most Stringent w/abandon (total- 99-01 includes processing)	130,246,093	122,417,470	145,062,063	249,488,938	285,968,543	300,491,654
EDP (using) PR1 in 2000 US $	**617,223,213**	**704,174,159**	**798,645,837**	**822,605,349**	**828,573,695**	**878,543,161**
#12 Region III mining profits 2000 US $ (mil)	50.6	24.8	-12.0	399.1	174.9	274.3

TABLE A-3-11. User Cost Calculations (continued)

User Cost in 2000 US $	**1998**	**1999**	**2000**	**2001**	**2002**	**2005**
Regional GDP in 2000 US $ (mil)	1,439	1,417	1,391	1,454	1,397	1,505
#1 Consumption of Fixed Capital - Regional 2000 US $ (mil)	183	196	197	208	210*	217*
El Serafy (User Cost) Resource Depletion 2000 US $	882,642	8,842,754	17,336,273	25,624,221	27,108,110	44,072,835
Region III #1- Least Stringent (total - 95-05 incl. processing)	14,059,447	14,678,283	13,235,649	13,922,613	13,359,818	14,085,706
EDP (using PR2) in 2000 US $	**1,241,057,911**	**1,197,478,963**	**1,163,428,078**	**1,206,453,166**	**1,146,532,072**	**1,229,841,459**
Region III #4 - Most Stringent w/abandon (total-99-01 includes processing)	343,897,494	362,406,610	326,946,810	344,214,295	327,739,452	343,592,730
EDP (using) PR1 in 2000 US $	**911,219,864**	**849,750,636**	**849,716,917**	**876,161,484**	**832,152,438**	**900,334,435**
#12 Region III mining profits 2000 US $ (mil)	105.0	108.2	162.0	121.1	68.0	437.6

#1 Region III
based upon % of
national CFC
*based upon
1.1%
annual growth

APPENDIX #4 – Environmental Cost Projections

TABLE A-4-1. Regulatory Component Scenarios

Regulatory Scenarios and Components

Component	**Scenario #1 Least Stringent**	**Scenario #2 Moderate**	**Scenario #3 Stringent**
PERMITTING			
Facility Site Characterization:			
Unit Description	X	X	X
Waste Characterization	X	X	X
Geotechnical Study	X	X	X
SITE SECURITY			
Fence, Gate(s), and Signs	X	X	X
FINANCIAL RESPONSIBILTY			
Corporate Guarantee	X	X	X
RUN-ON/RUN OFF CONTROLS			
Unlined Ditches		X	X
Unlined Stormwater Impoundment		X	X
Increase Freeboard		X	X
LINER			
Single System Liner			X
Double Synthetic/Composite Liner System (for surface water impoundment)			
Double Synthetic/Composite Liner System with Leach Detection and Collection (for dump/heap leach and waste piles)			
ENVIRONMENTAL MONITORING			
Groundwater Monitoring Plan	X	X	X

Hydrogeologic Study	X	X	X
One Upgradient Well - Downgradient Wells Placed at 500 Foot Intervals	X	X	X
A Three Well Cluster and Three Shallow Wells Upgradient and Three Well Clusters Downgradient at 150 Foot Clusters			
Groundwater Monitoring for pH, Specific Conductance, and Metals	X	X	X
Groundwater Monitoring for pH, Specific Conductance, Metals, TOC, and TOX			
Air Monitoring			X
Surface Water Monitoring	X	X	X
CLOSURE			
Closure Plan	X	X	X
Certification	X	X	X
Grading and Erosion Control	X	X	X
Drain & Regrade Surface Impoundment	X	X	X
Vegatative Cover		X	
Synthetic Cap with Drainage			X
Synthetic Cap with Clay			
POST-CLOSURE			
Post-Closure Plan	X	X	X
Part 264 Post-Closure Permit			
Cover Maintenance *		X	X
Groundwater Monitoring *	X	X	X
Air Monitoring *			X
Surface Water Monitoring *	X	X	X
CORRECTIVE ACTION			
Withdrawal and Treatment	X	X	X
Development of an Alternative Water Supply	X	X	X

*Five year post-closure for Scenarios #1 & #2
Thirty year post-closure for Scenarios #3 & #4

Source: Resource Strategies, Inc.

TABLE A-4-1. Regulatory Component Scenarios (continued)

Regulatory Scenarios and Components

Component	**Scenario #3 Stringent w/abandonment**	**Scenario #4 Most Stringent**	**Scenario #4 Most Stringent w/abandonment**
PERMITTING			
Facility Site Characterization:			
Unit Description	X	X	X
Waste Characterization	X	X	X
Geotechnical Study	X	X	X
SITE SECURITY			
Fence, Gate(s), and Signs	X	X	X
FINANCIAL RESPONSIBILTY			
Corporate Guarantee	X	X	X
RUN-ON/RUN OFF CONTROLS			
Unlined Ditches	X	X	X
Unlined Stormwater Impoundment	X	X	X
Increase Freeboard	X	X	X
LINER			
Single System Liner	X		
Double Synthetic/Composite Liner System (for surface water impoundment)		X	X

Double Synthetic/Composite Liner System with Leach Detection and Collection (for dump/heap leach and waste piles)		X	X
ENVIRONMENTAL MONITORING			
Groundwater Monitoring Plan	X	X	X
Hydrogeologic Study	X	X	X
One Upgradient Well - Downgradient Wells Placed at 500 Foot Intervals	X		
A Three Well Cluster and Three Shallow Wells			
Upgradient and Three Well Clusters Downgradient at 150 Foot Clusters		X	X
Groundwater Monitoring for pH, Specific Conductance, and Metals	X		
Groundwater Monitoring for pH, Specific Conductance, Metals, TOC, and TOX		X	X
Air Monitoring	X	X	X
Surface Water Monitoring	X	X	X
CLOSURE			
Closure Plan	X	X	X
Certification	X	X	X
Grading and Erosion Control	X	X	X
Drain & Regrade Surface Impoundment	X		
Vegatative Cover			
Synthetic Cap with Drainage	X		
Synthetic Cap with Clay		X	X
POST-CLOSURE			
Post-Closure Plan	X		
Part 264 Post-Closure Permit		X	X
Cover Maintenance *	X	X	X
Groundwater Monitoring *	X	X	X
Air Monitoring *	X	X	X
Surface Water Monitoring *	X	X	X

CORRECTIVE ACTION			
Withdrawal and Treatment	X	X	X
Development of an Alternative Water Supply	X	X	X
*Five year post-closure for Scenarios #1 & #2 Thirty year post-closure for Scenarios #3 & #4	X		X

Source: Resource Strategies, Inc.

TABLE A-4-2. Environmental Costs by Company

COPPER DEPLETION ENVIRONMENTAL CALC.	1992	1993	1994	1995	1996	1997
Environmental Costs (12) 2000 US $						
A-001 #1-Least Stringent (3-total)	**2,840,021**	**2,779,049**	**2,705,240**	**2,811,140**	**2,939,502**	**2,891,366**
A-001 #4-Most Stringent w/abandonment (3-total)	**70,238,556**	**68,730,610**	**66,905,201**	**69,524,266**	**72,698,890**	**71,508,406**
A-001 #4 - Most Stringent w/closure & maintenance (3-total)	**199,009,242**	**194,736,727**	**189,564,736**	**196,985,419**	**205,980,187**	**202,607,149**
A-002 expenses #1 Least Stringent (3)				**74,075**	**141,976**	**154,322**
A-002 expenses #4 Most Stringent w/closure & maintenance (3)				**99,472**	**190,654**	**207,232**
A-003 #1-Least Stringent (3-total)			**901,747**	**4,823,222**	**4,389,998**	**4,999,720**
A-003 #4 -Most Stringent w/abandonment (3-total)			**22,301,734**	**119,286,497**	**108,572,141**	**123,651,605**
A-003 #4 - Most Stringent w/closure & maintenance (3-total)			**63,188,245**	**337,978,408**	**307,621,066**	**350,346,214**
A-006 #1-Least Stringent (10-total)	**779,642**	**547,017**	**751,242**	**650,476**	**688,344**	**695,340**
A-006 #4 -Most Stringent w/abandonment (10-total)	**19,281,873**	**13,528,660**	**18,579,487**	**16,087,407**	**17,023,921**	**17,196,938**
A-006 #4 - Most Stringent w/closure & maintenance (10-total)	**54,631,972**	**38,331,204**	**52,641,880**	**45,580,987**	**48,234,443**	**48,724,658**

A-005 - Paipote Smelter
#4 Most Stringent
w/abandonment (13)

A-005 - Paipote Smelter
#4 Most Stringent
w/closure (13)

TABLE A-4-2. Environmental Costs by Company (continued)

COPPER DEPLETION ENVIRONMENTAL CALC.	1998	1999	2000	2001	2002	2005
Environmental Costs (12) 2000 US $						
A-001 #1-Least Stringent (3-total)	2,884,947	3,003,683	2,637,849	2,647,477	2,342,616	2,538,369
A-001 #4-Most Stringent w/abandonment (3-total)	71,349,674	74,286,202	65,238,523	65,476,620	57,936,888	62,778,190
A-001 #4 - Most Stringent w/closure & maintenance (3-total)	202,157,411	210,477,571	184,842,482	185,517,090	164,154,516	177,871,537
A-002 expenses #1 Least Stringent (3)	154,322	154,322	154,322	154,322	108,025	192,903
A-002 expenses #4 Most Stringent w/closure & maintenance (3)	207,232	207,232	207,232	207,232	145,063	259,041
A-003 #1-Least Stringent (3-total)	6,896,275	7,281,363	6,540,070	7,079,193	6,389,244	5,221,145
A-003 #4 -Most Stringent w/abandonment (3-total)	170,556,674	180,080,546	161,747,093	175,080,514	158,016,910	129,127,831
A-003 #4 - Most Stringent w/closure & maintenance (3-total)	483,243,911	510,228,215	458,283,430	496,061,455	447,714,577	365,862,188

A-006 #1-Least Stringent (10-total)	**552,600**			
A-006 #4 -Most Stringent w/abandonment (10-total)	**13,666,756**			
A-006 #4 - Most Stringent w/closure & maintenance (10-total)	**38,722,476**			
A-005 - Paipote Smelter #4 Most Stringent w/abandonment (13)		**3,204,254**	**3,423,259**	**3,700,950**
A-005 - Paipote Smelter #4 Most Stringent w/closure (13)		**9,612,761**	**10,269,776**	**11,102,851**

SOURCES:

(3) Michael Farrell

(6) Anuario - del Cobre.. 1986-2005 COCHILCO

(10) K. Long - USGS

(12) Resource Strategies, Inc. (converted to 2000 $)

(13) ENAMI Annual Reports 2000 and 2001

TABLE A-4-3. Environmental Costs - Regional

Environmental Costs (1) 2000 US $	1992	1993	1994	1995	1996	1997
Region III #1-Least Stringent (2-total)	**5,266,361**	**4,949,818**	**5,865,429**	**10,087,817**	**11,562,831**	**12,150,056**
Region III #4 -Most Stringent w/abandonment (2-total)	**130,246,093**	**122,417,470**	**145,062,063**	**249,488,938**	**285,968,543**	**300,491,654**
Region III #4 - Most Stringent w/closure & maintenance (2-total)	**369,010,357**	**346,849,498**	**411,009,178**	**706,885,325**	**810,244,204**	**851,393,019**
Region III #1-Least Stringent (2-total) w/processing				**10,161,892**	**11,704,807**	**12,304,378**
Region III #4 -Most Stringent w/abandonment (2-total) w/processing						
Region III #4 - Most Stringent w/closure & maintenance (2-total) w/processing				**706,984,797**	**810,434,858**	**851,600,251**

SOURCES:

(1) Resource Strategies Inc.

(2) Anuario - del Cobre 1985-2005 COCHILCO

TABLE A-4-3. Environmental Costs - Regional (continued)

Environmental Costs (1) 2000 US $	**1998**	**1999**	**2000**	**2001**	**2002**	**2005**
Region III #1-Least Stringent (2-total)	**13,905,125**	**14,523,961**	**13,081,327**	**13,768,291**	**13,251,793**	**13,892,803**
Region III #4 -Most Stringent w/abandonment (2-total)	**343,897,494**	**359,202,356**	**323,523,551**	**340,513,345**	**327,739,452**	**343,592,730**
Region III #4 - Most Stringent w/closure & maintenance (2-total)	**974,376,233**	**1,017,740,010**	**916,650,061**	**964,787,810**	**933,092,497**	**973,512,735**
Region III #1-Least Stringent (2-total) w/processing	**14,059,447**	**14,678,283**	**13,235,649**	**13,922,613**	**13,359,818**	**14,085,706**
Region III #4 -Most Stringent w/abandonment (2-total) w/processing		**362,406,610**	**326,946,810**	**344,214,295**		
Region III #4 - Most Stringent w/closure & maintenance (2-total) w/processing	**974,583,465**	**1,027,560,003**	**927,127,069**	**976,097,893**	**933,237,560**	**973,771,776**

SOURCES:

(1) Resource Strategies Inc.

(2) Anuario - del Cobre 1985-2005 COCHILCO

APPENDIX #5 – Social Factors and Social Activity

TABLE A-5-1. National GDP by Sector at Current Prices (1986 – base)

Producto interno bruto por clase de actividad económica, a precios constantes, base 1986
(Millones de pesos de 1986)

	Agropecuario-silvícola	Pesca	Minería	Industria Manufacturera	Electricidad, gas y agua	Construcción
86	253388	39625	342852	610935	91757	163546
87	277645	43276	341729	643172	96767	178494
88	312716	45157	368478	699852	102226	193826
89	329577	50655	397197	776498	94208	215410
90	360183	54685	400882	784161	85995	237010
91	364667	60275	450532	826013	109182	233382
92	405666	70281	444040	920293	139295	265228
93	416615	74195	443323	987062	146047	327508
94	441515	86316	482754	1027352	155111	324038
95	464295	100040	527800	1104750	166945	356179
96	470393	109771	610991	1140257	160678	386859
97	452135	120014	659273	1203641	177604	416875
98	481354	122948	708088	1185360	185487	419893
99	475246	125032	822881	1176902	188617	378055
0	499964	146151	855415	1227873	221192	378025

'(1) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.

'(2) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes, base 1986
(Millones de pesos de 1986)

	Comercio, restaurantes y hoteles	Transporte y comunicaciones	Servicios financieros (1)	Propiedad de vivienda
86	482799	216927	418315	195384
87	535403	237678	451792	197156
88	563842	258553	493020	199750
89	652974	295393	559147	203046
90	683138	318672	569942	208349
91	748841	345487	653965	212567
92	880336	405359	727876	216483
93	944208	428874	778204	223282
94	992606	451964	833577	230223
95	1133117	518310	915060	237006
96	1241044	571042	977702	244442
97	1356432	644539	1053615	253518
98	1412328	703749	1113055	262059
99	1362332	723026	1101637	269665
0	1426053	791780	1154823	274455

'(1) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.
'(2) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes, base 1986
(Millones de pesos de 1986)

	Servicios personales (2)	Administración pública	Subtotal	Menos: imputaciones bancarias	PIB a costo de factores
86	303154	149736	3268418	234428	3033990
87	311154	147255	3461521	249736	3211785
88	323347	147928	3708695	273286	3435409
89	333234	147455	4054794	300905	3753889
90	341299	149159	4193475	311737	3881738
91	355514	151646	4512071	334806	4177265
92	379817	156052	5010726	368688	4642038
93	393636	158949	5321903	391916	4929987
94	408829	160676	5594961	409702	5185259
95	422005	162933	6108440	444527	5663913
96	446580	165172	6524931	477422	6047509
97	461691	167421	6966758	511318	6455440
98	473926	169818	7238065	528703	6709362
99	472229	172115	7267738	518830	6748908
0	483227	174551	7633509	545221	7088288

'(1) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.
'(2) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes, base 1986
(Millones de pesos de 1986)

	Más: IVA neto recaudado	Más: derechos de importación	PIB a precios de mercado
86	271748	113471	3419209
87	293445	139451	3644681
88	318286	157459	3911154
89	361380	208912	4324181
90	378200	224133	4484071
91	415536	248646	4841447
92	477230	316613	5435881
93	519655	366004	5815646
94	557597	404754	6147610
95	616869	520170	6800952
96	677394	580238	7305141
97	742402	647290	7845132
98	776005	667644	8153011
99	751935	558924	8059767
0	786971	618143	8493402

'(1) Incluye servicios financieros,

seguros, arriendo de inmuebles y servicios prestados a empresas.
'(2) Incluye educación, salud y otros servicios.

Source: Banco Central – Chile

TABLE A-5-1. National GDP by Sector at Current Prices (1996 – base) – continued

Producto interno bruto por clase de actividad económica, a precios constantes (Base 1996)(1)(2)(3)
(Millones de pesos de 1996)

	Agropecuario-silvícola	Pesca	Minería	Cobre	Resto	Industria Manufacturera	Alimentos, bebidas y tabaco
96	1323492	382931	2089442	1745018	344424	5468314	1709964
97	1345469	419419	2325065	1951054	374011	5727067	1740210
98	1412513	393492	2517712	2111631	406081	5595383	1717167
99	1401496	418841	2784348	2410646	373702	5566725	1745553
0	1485916	454477	2873613	2505058	368554	5840248	1829741
1	1575996	510558	3036605	2649496	387108	5876150	1905633

2	1647623	581479	2908345	2525519	382826	5987262	1939067
3	1746970	540375	3068643	2695997	372646	6184064	1977561
4	1901556	604537	3284760	2918046	366715	6627640	2111347
5	2009575	592402	3290737	2894208	396529	6975003	2263536

'(1) Año 2004: cifras provisionales
'(2) Año 2005: cifras preliminares
'(3) Cifras trimestrales son preliminares
'(4) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.
'(5) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes (Base 1996)(1)(2)(3)
(Millones de pesos de 1996)

	Textil, prendas de vestir y cuero	Maderas y muebles	Papel e imprentas	Química, petróleo, caucho y plástico
96	484249	426846	633254	1078144
97	495575	485531	645828	1142276
98	467754	466509	651093	1144301
99	439758	475650	677456	1167009
0	425629	514859	700077	1241809
1	373984	510745	663070	1284873
2	359275	509049	714909	1342770
3	366076	543432	769814	1393040
4	389351	581812	851072	1471241

5	380632	618388	837351		1584768

'(1) Año 2004: cifras provisionales
'(2) Año 2005: cifras preliminares
'(3) Cifras trimestrales son preliminares
'(4) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.
'(5) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes (Base 1996)(1)(2)(3)
(Millones de pesos de 1996)

	Productos minerales no metálicos y metálicas básicas	Productos metálicos, maquinaria, equipos y resto	Electricidad, gas y agua	Construcción
96	501357	634500	889376	2911728
97	528263	689383	962995	3094243
98	510325	638235	1005482	3152276
99	460288	601012	957735	2841012
0	491375	636758	1048781	2820940
1	499074	638772	1064716	2936609
2	497250	624942	1099672	3010304
3	524989	609152	1147253	3140504
4	594402	628415	1207402	3272009
5	629006	661321	1289995	3591066

'(1) Año 2004: cifras provisionales
'(2) Año 2005: cifras preliminares
'(3) Cifras trimestrales son preliminares
'(4) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.
'(5) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes (Base 1996)(1)(2)(3)
(Millones de pesos de 1996)

	Comercio, restaurantes y hoteles	Transportes	Comunicaciones	Servicios financieros (4)	Propiedad de vivienda
96	3477173	1420156	583999	3785812	2352585
97	3739872	1548911	673119	4054474	2443387
98	3872556	1600544	769022	4296392	2527677
99	3700779	1514372	873787	4253915	2602572
0	3862791	1600817	992778	4467864	2662848
1	3964962	1652960	1132711	4629666	2717610
2	4000472	1718074	1216135	4773579	2776279
3	4195260	1822352	1281305	4925892	2834014
4	4478418	1915658	1379381	5229771	2897596
5	4859210	2053342	1516206	5574921	2967390

'(1) Año 2004: cifras provisionales
'(2) Año 2005: cifras preliminares
'(3) Cifras trimestrales son preliminares
'(4) Incluye servicios

financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.

'(5) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes (Base 1996)(1)(2)(3)

(Millones de pesos de 1996)

	Servicios personales (5)	Administración pública	Subtotal	Menos: imputaciones bancarias	PIB a costo de factores
96	3312917	1257602	29255529	1015444	28240085
97	3515182	1276089	31125292	1090351	30034941
98	3626197	1295357	32064604	1131784	30932820
99	3696599	1314140	31926320	1118043	30808277
0	3825552	1334034	33270658	1156782	32113876
1	3947908	1356922	34403373	1192988	33210385
2	4056067	1382840	35158130	1218041	33940089
3	4167662	1410232	36464527	1265545	35198982
4	4322905	1439573	38561206	1351866	37209340
5	4520659	1483547	40724054	1443490	39280564

'(1) Año 2004:

cifras provisionales
'(2) Año 2005: cifras preliminares
'(3) Cifras trimestrales son preliminares
'(4) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.
'(5) Incluye educación, salud y otros servicios.

Producto interno bruto por clase de actividad económica, a precios constantes (Base 1996)(1)(2)(3)
(Millones de pesos de 1996)

	Más: IVA neto recaudado	Más: derechos de importación	PIB a precios de mercado
96	2309491	687713	31237289
97	2490341	775411	33300693
98	2613346	830431	34376598
99	2581856	724910	34115042
0	2698765	833852	35646492
1	2782956	856947	36850288
2	2843516	871534	37655139

3	2965021	966054	39130058
4	3183149	1149318	41541807
5	3481007	1417283	44178853

'(1) Año 2004: cifras provisionales
'(2) Año 2005: cifras preliminares
'(3) Cifras trimestrales son preliminares
'(4) Incluye servicios financieros, seguros, arriendo de inmuebles y servicios prestados a empresas.
'(5) Incluye educación, salud y otros servicios.

Source: Banco Central – Chile

TABLE A-5-2. Region III (Atacama) GDP by Sector at Current Prices (1986 – base)

III Región de Atacama - Producto Interno Bruto por clase de actividad económica. (B86)
(Millones de pesos de 1986)

	Agropecuario-silvícola	Pesca	Minería	Industria Manufacturera	Electricidad, Gas y Agua	Construcción
85	4272	1213	22498	1735	1139	2831
86	5143	1577	20825	2346	1318	2944
87	8195	1931	21197	2339	1339	2677
88	8423	2540	21315	2822	1433	3299
89	11916	2791	26156	3206	-4014	4418
90	10838	2885	30115	2847	-4518	4923
91	14715	2507	33466	2566	-1215	5763
92	13825	2808	38153	2357	2139	6938
93	13816	4267	39920	2690	2199	11777
94	14579	6003	46148	3019	2377	14453
95	15288	5515	60593	3873	2923	12941
96	21844	4506	71794	2894	7389	8222
97	21555	4457	75248	3129	9562	8508
98	-	-	-	-	-	-

'(1) Incluye servicios financieros, seguros, arriendos de inmuebles y servicios prestados a empresas.
'(2) Incluye además educación y salud, pública y privada

III Región de Atacama - Producto Interno Bruto por clase de actividad económica. (B86)
(Millones de pesos de 1986)

	Comercio, Restaurantes y Hoteles	Transportes y Comunicaciones	Servicios Financieros (1)
85	4218	2169	1728
86	4048	2167	1842
87	5105	2042	1932
88	5617	2460	2190
89	6846	2968	2468
90	7834	3495	2578
91	8992	3707	3153
92	10656	4065	3746
93	11689	4193	4037
94	13154	5090	4430
95	14398	5363	5117
96	16990	5409	5490
97	17632	6189	5924
98	-	-	-

'(1) Incluye servicios financieros, seguros, arriendos de inmuebles y servicios prestados a empresas.
'(2) Incluye además educación y salud, pública y privada

III Región de Atacama - Producto Interno Bruto por clase de actividad económica. (B86)
(Millones de pesos de 1986)

	Propiedad de Vivienda	Servicios Personales (2)	Administración Pública	Menos: Imputaciones Bancarias	Producto Interno Bruto
85	2641	4076	1580	-540	49560
86	2664	4089	1638	-522	50079
87	2689	4255	1599	-490	54810
88	2726	4324	1648	-561	58236
89	2771	4372	1648	-737	64809
90	2846	4546	1593	-836	69146
91	2905	4721	1627	-1054	81853
92	2962	5088	1715	-1550	92902
93	3056	5329	1640	-1893	102720
94	3150	5513	1708	-2249	117375
95	3243	5706	1733	-2693	134000
96	3358	6059	1855	-3052	152758
97	3496	6038	1907	-3180	160465
98	-	-	-	-	172207

'(1) Incluye servicios financieros, seguros, arriendos de inmuebles y servicios prestados a empresas.
'(2) Incluye además educación y salud, pública y privada

Source: Banco Central – Chile

TABLE A-5-2. Region III (Atacama) GDP by Sector at Current Prices (1996 – base) continued

III Región de Atacama - Producto Interno Bruto por clase de actividad económica. (B96)
(Millones de pesos de 1996)

	Agropecuario-silvícola	Pesca	Minería	Industria Manufacturera	Electricidad, Gas y Agua	Construcción
96	26396	11039	250519	18476	35060	47754
97	26177	10509	270953	19296	41006	49843
98	26566	8995	293179	15973	49722	64299
99	29136	9428	303759	14151	48679	45652
0	28532	9538	289954	15079	41448	48047
1	28153	10434	294837	16162	42224	62601
2	28453	11485	250035	16553	44306	72519
3	31021	18579	262392	17990	48993	54897
4	-	-	-	-	-	-

'(1) Incluye servicios financieros, seguros, arriendos de inmuebles y servicios prestados a empresas.
'(2) Incluye además educación y salud, pública y privada

III Región de Atacama - Producto Interno Bruto por clase de actividad económica. (B96)
(Millones de pesos de 1996)

	Comercio, Restaurantes y Hoteles	Transportes y Comunicaciones	Servicios Financieros y Empresariales (1)

96	47499	26475	27191
97	48914	28597	29045
98	45899	26644	29922
99	43738	24216	28975
0	45715	25989	30066
1	47979	26404	30343
2	48706	27938	30501
3	48737	28657	30650
4	-	-	-

'(1) Incluye servicios financieros, seguros, arriendos de inmuebles y servicios prestados a empresas.
'(2) Incluye además educación y salud, pública y privada

III Región de Atacama - Producto Interno Bruto por clase de actividad económica. (B96)
(Millones de pesos de 1996)

	Propiedad de Vivienda	Servicios Personales (2)	Administración Pública
96	40313	42563	18865
97	42034	45439	18903
98	43646	46303	18951
99	45099	46667	19366
0	46230	47568	19693
1	47338	50257	20129
2	48515	51660	20482

3	49674	53208	20908
4	-	-	-

'(1) Incluye servicios financieros, seguros, arriendos de inmuebles y servicios prestados a empresas.
'(2) Incluye además educación y salud, pública y privada

III Región de Atacama - Producto Interno Bruto por clase de actividad económica. (B96)
(Millones de pesos de 1996)

	Menos: Imputaciones Bancarias	Producto Interno Bruto
96	-6130	586020
97	-6502	624214
98	-6750	663349
99	-6355	652511
0	-6453	641406
1	-6517	670345
2	-6893	644260
3	-7319	658387
4	-	669684

'(1) Incluye servicios financieros, seguros, arriendos de inmuebles y servicios prestados a empresas.
'(2) Incluye además educación y salud, pública y privada

Source: Banco Central – Chile

TABLE A-5-3. Chile – population by age, sex and years

CHILE: Población total por sexo, segú años						
Terminados en 0 y 5 estimados al 30 de juino , según grupos						
quinquesales de edad. **1999 - 2020**						
GRUPO DE	**AÑOS**						
EDAD	1990	1995	2000	2005	2010	2015	2020
TOTAL	13.178.782	14.394.940	15.397.784	16.267.278	17.094.270	17.865.185	18.549.095
0-4	1.459.498	1.487.544	1.328.435	1.237.463	1.248.325	1.259.507	1.245.395
5-9	1.317.058	1.461.367	1.487.986	1.328.126	1.237.497	1.247.912	1.258.585
10-14	1.165.852	1.321.302	1.463.554	1.488.498	1.328.934	1.237.791	1.247.578
15-19	1.235.643	1.170.027	1.322.956	1.463.158	1.488.317	1.328.427	1.236.847
20-24	1.237.943	1.240.689	1.172.379	1.322.128	1.462.342	1.486.755	1.326.425
25-29	1.268.512	1.242.813	1.242.260	1.171.107	1.320.741	1.459.635	1.483.179
30-34	1.106.437	1.272.062	1.243.236	1.239.874	1.169.556	1.317.682	1.455.216
35-39	883.498	1.107.665	1.269.543	1.239.003	1.236.191	1.165.611	1.312.293
40-44	740.232	881.377	1.101.809	1.261.636	1.231.974	1.228.946	1.158.477
45-49	633.749	734.101	872.593	1.090.382	1.249.164	1.220.001	1.217.060
50-54	505.019	622.864	720.989	857.796	1.072.667	1.229.337	1.201.177
55-59	445.704	489.157	603.577	700.924	835.126	1.045.250	1.199.134
60-64	378.904	422.191	464.960	577.002	671.677	801.793	1.005.170
65-69	290.004	347.322	389.561	432.884	539.279	629.844	754.047
70-74	221.466	252.131	305.395	348.283	389.319	487.591	572.158
75-79	150.917	177.237	205.815	256.350	295.148	332.591	419.566
80+	138.346	165.091	202.736	252.664	318.013	386.512	456.788
HOMBRES	6.511.708	7.121.081	7.620.300	8.052.564	8.461.322	8.839.232	9.170.100
0-4	742.803	757.255	676.302	630.199	635.810	641.576	634.447
5-9	669.840	743.434	757.184	675.971	630.053	635.444	640.984
10-14	591.567	671.774	744.304	757.261	676.214	629.997	635.127
15-19	625.363	593.186	671.992	743.521	756.626	675.514	629.163

20-24	624.458	626.136	592.799	670.186	741.727	754.615	673.582
25-29	637.010	624.525	624.702	590.486	667.792	738.730	751.417
30-34	553.562	636.656	622.554	621.698	588.124	664.678	734.988
35-39	439.694	552.489	633.298	618.613	618.163	584.607	660.406
40-44	365.038	437.097	547.536	627.266	613.175	612.713	579.406
45.49	308.562	360.424	430.758	539.610	618.588	604.884	604.533
50-54	242.581	301.517	351.790	420.961	527.804	605.330	592.269
55-59	208.366	232.757	289.380	338.904	406.235	509.906	585.498
60-64	172.853	194.258	217.906	272.780	320.361	384.868	484.046
65-69	127.785	154.758	175.126	198.612	249.712	294.376	354.798
70-74	92.885	107.016	131.241	151.602	173.101	218.907	259.385
75-79	59.609	69.889	82.581	105.023	122.538	141.166	179.863
80+	49.732	57.920	70.847	89.871	115.299	141.921	170.188
MUJERES	6.667.074	7.273.859	7.777.484	8.214.714	8.632.948	9.025.953	9.378.995
0-4	716.696	730.289	652.133	607.264	612.515	617.931	610.948
5-9	647.218	717.933	730.802	652.155	607.444	612.468	617.601
10-14	574.285	649.528	719.250	731.237	652.720	607.794	612.451
15-19	610.280	576.841	650.964	719.637	731.691	652.913	607.684
20-24	613.485	614.553	579.580	651.942	720.615	732.140	652.843
25-29	631.502	618.288	617.588	580.621	652.949	720.905	731.762
30-34	552.875	635.406	620.682	618.176	581.432	653.004	720.228
35-39	443.804	555.176	636.245	620.390	618.028	581.004	651.887
40-44	375.194	444.280	554.273	634.370	618.799	616.233	570.071
45.49	325.187	373.677	441.835	550.772	630.576	615.117	612.527
50-54	262.438	321.347	369.199	436.835	544.863	624.007	608.908
55-59	237.338	256.400	314.197	363.020	428.891	535.344	613.636
60-64	206.051	227.933	247.054	304.222	351.316	416.925	521.124
65-69	126.219	192.574	214.435	234.272	289.567	335.468	399.249
70-74	128.581	145.115	174.154	196.681	216.218	268.684	312.773
75-79	91.308	107.348	123.234	151.327	172.610	191.425	239.703
80+	88.614	107.171	131.889	162.793	202.714	244.591	286.600

Source: National Institute of Statistics (INE) Population Projection

TABLE A-5-4. Region III (Atacama) – population by age, sex and years

REGIÓN DE ATACAMA: Población total por sexo, segú años
Terminados en 0 y 5 estimados al 30 de juino , según grupos
quinquesales de edad. **1999 - 2020**

GRUPO DE EDAD	AÑOS						
	1990	1995	2000	2005	2010	2015	2020
TOTAL	228.412	245.155	260.19	270.371	280.543	290.71	299.954
0-4	27.715	28.336	24.809	22.389	22.495	22.732	22.420
5-9	24.354	27.063	27.562	24.407	22.028	22.153	22.413
10-14	20.984	24.128	27.004	27.016	23.985	21.635	21.775
15-19	20.243	18.718	22.238	25.365	25.613	22.793	20.478
20-24	20.820	20.939	18.036	19.983	23.224	23.765	21.233
25-29	22.941	19.973	19.920	18.406	20.301	23.640	24.186
30-34	19.989	21.665	21.372	30.184	18.822	20.579	23.952
35-39	16.318	19.582	21.939	21.191	20.082	18.810	20.396
40-44	12.892	15.152	18.680	21.290	20.708	19.659	18.440
45-49	10.501	12.281	14.736	17.773	20.430	19.980	18.992
50-54	8.298	10.072	11.544	14.051	16.996	19.667	19.341
55-59	7.161	7.730	9.251	10.935	13.355	16.188	18.843
60-64	5.791	6.539	7.273	8.634	10.226	12.533	15.223
65-69	3.884	5.109	6.012	6.631	7.905	9.394	11.564
70-74	2.849	3.434	4.451	5.318	5.920	7.099	8.480
75-79	1.901	2.353	2.845	3.731	4.505	5.078	3.134
80+	1.771	2.081	2.518	3.067	3.948	5.005	6.076
HOMBRES	117.244	125.463	132.494	137.869	143.199	148.463	153.205
0-4	14.098	14.417	12.628	11.393	11.449	11.571	11.417
5-9	12.399	13.631	13.861	12.401	11.188	11.253	11.387
10-14	10.742	12.383	13.866	13.628	12.226	10.026	10.097
15-19	10.395	9.804	11.254	13.111	12.974	11.674	10.493

20-24	10.668	10.744	9.239	10.152	12.119	12.103	10.948
25-29	11.816	10.192	10.214	9.495	10.331	12.390	12.364
30-34	10.342	11.155	11.016	10.377	9.779	10.490	12.605
35-39	8.636	10.186	11.297	10.984	10.382	9.876	10.458
40-44	6.755	7.856	9.541	10.935	10.724	10.147	9.708
45.49	5.527	6.460	7.724	9.071	10.484	10.353	9.794
50-54	4.362	5.225	5.959	7.341	8.636	10.049	9.993
55-59	3.811	4.104	4.786	5.618	6.964	8.199	9.592
60-64	2.990	3.343	3.732	4.430	5.209	6.500	7.658
65-69	1.841	2.504	3.004	3.339	3.988	4.702	5.912
70-74	1.353	1.661	2.190	2.616	2.942	3.539	4.194
75-79	812	1.005	1.241	1.792	2.163	2.466	2.989
80+	697	792	942	1.186	1.641	2.125	2.596
MUJERES	111.168	119.693	127.696	132.502	137.344	142.247	146.749
0-4	13.617	13.919	12.181	10.960	11.046	11.161	11.011
5-9	11.955	13.432	13.701	12.006	10.840	10.900	11.026
10-14	10.242	11.745	13.138	13.388	11.759	10.609	10.678
15-19	9.848	8.914	10.984	12.254	12.639	11.119	9.985
20-24	10.152	10.195	8.797	9.831	11.102	11.662	10.285
25-29	11.125	9.781	9.706	8.911	9.970	11.250	11.822
30-34	9.647	10.510	10.356	9.807	9.043	10.089	11.347
35-39	7.682	9.396	10.642	10.207	9.700	8.934	9.938
40-44	6.137	7.296	9.139	10.355	9.984	9.512	8.732
45.49	4.974	5.821	7.012	8.702	9.946	9.627	9.198
50-54	3.936	4.847	5.585	6.710	8.360	9.618	9.348
55-59	3.350	3.626	4.465	5.317	6.391	7.989	9.251
60-64	2.801	3.196	3.541	4.204	5.017	6.033	7.565
65-69	2.043	2.605	3.008	3.292	3.917	4.692	5.652
70-74	1.496	1.773	2.261	2.702	2.978	3.560	4.286
75-79	1.089	1.348	1.604	1.939	2.342	2.612	3.145
80+	1.074	1.289	1.576	1.881	2.307	2.880	3.480

Source: National Institute of Statistics (INE) Population Projection