ECONOMIC GROWTH, ECOLOGICAL LIMITS, AND THE EXPANSION OF THE PANAMA CANAL

Mark Brooks
Department of Geography
McGill University
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Abstract

This thesis explores the controversial Panama Canal expansion proposals using an analytical framework developed by Herman Daly, an ecological economist at the University of Maryland and a critic of traditional models economic development. At a time when nearly every nation seeks to increase the size of its economy, Daly has been an ardent advocate of setting limits to economic growth, arguing that, as the earth is materially closed, there cannot be infinite growth of the consumption of material and energy resources within a finite (non-growing) biosphere. These limits should be defined by the regenerative and waste absorptive capacities of the biosphere. My objective here is to test the feasibility of implementing a policy at the local resource management level that is guided by the recognition of ecological limits to economic growth. I employ a water management technique developed by The Nature Conservancy called the Range of Variability Approach (RVA) and test its utility in setting an ecologically-based limit to water withdrawal and river system modification in the Panama Canal watershed. In doing so, I also investigate the benefits and shortcomings of Daly's work in contributing to resource management issues and economic planning at the local level. The canal expansion is fundamentally an initiative that has arisen in response to a perceived need to foster continued economic growth for Panama and to maintain the canal's importance to global shipping. However proceeding with the expansion is likely to be extremely expensive and result in significant social and environmental costs. Chapter 1 begins by reviewing those of Daly's ideas that are most pertinent to my purposes here and contrasts them with prevailing neoclassical economic views. Chapter 2 is an exploration of the canal expansion proposals themselves. Chapter 3 considers some of the important risks and opportunities associated with the project. Chapter 4 presents the results of a RVA analysis and concludes that it is a potentially useful policy instrument in dealing with economic scale issues at a local level. I also revisit Daly's ideas presented in the first chapter to assess both the viability of the Panama Canal expansion proposals from an ecological economics perspective as well as the merits of Daly's work in contributing to local resource management issues and decision making.

Résumé

Cette thèse se veut une investigation des controversées propositions d'expansion du canal de Panama à la lumière des structures analytiques développées par Herman Daly, économiste de l'écologie a l'université du Maryland, dont on connaît les critiques des modèles traditionnels de développement. A l'heure où chaque nation cherche à faire croître la taille de sa propre économie, Daly se pose en un ardent défenseur de limites à la croissance économique. Puisque la terre est matériellement close et par la même la biosphère un entité finie a croissance nulle, le monde ne peut selon lui se prévaloir d'une croissance infinie de la consommation de matières premières et des ressources énergétiques. Celui-ci devrait au contraire fixer pour limites à sa consommation galopante les capacités d'absorption et de régénération de la même biosphère. Cette thèse à l'ambition mesurée d'évaluer la faisabilité d'implémentation d'une politique de gestion des ressources à l'échelle locale guidée pas ces mêmes idées. Une technique de gestion de l'eau dénomme Approche par Intervalles de Variabilité (AIV) est ainsi utilisée afin de tester l'impact d'une limite écologique impose au montant d'eau consommée et aux modifications du bassin versant du canal de Panama. L'objectif est par la même de mesurer les bénéfices et les limites des travaux de Daly à l'échelle locale. Les idées de Daly sont utilisées afin d'évaluer la viabilité des projets d'expansion du canal au regard d'une économie écologique et de démontrer leurs mérites dans le cadre de prises de décision et de gestion des ressources au plan local.

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Chapter 1: Economic Growth and Ecological Limits

1.1 Introduction

Governments and international organizations today increasingly recognize the importance of environmental sustainability to achieving long-term development objectives. Despite this, many development initiatives have been criticized for encouraging ecologically unsustainable increases in the production and consumption of resources through policies designed to stimulate economic growth (Brown 2001; Wackernagel and Rees 1996; Daly 1996, 1991; Daly and Cobb 1996). The need to limit human impacts on the ecological systems that support us is clear; but how we are to achieve this goal is a matter of continuing debate.

In an effort to contribute to this important discussion, this thesis explores the controversial Panama Canal expansion proposals using an analytical framework developed by Herman Daly, an ecological economist at the University of Maryland and a critic of traditional models of economic development. As the canal, completed in 1914, is approaching its daily transit capacity limit and cannot accommodate the growing fleet of post-Panamax sized vessels – ships that are too large to fit within the capacity restrictions of the locks – a construction of a third set of larger locks is being considered by the Autoridad del Canal de Panamá (ACP), the government agency responsible for the canal's administration and operations. Despite the expected social and environmental impacts, canal modernization has been deemed essential by the ACP in order to remain competitive and foster continuing economic growth for Panama (Sabonge pers. comm. 2004; Miguez pers. comm. 2004).

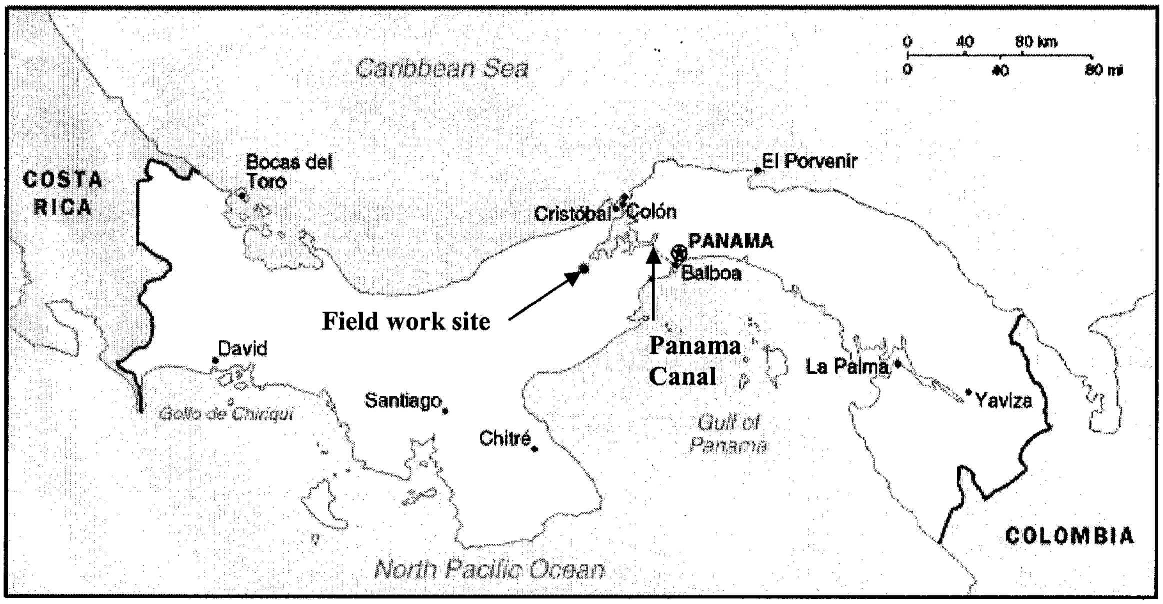
At a time when nearly every nation today seeks to increase the size of its economy, Daly (1994, 1996) has been an ardent advocate of setting limits to economic growth, arguing that, as the earth is materially closed, there cannot be infinite growth of materials and energy consumption within a finite (non-growing) biosphere. For instance, as sustaining current levels of energy consumption depends upon on the rapid depletion of natural capital in the form limited fossil fuel reserves, it is possible that, barring a major technological breakthrough, humans may eventually have to live only on energy resources provided directly (e.g. solar panels) or indirectly (e.g. hydropower, wind power, etc.) by the sun. Unrestrained economic growth is an ecological impossibility according to Daly if, by *growth,* we mean a perpetually increasing flow of materials and energy through the global economy (1996).

Although economic growth is not solely caused by increases in the consumption of resources, the rapid economic growth and rising material standards of industrialized countries in recent decades have been supported by accelerating levels of resource and energy consumption (Wackernagel and Rees 1996). A nation's economic growth is measured by its Gross Domestic Product (GDP). The main cause of GDP growth is considered to be an increasing level of potential output which is in turn due to increases in the supplies of labour and capital (Ragan and Lipsey 2005). Output will increase when technological improvements increase productive efficiency or when there is growth in the labour force, human capital, or physical capital (including the consumption of natural resources). As stated by Ragan and Lipsey (2005) in their introductory macroeconomics textbook, "We can account for growth in real GDP by increases in the *amount* of available factors of production, increases in the *quality* of the available factors of production, or increases in the state of *technology* that determines how much output we are able to get from a given set of factors of production" (p. 643, italics in original).

While it is generally acknowledged that economic growth will not solve all environmental problems and indeed can even exacerbate them (World Bank 2002), much current development policy continues to promote growth as an effective strategy to both alleviate poverty and improve the environment (World Bank 1992, 2003; WCED 1987; UN 1992, 2002). This study aims to consider the role of economic growth in contributing to environmental and social degradation by considering the implications of the Panama Canal expansion proposals as they might be viewed through Daly's lens. The objective of my investigation is threefold: 1) to test the usefulness of a water management technique called the Range of Variability Approach as a potential policy instrument in helping to determine appropriate economic scale at a local level; 2) to understand if Daly's work helps us to advance our understanding of natural resource management, economic development, and sustainability; and 3) using Daly's analytical framework, to speculate on the advantages and disadvantages of proceeding with the canal expansion as it is proposed.

1.2 Methodology

A total of 11 months of field work was undertaken in Panama between January 2003 and June 2004 (Map 1.1). Most of the work was carried out in Panama City based at the Smithsonian Tropical Research Institute (STRI) under the supervision of Dr. Stanley Heckadon. Numerous interviews were conducted with parties relevant to the canal expansion proposals in an effort to understand the plans under consideration and the motivation for the expansion proposals (see Appendix 1 for a complete list of interviewees and a summary of the interview methodology utilized). Interviews were conducted with employees of the Autoridad del Canal de Panamá (ACP) including representatives of the following departments: Environment, Corporate Planning, Marketing and Finance, Sociology, Hydrology, Canal Capacity Projects, and the Master Planning Team. I also spoke with ex-Panama Canal Commission executives; non-governmental organizations such as Pastoral Social-Carítas Panamá (social justice branch of the Catholic church in Panama), Centro de Estudios y Acción Social Panameño (CEASPA), the Conservation Strategy Fund, and The Nature Conservancy (Panama office); Pronat, a government agency responsible for land titling in the canal watershed; independent companies commissioned by the ACP to execute studies in the region; the Inter-Institutional Commission of the Panama Canal Watershed (CICH); the Panama Ports Company; shipping companies; faculty members from the University of Panama; the Canal Pilots Union; and the Coordinadora Campesina Contra las Embalses (CCCE) – a rural peasants organization opposed to the construction of a new dam in the canal watershed. Resource materials were obtained directly from interview subjects and from other sources such as the library of the Autoridad del Canal de Panamá, the Smithsonian Tropical Research Institute library, the Institute for the Study of the Panama Canal at the University of Panama, academic journals, newspaper and popular magazine articles, books, and various internet websites.



Map 1.1. The Republic of Panama showing the Panama Canal, Panama City, and the location of communities where field work was carried out (Limón de Chagres and Boca de Uracillo).

Work was also carried out in two communities in the watershed that may be flooded by a new reservoir should the canal expansion proceed: Limón de Chagres and Boca de Uracillo in the province of Colón. Both towns are situated in the interior of the country along the banks of the Río Indio, with only a few kilometers (or an approximate 1 hour walk) separating the two (see maps in Appendix 4). Field work involved meeting with community members on an informal basis in their homes over a total period of 2 weeks to discuss their feelings about the canal expansion and the possible inundation of their lands, as well as more general conversations regarding their community and family histories, means of livelihood, problems facing their communities, and so on. There were no formal questionnaires or surveys used for this study as it is not strictly speaking a social survey and it was therefore felt that questionnaires would not be necessary to meeting project objectives.

The quantitative component of my research involved a hydrological analysis of the Río Indio's daily flow regime over a 20-year period. I analyzed the river's streamflow data using an analytical technique developed by river ecologists at The Nature Conservancy called the Range of Variability Approach (RVA). Although other water management techniques exist, the RVA was chosen for its capacity to set limits to the qualitative (flow regime) and quantitative (flow amount) alteration of river systems based on the ecological requirements of the system. Rather than merely prescribing minimum flow requirements, the RVA offers an approach to freshwater resource management that considers the entire river ecosystem rather than only selected species and it recognizes the biophysical system as a legitimate water user. Not only is maintaining a river's natural flow regime recognized in the ecological literature as being essential to the ecological health of the whole system, but such a prescription also fits well with Daly's ideas regarding optimum scale as we shall see. The RVA is discussed in detail in chapter 4. My objective was to determine if the RVA might provide a means to help determine optimum economic scale based on the water requirements needed by a river to maintain natural functioning. This could potentially provide the basis for setting an ecological limit to water withdrawals and to modification of the Río Indio's flow regime. By determining in advance the optimal limit based on ecological criteria, it was hoped the RVA would prove to be a useful policy instrument in helping guide the normative, *social* decision of appropriate scale. The scale is limited to a level judged to be ecologically sustainable according to RVA criteria and, as Daly suggests, the issue of sustainable or optimal scale is settled at the outset before a resource can be unsustainably exploited.

1.3 Limits to Growth: the Anthropocentric and Biocentric Optimums

Economic growth has long been cited as an effective solution to environmental problems. Building upon the work of Simon Kuznets (1955), the Environmental Kuznets Curve was developed to explain a pattern whereby many countries seem to "grow" out of their environmental problems. The theory is that, as a country's economy grows and creates wealth, more resources will be available to deal with environmental deterioration (Stern 1998; Beckerman 1992; Grossman 1995). Indeed, wealthier nations do tend to have higher levels of environmental protection as their citizenry makes demands for such provisions. However, despite a fivefold increase in the size of the world economy since 1950 (World Bank 1997), environmental degradation continues and, in some cases, seems to be accelerating, even in countries with developed economies. Climate change, loss of biodiversity, soil degradation, and fisheries collapses may be symptoms of a global economy that has exceeded the capacity of the biosphere to sustain it.

In an effort to confront some of the most serious environmental problems, proposals to set limits on the emission of greenhouse gases, air and water pollutants, and chlorofluorocarbons among others, are being considered or have already been implemented. Moreover, many countries are now limiting their annual allowable cuts in forestry, and their fisheries harvests. Herman Daly (1994, 1996) argues that such limits should be applied not merely to individual resources but to the very size of the human economy itself. The maximum scale of the economy is limited by the regenerative or absorptive capacity of the ecosystem; however the economy's *optimum* scale is much smaller and can be distinguished by two concepts, both defined here by Daly (1996, pps. 51-52).

a. "The Anthropocentric Optimum – The rule is to expand scale (i.e. grow) to the point at which the marginal benefit to human beings of additional man-made physical capital is just equal to the marginal cost to human beings of sacrificed natural capital. All nonhuman species and their habitats are valued only instrumentally according to their capacity to satisfy human wants. Their intrinsic value (capacity to enjoy their own lives) is assumed to be zero.

b. "The Biocentric Optimum – Other species and their habitats are preserved beyond the point necessary to avoid ecological collapse or cumulative decline, and beyond the point of maximum instrumental convenience, out of recognition that other species have intrinsic value independent of their instrumental value to human beings. The biocentric optimal scale of the human niche would therefore be smaller than the anthropocentric optimum."

Economic growth beyond the anthropocentric optimum may in fact be *un*economic in that it increases aggregate environmental and social costs to humans faster than it increases production benefits (Daly 1996). In other words, continued economic growth beyond this point may not necessarily make us any better off when all costs are considered: if the scale of economic activity is too big relative to the ecological support base, natural capital depreciation, defensive expenditures against unwanted side effects of production and consumption, sacrificed ecosystem services, biodiversity loss, climate change, increased pollution, and other costs may well make us poorer although our economies continue to expand.

While further growth beyond the biocentric optimum scale may yet be economic in the sense described, Daly (1996) still advocates limiting economic activity to this point on the grounds that it is the more ethically sound alternative. Some consideration must be given to the moral justification for this assumption. The biocentric optimum reflects views espoused previously by the likes of Leopold (1949), Naess (1973), and Devall and Sessions (1985). Such a vision promotes a fundamentally transformative shift in thinking so that the entire community of living things is included within its purview (Brown 2001). More than an act of kindness, the biocentric ethic considers it a duty to respect the rights of other species to exist and flourish. Under this ideology, humans relinquish their role as conqueror of the earth to plain member and citizen of it (Leopold 1954). Species are recognized as having an inherent worth independent of their utility to humans. All species are recognized as having ecological importance and intrinsic value. Just as the human sphere of morality has expanded over time now to encompass all of humanity, so too can it be expanded again. Such an extension of ethics is, according to Leopold, a normal, perhaps inevitable, progression.

A neoclassical economist might argue that the biocentric optimum has no place in economic theory because economics is not a normative discipline. Yet as Brown (2001) points out, neoclassical economics does indeed have normative objectives: namely Gross Domestic Product (GDP) growth in macroeconomics and efficiency in microeconomics. As scientific and objective as it presumes to be, neoclassical economic theory is not ideologically neutral. It presents (even celebrates) a view of human nature as being fundamentally self-interested. This is an ethic, not a truism; and there is no consensus in favour of such beliefs.

Developing policies that recognize the existence of a biocentric or an anthropocentric optimum scale to economic activity will require a new approach to economic thinking according to Daly (1996): one that shifts our economy away from materials and energy expansion and towards qualitative improvement as the path of future progress. Daly's (1991) concept of steady-state economics describes a process of eventual zero-growth in materials and energy throughput in which the goal of economics is not economic growth but improved well-being through economic development. As economic growth in the form of higher GNP per capita has been shown, after a point, to no longer correlate with improved well-being (Wackernagel and Rees 1996; Seligman 2002), Daly and Cobb (1994) support Power's (1988) notion that qualitative development should include the following list of policy goals:

1. The availability of satisfying and useful work for members of the community.
2. Security for members of the community in access to biological and social necessities.
3. Stability in the community.
4. Access to the qualities that make life varied, stimulating, and satisfying.
5. A thriving, vital community.

Following Shue (1980), Brown (2001) advocates a tripartite rights-based concept which contains three rights, each of which must be satisfied "for a society to be just and for development to be successful" (p. 20). These are the rights of bodily integrity, rights of moral, political, and religious choice, and subsistence rights. These rights enshrine not only the right to security against murder, torture, and assault, but crucially, also the right to clean air and water, adequate food provisions and shelter, and a basic level of health care for those who cannot provide for themselves. Amartya Sen (2000) promotes a concept of development that does not emphasize aggregate wealth as an indicator of well-being but rather focuses on expanding the real freedoms that people enjoy as a more sentient objective of development policy. These include expanded economic opportunities, political freedoms, social facilities, transparency guarantees, and protective securities.

My assessment of the viability of the canal expansion proposals in Chapter 4 will be guided by these conceptions of well-being and development as a process of qualitative social and ecological improvement. Improved well-being will be considered not simply the result of an increase in the physical scale of the matter/energy throughput that sustains the economic activities of production and consumption, but the result of improved technical knowledge, efficiency increases, and a deeper understanding of purpose (Daly and Cobb 1994). Although an important contribution to economic thinking, Daly's ideas about qualitative improvement as a policy goal are vague and their applicability to local resource management and decision making unclear. My objective here, therefore, is to test the feasibility of implementing policy at the local level that is guided by the recognition of ecological limits to macroeconomic growth and inspired by the goal of achieving qualitative improvements in social, ecological, and economic health. Before proceeding further, however, a closer examination of some of Daly's central arguments is essential.

1.4 Herman Daly and Ecological Economics

While Daly (1994, 1996) makes a number of arguments that cover a broad range of economic issues, several are particularly relevant to our purposes here. Each is described below, contrasted with the traditional neoclassical economic view, and placed within either an anthropocentric and biocentric context where relevant. These points will be revisited again in Chapter 4 as part of an analysis of the Panama Canal expansion proposals as they might be seen through Daly's lens.

1.4.1 Optimal Scale and Optimal Allocation

Neoclassical economic theory tends to view environmental problems as market failures. Get the prices right by internalizing environmental and social costs, and the problems can be solved with market solutions. For example, in an efficiently functioning market that fully internalizes environmental costs, the price of gasoline would likely be much higher than it is today if public health costs due to air pollution and the costs of climate change were included. Higher prices would create a demand for cheaper, cleaner energy and a profit incentive for firms to meet this demand. Leaving aside the question of whether environmental and social costs can be accurately internalized, Daly (1994, 1996) claims that, even if we were able to get all prices "right" in this manner, neoclassical economics provides no answer to the question of how big the size of the economy should be. Just as an overloaded boat will sink even if its weight is optimally distributed, a properly allocated economy cannot be sustained if its size is too big relative to the ecological support base. This is a question of scale – the physical size of the economy in terms of population per capita resource and energy use.

Daly believes therefore that economic scale issues should be treated as fundamentally different from allocation issues. While problems with the latter can be solved by properly functioning, efficient markets, problems with the former cannot. Different policy goals require different policy instruments. An anthropocentric or biocentric optimal scale is a macroeconomic goal that is not determined by prices but is a social decision reflecting ecological limits. Prices serve efficiency; income redistribution policies serve equity; scale requires some 3rd policy instrument – one that predetermines acceptable volumes of resource flows based on the renewable biospheric capacities of regeneration and waste absorption (Daly 1996).

The policy instrument I will use to attempt to measure the biocentric and anthropocentric optimum scale in the case of the Panama Canal expansion project will be the Nature Conservancy's Range of Variability Approach (RVA). Described in detail in chapter 4, the RVA characterizes important ecological attributes of a river's natural flow regime and then recommends limitations to its hydrological modification. RVA guidelines may help to determine different optimum scales based on the water requirements needed to maintain a river ecosystem at varying functional levels. Assisted by RVA results and analysis, resource managers and other stakeholders may then be able to agree upon a limit that is judged to be both ecologically sustainable and socially acceptable.

1.4.2 The economic system and the ecological system

Neoclassical macroeconomic theory posits that a growing economy can be achieved through technological advances (improved efficiency) or an expanding resource supply (McConnell et al. 1996). Resources in this sense could mean the total supply of labour, capital, entrepreneurial ability, or natural resources. Labour and capital are typically viewed as the limiting factors of production while natural capital is presumably either unlimited or, due to resource and capital substitutability, its limits are not relevant. If we were to run out of a resource such as fish, we can simply substitute some other resource in its place, such as soybeans. Moreover, as human and natural capital are treated as substitutes in neoclassical economics, the shortage of one does not necessarily limit the productivity of the other. This view holds that it is perfectly acceptable to deplete natural capital if human capital increases sufficiently to compensate for the loss. As one introductory macroeconomics textbook states,

> *"The stock of capital will affect the capacity of an economy...The discovery of new sources of energy and mineral resources will contribute to increasing output. The greater abundance of resources results in a greater output."* (McConnell et al. 1996, p. 34-35)

While biomass does technically grow and carbon deposits therefore increase over time, significant increases take place on a geological time scale. Growth of material and energy consumption is occurring at a rate many times faster than the growth of global biomass and carbon reserves are meanwhile being rapidly depleted at a rate many times faster than their replacement. Daly (1996) argues, therefore, that the economy is an open subsystem of a larger, finite, materially closed, effectively non-growing ecosystem. The economy depends on the ecosystem for a steady provision of material resources. As the economy grows, it requires more resources and produces more wastes. The solar flux and the turnover rates of biogeogchemical cycles stay roughly constant. Therefore as the economy grows it becomes larger relative to the ecosystem and stresses it to an ever greater degree. A subsystem cannot grow beyond the scale of the total system (the biosphere). The total system provides services that the subsystem cannot provide for itself; therefore at the anthropocentric optimum, the subsystem must be limited to the extent that it avoids debilitating the ability of the parent system to provide services to humans. At the biocentric optimum, the subsystem would be limited still further so that the parent system is not impeded in its ability to provide habitat and resources sufficient for the survival of other species.

While labour or human capital can still be a limiting factor of production, it is natural capital that is becoming the increasingly important limiting factor in a resource scarce world according to Daly (1996). Human capital fundamentally depends on natural capital, making them complements, not substitutes. To use Daly's (1996) example, fishery harvests are limited by the number of fish remaining in the ocean (natural capital) not by the number of fishing boats available to catch them (human capital). Moreover, while some resources may be theoretically substitutable (e.g. soybeans for fish, bricks for lumber), dismissing concerns over resource depletion based on this assumption ignores larger ecological consequences as well as the adverse effects on regional employment and culture (Brown 2001). Significantly, some resources such as available freshwater or clean air are simply not substitutable. To disregard the depletion of basic, life-sustaining elements based on an assumption of infinite resource substitutability should be considered injudicious in the extreme.

According to neoclassical economic theory, humans work to economize on scarce resources and the limiting factor of production which, in Daly's (1996) view, is natural capital in a resource scarce world. However, with an objective of increasing economic growth, Daly believes current macroeconomic policies do just the opposite: encouraging the consumption and depletion of limited natural capital reserves such as fossil fuels, fisheries, and forests. Daly suggests this is because macroeconomic activity is not conceived in neoclassical economic theory as having an optimum extent. There is no point at which marginal costs of further growth become greater than the marginal benefits. Because the macroeconomy is not seen as being part of anything larger, it can grow forever; there is no absolute scarcity limiting scale. In microeconomics, the Law of Diminishing Marginal Utility recognizes an optimal point at which the additional benefits (utility) to be gained by a consumer in an economic transaction will eventually be equal to or less than the cost of the transaction. In other words, after a certain point, there is no additional utility to be gained by the consumer in continuing to purchase the commodity because the benefits of doing so will be outweighed by the costs. By implication, the economic activity should not grow beyond this point.[1] When all microeconomic units are aggregated however, Daly (1996) claims the notion of an optimal point beyond which further growth becomes uneconomic disappears completely.

The term *un*economic is subject to a number of interpretations. In the strictest sense of the term, it could simply mean for example that the Panama Canal expansion project is unable to meet projected construction costs without seriously debilitating national expenditures in other areas such as health, education, or poverty eradication. The

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[1] Law of Diminishing Marginal Utility: "The utility that any consumer derives from *successive* units of a particular product diminishes as total consumption of the product increases (if the consumption of all other products is unchanged)." (italics in original). From: Lipsey and Ragan 2001, p. 129.

costs of the project, however, are not limited to construction expenditures alone and should also include social, environmental, and other impacts. While cost-benefit analyses for the project may include some environmental and social accounting, attempting to correctly internalize all project costs can be unfeasible because some costs are extremely difficult to quantify in monetary terms (Ackerman and Heinzerling 2004; Daly and Cobb 1994). Moreover, overall well-being (human and ecological) may not necessarily improve simply because perceived benefits outweigh costs. Costs may not be shared equally and, if the scale of economic activity is still too big relative to the ecological support base, we may be worse off in the end (Daly 1996).

For example, as numbers of individuals in a species decline and their scarcity increases, perhaps due to conversion of their habitat for economic subsistence purposes, their existence value – according to neoclassical economic theory – and interest to save them should rise dramatically. In other words, the benefits of saving the species should outweigh the costs of doing so. However, this is not always the case. In fact, their scarcity could be precisely what ultimately seals their extinction if it creates an incentive to hunt the remaining few individuals for trophies (Mowatt 1984). Moreover, even if scarcity does cause their value to rise dramatically, an exorbitant price value for the remaining individuals does not ensure their protection if someone is still willing to pay any price for the privilege of hunting them.

Advocates of traditional cost-benefit analysis may yet argue the process still works because the remaining individuals' must have had greater economic value dead than they did alive or they would have been preserved; however, such analysis reveals the important difference between biocentric and anthropocentric worldviews. The anthropocentric view cannot account for the ecological loss or the existence value of the species. As economic scale pushes ecological limits and a species is threatened with extinction, economic benefits in saving the species may still not outweigh costs, yet we (and the species itself!) can be worse off in the end with its loss.

1.4.3 National Accounts

Currently, the economic goal of almost every nation is to maximize GNP (Gross National Product), the standard measure of a country's economic productivity and income. A higher GNP is equated to higher standards of living and a higher well-being. However, it is well-recognized that GNP, as a measure of total economic activity and income, includes costs that by any measure do not contribute to well-being. For example, an oil spill that devastates a marine environment and requires a massive clean-up effort will increase a nation's GNP. Higher rates of skin cancer due to a depleted ozone layer call for more medical treatment and thus contribute to GNP. An increase in traffic accidents causing death will lead to more medical provisions, insurance services to assess costs, and possibly legal services if liability is involved: all these increase the GNP. These, according to Daly, are defensive expenditures against the unwanted side effects of economic growth and should be subtracted from, not added to, a country's GNP.

In addition to its inability to measure economic "bads", GNP is not even an accurate measure of the "goods" that contribute to human well-being. Only human activities that are rewarded by payment are taken into account in calculating GNP; all others, such as family tasks, volunteer work, caring for children, leisure time activities, are not included in standard economic indicators. Moreover, as natural capital consumption also contributes to GNP, declines in our natural capital reserves (forests, fisheries) are being counted as income. Daly (1996) insists therefore that our system of national accounting is incomplete and it works to maximize costs and resource throughput. As an alternative, Daly proposes that the GNP be modified and renamed the Sustainable Social Net National Product (SSNNP) (figure 1.1). The SSNNP should equal the Net National Product (GNP minus depreciation of human capital) minus defensive expenditures (DE) against unwanted side effects of production and consumption minus depreciation of natural capital (DNC).

Net National Product (NNP) – Defensive Expenditures (DE) – Depreciation of Natural Capital (DNC)

= Sustainable Social Net National Product (SSNNP)

Fig. 1.1. Daly's (1996) equation for the Sustainable Social Net National Product

Although Daly does not clarify this point, presumably the SSNNP could be either an anthropocentric or biocentric measure depending on whether the DNC column accounts for biodiversity and habitat loss that has no appreciable impact on human welfare. A biocentric SSNNP would therefore produce a lower measure even when all other values and inputs are the same. In both cases, proper measurement of income requires that natural capital maintenance takes priority. The optimum anthropocentric or biocentric scale would be measured by 3 national accounts – costs, benefits, and capital – instead of just one (GNP).

Although the SSNNP is a more accurate measure of economic activity and income, it is not an indicator of welfare. Daly and Cobb (1994) therefore propose a new method by which to measure more accurately declines or improvements in welfare. They call it the Index of Sustainable Economic Welfare (ISEW) and, although it is based on contemporary mainstream economic ideas and is far from perfect, it better reflects actual changes in well-being. Policies directed to improvement as measured by the ISEW would almost certainly redirect economics to the service of community and sustainability. Daly and Cobb proceed in three steps:

1. They construct an indicator of aggregate welfare by taking into account the current flow of services to humanity from all sources (and not only the current output of marketable commodities which is relevant to economic welfare).
2. They deduct spending whose purpose is defensive and not welfare producing.
3. They account for the creation and losses of all forms of capital by adding the creation of human capital and deducting the depletion of natural capital.

The ISEW takes into account hidden costs such as defensive private spending on health and education, cost of commuting and auto accidents, cost of air, water, and noise pollution, loss of wetlands and farmland, depletion of non-renewable resources, costs imposed on future generations by the depletion of natural resources, and the long-term damage from nuclear wastes, greenhouse gases, and ozone depletion. Using the ISEW, the authors found that not only is GNP itself a misleading indicator of income, but *growth* of GNP per capita can give a misleading message about improved welfare. Including long-term environmental costs, the ISEW in the United States increased between 1950 and 1975 but has been constant or declining ever since. This is in contrast to a steady growth of GNP (see Appendix 3).

1.4.4 Impossibility Hypothesis

Levels of resource consumption in developed countries cannot be extended to the rest of the world. This is Daly's (1996) impossibility hypothesis and it is similar to other work that has attempted to characterize the total scope of human influence on the biosphere. Inspired by the rise in per capita energy and material consumption of the last 40 years, Wackernagel and Rees (1996) developed an ecological footprint model that measures the flows of energy and matter required to support the consumption and waste disposal habits of an individual, nation, or the entire global community and then converts these into a corresponding land/water area requirement. The ecological footprint is a measure of the "load" imposed by a given population on nature. Sanderson et al. (2002) expounded on this idea to develop the concept of the human footprint. By summing the total of ecological footprints of the human population, the authors calculated a total human influence index that showed 83% of the earth's land surface is already directly influenced by human beings. Wackernagel and Rees estimated that, based on the ecological footprint concept, we would require the resource equivalent of three more earths for everyone in the world to enjoy the same standard of living as the average North American.

1.5 Summary

This first chapter has presented several of Daly's criticisms of the shortcomings neoclassical economic theory. We have seen that traditional macroeconomic theory ignores issues of appropriate economic scale – the physical size of the economy relative to the biosphere. Daly believes scale issues are fundamentally different from allocation issues and therefore require different policy instruments to determine optimum levels. Optimal scale is not determined by prices but is a social decision that can be set at either an anthropocentric or biocentric optimum and should be guided by the regenerative and waste absorptive capacities of ecosystems. Economic scale beyond the anthropocentric optimum will be uneconomic in the sense that it will increase social and environmental costs to humans faster than it increases production benefits. Beyond the biocentric optimum, the marginal benefits to humans of increased economic scale may still outweigh the costs; however other species and their habitats may not be protected sufficiently to prevent continuing biodiversity loss, ecological decline, or ecosystem collapse. Chapter 4 will revisit the ideas presented in this chapter as part of an assessment of the viability of the Panama Canal expansion proposals from an ecological economics perspective. Before so doing, an in-depth evaluation and analysis of the proposed canal expansion plans is essential.

Chapter 2: The Panama Canal Expansion Proposals

2.1 A brief history of the Panama Canal

Completed in 1914 by the United States, the Panama Canal has been described as "one of the supreme achievements of all time" (McCullough 1977) and "the greatest liberty Man has ever taken with Nature" (Petroski 1997). Including the failed French effort to build a canal across the isthmus in the late 19^{th} Century, it is estimated that at least 20,000 workers died during construction of the 80 km waterway due primarily to yellow fever and malaria. The French had originally planned to construct the canal at sea level but excavation, particularly through the treacherous Gaillard Cut, proved to be much more difficult than anticipated. Panama's infamous torrential rains caused frequent landslides sometimes wiping out months of excavation work in minutes (McCullough 1977).

The original treaty that granted the United States the rights to construct a transit through the Isthmus was completed without a single Panamanian present and was described by John Hay, the American signatory, as "very satisfactory, vastly advantageous to the US" and "not so advantageous to Panama" (McCullough 1977). The most significant aspect of the original canal treaty was the creation of a 10-mile wide Canal Zone within which the US was granted all rights, power, and authority as if it were sovereign, US territory. Although the canal construction was completed in 1914, US dominion over the canal and within the Canal Zone was a continuing source of tension between the two countries. A new treaty was finally signed in 1977 between US President Jimmy Carter and Panamanian President Omar Torrijos that transferred ownership and control of the canal to Panama on December 31, 1999. It also provided for the phasing out of US military bases in Panama.

The United States almost did not build a canal in Panama, instead preferring at first a route through Nicaragua. Endowed with a large lake which would have reduced considerably the amount of excavation work required, Nicaragua had a natural advantage over its Central American neighbour to the south. When the U.S. finally settled upon Panama as their preferred location, perhaps more for political than geophysical reasons, it was decided that, rather than attempt a sea level canal as the French had done, the U.S. would create what already existed in Nicaragua (McCullough 1977). A dam was constructed at the Atlantic mouth of the Chagres River thereby creating a 163 square mile reservoir called Lake Gatún at 26 meters above sea level. Two sets of parallel locks able to accommodate two-way traffic would lift ships up to the lake where they could sail across and be lowered by another set of locks on the other side. A simple yet brilliant scheme, construction of the Panama Canal is considered, to this day, one of the great engineering triumphs of all time.

The canal's system of locks – compartments with entrance and exit gates – functions as a series of water steps (Fig. 2.1). Water enters the locks through a system of main culverts that extend under the lock chambers from the sidewalls and the center wall. As gravity carries water down from Lake Gatún to sea level, the locks fill to lift ships progressively higher until they eventually reach the level of the lake. Canal operations, then, are entirely dependent upon a reliable and continuous supply of vast quantities of fresh water – approximately 52 million gallons or 200 million liters per transit. An additional reservoir on the Chagres River, Lake Alhajuela, was constructed in 1935 to act as a water reserve for Lake Gatún, supplying additional water during dry periods and holding extra water when Lake Gatún is at full capacity.

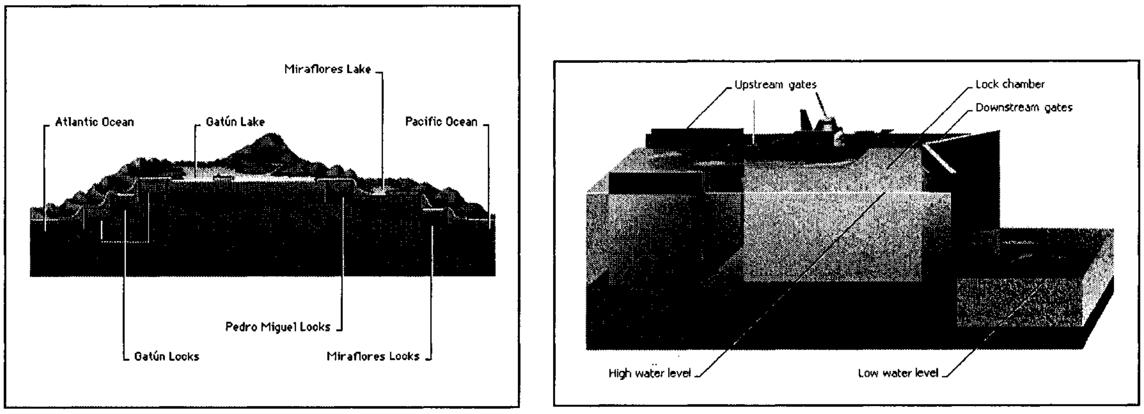
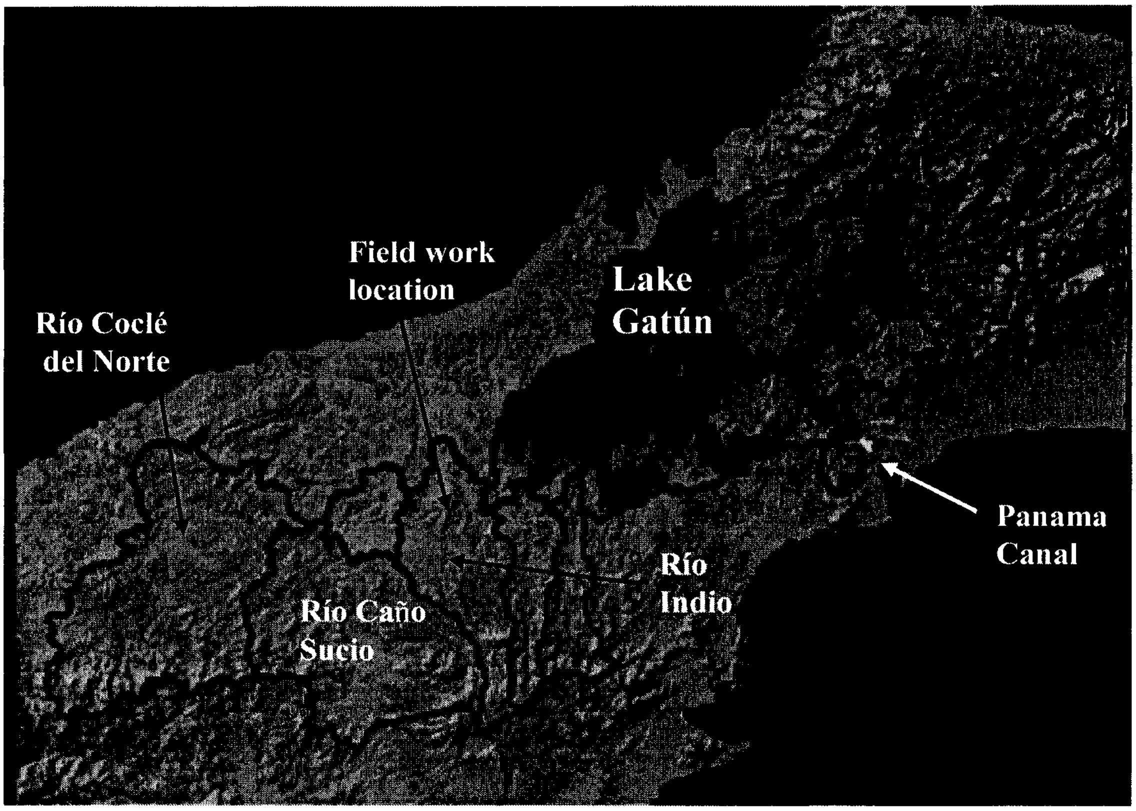


Fig. 2.1. Schematic illustrations showing operation of the Panama Canal. Ships are lifted by two sets of locks on the Pacific side (Pedro Miguel and Miraflores) and one on the Atlantic side (Gatún) to the level of Lake Gatún. Vessels sail across the lake to be lowered by the locks back to sea level. Locks are dependent upon a constant supply of freshwater from Lake Gatún which is in turn supplied primarily by the Chagres River. Source: www.pancanal.com

Since its construction, the canal's freshwater needs have been capably supplied by the mighty Chagres River which surges to extremely high volumes throughout Panama's 8-month rainy season (ACP 2004). In recent years, however, Lake Gatún has been experiencing occasional water shortages during Panama's dry season between December and April. The reservoir provides water not only for the canal but also for the inhabitants of Panama City, Colón, Arraijan, La Chorrera and San Miguelito. A burgeoning population and increasing canal transits are increasing water demands on the reservoir. The canal even experienced a water shortage during the last El Niño event in 1997 which restricted ship draft (reach under water) due to low water levels thereby reducing cargo capacity of transiting vessels (Vargas pers. comm. 2004).

Realizing that the water demands on Lake Gatún would eventually outstrip its supply, particularly in the event of an eventual canal expansion, the Panama Canal Authority initiated a process in the 1990's to enlarge the legal boundaries of the Panama Canal watershed. In 1997, the controversial Law 44 was passed by the Panamanian Legislative Assembly which added an additional 213,112 hectares west of the existing watershed boundary creating a total watershed size of 552,761 hectares or 7% of Panama's total land base (Hughes 2002; ACP 2004; Arosemena pers. comm. 2004a). The new boundaries encompassed major river basins west of Lake Gatún in the so-called Region Occidental (ROCC) including the Indio, Caño Sucio, and Cocle del Norte rivers (Map 2.1). Justified as being necessary to "supply the future needs of the population of Panama and the Canal" (ACP 2004; Panama Legislative Assembly 1999), Law 44 provided the ACP the authority they needed to explore water acquisition possibilities in the region. Their tentative plans at that time included the construction of 3 new dams and reservoirs in the ROCC that would flood an estimated $448km^2$ of land and potentially displace up to 35,000 people in order to supply additional water to Lake Gatún in the event of a future canal expansion (Hughes 2002; Lindsay-Poland 2002).



Map 2.1. Map shows the legal boundaries of the enlarged Panama Canal Watershed region and separate boundaries of the Lake Gatún, Río Indio, Río Caño Sucio, and Río Cocle del Norte watersheds

Opposition to the new law was swift. Formally approved on the last day of the outgoing Democratic Revolutionary Party's term in office, Law 44 immediately generated surprise and even outrage among inhabitants of the region, mostly poor campesino farmers and their families, who were not informed of the ACP's plans (Hernandez, F. pers. comm. 2004). A group called *La Coordinadora Campesina Contra las Embalses* or *CCCE* (The Organization of Peasants against the Reservoirs) was established to fight for the repeal of Law 44 and to oppose any plans involving the inundation of their lands. Among other activities, the CCCE has organized in communities throughout the new canal watershed and has staged numerous protests in the cities of Colón and Panama.

Although rejecting the Coordinadora's demands, the ACP has scaled back their plans to some extent. It seems they are no longer considering 3 new dams in the western watershed, believing instead that water demands can be reduced substantially through a combination of sophisticated water recycling technologies in the canal's locks and an increase in the storage capacity of existing reservoirs (Sabonge pers. comm. 2004; de la Guardia pers. comm. 2004). Despite these efficiency improvements, one new dam – most likely on the Indio but possibly on the Trinidad, or Cirí Grande rivers – will almost certainly be required should a decision be made to expand the canal. And, as far as the ACP is concerned, expand they must.

2.2 Justification for Expansion

The idea for a third canal lane had been considered as far back as the 1930s (Lindsay-Poland 2003; ACP 2004a). It was felt, and this view persists in some circles to this day, that a sea-level canal would be cheaper to maintain and easier to defend against attack. Even minor damage to the locks could render the canal impassable. As a critical transport and supply route, the security of the Panama Canal was considered to be of paramount importance to the U.S. government. So much so that the original agreement between the United States and Panama for the construction of the canal, the Hay-Bunau Varilla Treaty of 1903, included provisions granting the U.S. broad intervention into Panamanian affairs for exactly this reason (McCullough 1977). Even the Carter-Torrijos Treaty of 1977 grants the United States the right, even now, to intervene military if it is deemed that the security of the waterway is at risk (Carter-Torrijos Treaty 1977).

When plans for a sea-level canal were dismissed as being too expensive or unworkable, the United States began planning and preliminary excavation on a third set of locks in 1939 (Lindsay-Poland 2003). Amidst other pressing wartime demands, work was ultimately halted in 1942 and was not revived due to continuing concerns over the defensibility of a lock and lift canal. The U.S., still in pursuit of its canal at sea-level, then considered very seriously in the 1950s and 1960s the possibility of a nuclear excavation project through the largely uninhabited Darien province of eastern Panama bordering Colombia. Over 250 nuclear detonations were called for to complete the job at relatively minimal cost and with much greater efficiency than conventional excavation (Lindsay-Poland 2003). While fears that the detonations would cause structural damage to the current canal as well as to buildings 500 miles away in San Jose, Costa Rica, plans for a nuclear canal were finally derailed and the project terminated completely over the emerging safety and environmental concerns of radiation.

In 1997, a Universal Congress of the Panama Canal was held in Panama City. Bringing together a wide consortium of international engineers, consultants, and political representatives, the meeting served as a forum to discuss the current state of the canal and to make recommendations on its future. Out of this meeting came a proposal to expand the canal by building a third set of giant-sized locks able to accommodate so-called "post-Panamax" vessels (ships that are too large to fit through the canal's current capacity restrictions). The Congress concluded that, without modernization, the canal will become "progressively obsolete" in its importance to global shipping. Lake Gatún was also deemed insufficient to meet the future water needs of the canal and the demands of Panama's growing population (Proceedings 1997).

The Universal Congress recommendations were based to a large degree on the results of a multi-year Tri-Partite Commission study into canal alternatives, which was completed in 1993. A joint effort between Panama, the United States, and Japan, the Tri-Partite Commission was established to determine how the canal could best meet the demands of world commerce in the 21st century (Comisión de Estudio de las Alternativas al Canal de Panamá 1993). After considering various proposals including, yet again, the construction of a new canal at sea-level, the Commission recommended a 3rd set of locks be built adjacent to the current locks. A sea level canal was deemed to be much too expensive and to pose unacceptable ecological risks. The new locks would also use Lake Gatún to transit vessels but would be able to accommodate ships more than twice the tonnage of the current canal maximums. The Universal Congress ultimately agreed with the Tri-Partite Commission's recommendations, concluding that the canal was not fit to meet the needs of future maritime industries.

There exist two constraints to the canal currently: vessel size and the number of daily transits. The canal capacity constraint of approximately 47 transits per day and 17,000 per year is expected to be reached by 2012 (Fig. 2.2). Even now, upon arrival at the canal, vessels must queue an average of 24 hours before transiting. The canal is also unable to accommodate post-Panamax vessels (Proceedings 1997). Approximately 60% of vessels on order for construction in 1999 were post-Panamax (Neisten and Reid, 2001) and 30% of the global fleet is projected to be post-Panamax size by 2020 (Proceedings 1997). Without expansion, the Panama Canal will lose its importance to global shipping and become obsolete within a few years according to the ACP (Sabonge pers. comm. 2004). In 2000, 4.5% of global shipping traffic passed through the canal; however it has been estimated that this figure would have been as high as 33% had the canal already had a third set of locks at that time. With expansion, commercial growth of the canal is projected to increase 400% between 1990 and 2060 (Proceedings 1997).

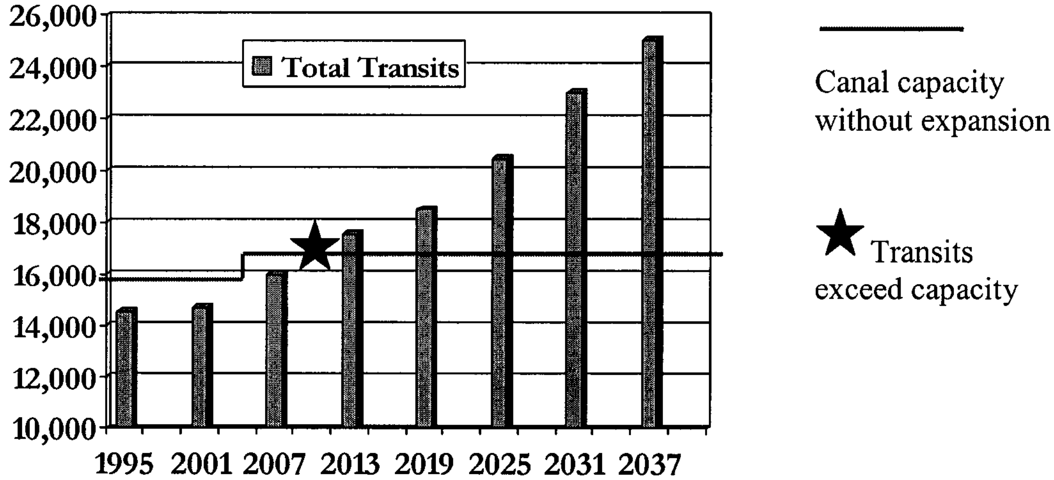


Fig. 2.2. Total annual canal transits are projected to rise, however canal capacity is currently limited to approximately 17,000 transits per year. The capacity restraint is expected to be reached by 2012 according to the Panama Canal Authority. The increase in capacity in 2003 was due the widening of the Gaillard Cut.

2.3. The Proposed Panama Canal Expansion Project

Various studies into the viability of canal expansion have been carried out by the ACP and are now in the process of completion. An announcement of the ACP Master Plan for the Panama Canal is expected to be made in July or August 2004 (Mitre pers. comm. 2004; de la Guardia pers. comm. 2004a; Serrano 2004). In addition to providing a comprehensive evaluation of the ACP's feasibility studies, the Master Plan will lay out a complete set of recommendations regarding the future of the waterway. It is widely-expected to propose an ambitious expansion plan that will include most or all of the following recommendations:

1. Construction of post-Panamax sized locks able to accommodate vessels up to 150,000 Gross Weight Tonnes or 8000 TEU's (twenty foot equivalent container units)
2. Widening and deepening of the canal channel and current Gatún and Alhajuela reservoirs to increase storage capacity
3. Rise in the level of the Alhajuela Reservoir to further increase storage capacity; resultant flooding of additional inhabited lands
4. Construction of a new dam with a hydropower installation most likely on the Rio Indio – the river closest to Lake Gatún – with a reservoir size of at least 4500 hectares (45 km^2) and the subsequent diversion of water to supplement the canal via tunnels connecting the new reservoir with Lake Gatún
5. Relocation of upwards of 3500 people living in the area to be flooded by the new dam
6. Deforestation and massive excavation of lands on western side of the canal to build new canal lane

The Master Plan is purported to be a "dynamic document", with optimistic and pessimistic scenarios envisioned (Miguez pers. comm. 2004). Once released, the Master Plan will be submitted to the Canal Authority's Board of Governors for approval. Should it be granted, the plan will next require endorsement from the Panamanian Legislative Assembly, a measure not likely to occur before September 2004 when a new administration headed by President Martin Torrijos begins its 5-year term. As Torrijos has already expressed his tentative approval for a canal expansion, it seems likely the plan will be approved by government. The decision to proceed, however, will ultimately lie with the people of Panama. In order to receive the final go-ahead, expansion plans must, by Panamanian law, be endorsed through a national referendum (Torrijos-Carter Treaty 1977). While it has been speculated that the plebiscite may be held before the end of 2004, a vote sometime in early 2005 seems more likely.

2.4. ACP Planning and Decision-Making Process

The ACP is in the final stages of preparing the Master Plan for the Panama Canal. This plan will be the result of several years of extensive studies that have been carried out at a cost of approximately USD $30 million (67% over original cost projections) by departments within the ACP as well as by externally contracted independent companies (Len-Ríos 2004; Jaén 2004; Miguez pers. comm. 2004). The 125 studies cover a broad range of themes including economic projections, shipping trends, capacity, price elasticity in toll structures, social and environmental assessments of and strategies for the canal watershed, revenue forecasts, engineering, debt amortization plans, and multi-scenario modeling. Utilizing an integrated system of modeling to project future demand, capacity, water needs, and revenues (figure 2.3), the plan is said to focus primarily on three areas: 1) projected increases in container traffic between China and the east coast of the United States; 2) other routes in competition with the canal (primarily the U.S. intermodal rail transport system); and 3) growth in the size of post-Panamax vessels (Fonseca 2004). Ultimately, the objective of the Master Plan is to present to the government, the people of Panama, and the international community one single recommended course of action for the future of the Panama Canal (Miguez pers. comm. 2004). This plan aims to be robust enough to accommodate all conceivable future outcomes, including worst-case scenarios, so that risk will be minimized and benefits to Panama and the canal's clients maximized.

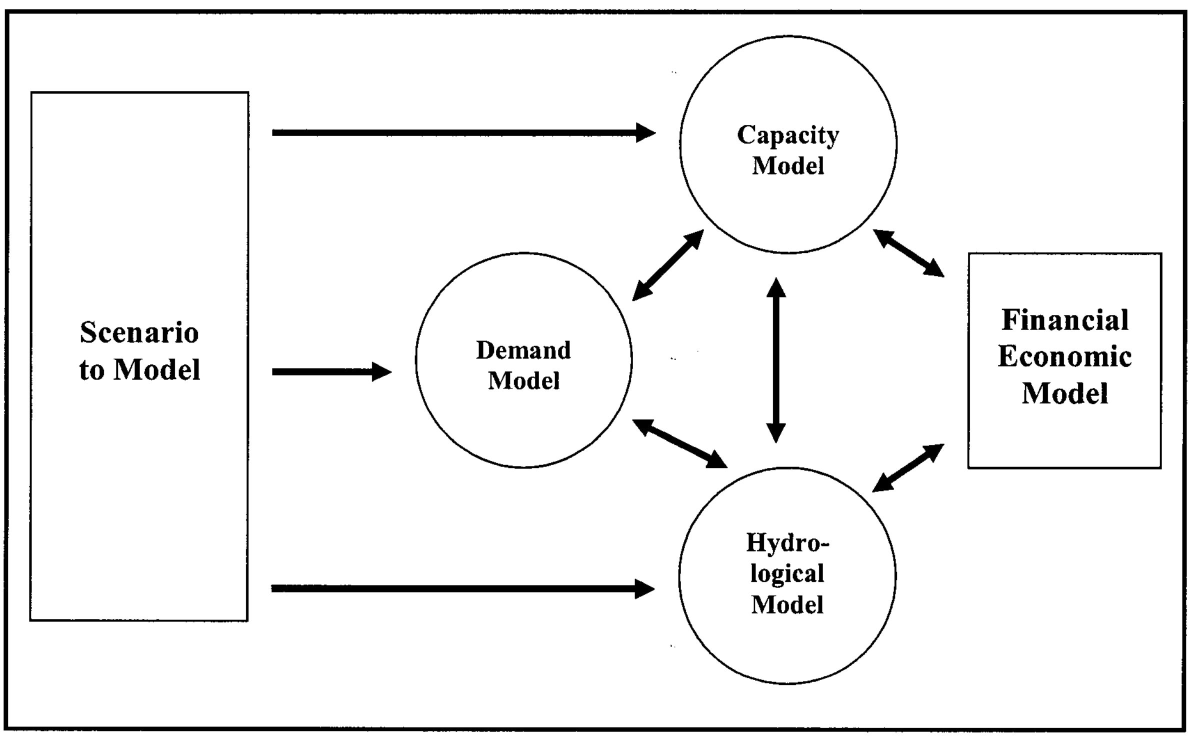


Fig. 2.3. ACP's integrated system of models for the analysis of the Master Plan. Source: Miguez, F. (El Faro May 28-June 10, 2004)

Stakeholders have been involved to varying degrees in the planning process. Shipping companies have been consulted periodically throughout the course of the ACP's studies but have not been included in the actual decision making. Individuals living in communities that may be impacted by the expansion plans have been consulted only at the most perfunctory level. According to Francisco Miguez (pers. comm. 2004), the Coordinator of the Panama Canal Master Plan, the ACP attempted to consult with communities early on in the planning process but decided to abandon this strategy when they saw their consultations and tentative plans being interpreted by the communities as formal, definite proposals. The ACP strategy now is to conduct comprehensive and transparent environmental and social impact assessments (EIAs) fully compliant with internationally recognized standards (Inter-American Development Bank, International Organization for Standardization, World Bank) and with the full participation and consultation of local communities, but only *after* the Master Plan has been prepared and released. Miguez concedes that in other countries EIAs are usually carried out before a project is planned. While an environmental or social assessment after the fact may not in itself be able to prevent implementation of the Master Plan, if executed soon enough, an EIA could pressure the Panamanian government to reject the ACP proposals or influence the outcome of the national referendum.

2.5. Details of canal expansion plans

Although the precise details of the Master Plan have not yet been made public, I have concluded, based on my research and my best judgment, that the following details will be included. It is this proposal that constitutes the basis for my project analysis in chapters 3 and 4. The canal expansion is expected to take about 10 years to complete.

2.5.1 Construction of a 3rd set of post-Panamax sized locks able to accommodate vessels up to 150,000 Gross Weight Tonnes or 8000 TEU's (ACP 2004a)

The current canal lock dimensions are 33.5 meters wide by 305 meters long and 12.6 meters deep. The new locks will be significantly larger at 61 meters wide, 427 meters long and 18.3 meters deep (Figure 2.4). The most important limitation of the current locks is their width. Due to berthing restrictions in port, today's large inter-oceanic vessels tend to be much wider but not substantially longer than ships of the past. The width of the new locks will be an astounding 82% larger than the current locks whereas lock length will increase by only 40%.

	Current locks (m)	**New locks (m)**	**% Increase**
Lock Width	33.5	61	82
Lock Length	305	426.8	40
Lock Depth	12.6	18.3	45
Max. Ship Beam (width)	32	55	72
Max. Ship Length	294.3	385.8	32
Max. Ship Draft (below water)	12	15.3	27.5
Max. GWT	65,000	150,000	131
Max. TEU's	4750	8000 – 12500	~100

Fig. 2.4. Table shows projected differences in new lock sizes (post-Panamax) compared to current dimensions (Panamax) and corresponding differences in maximum vessel sizes, Gross Weight Tonnes (GWT) and number of standard twenty-foot container units (TEU's) that can be accommodated. All dimensions in meters. Greatest increases will be in lock width and therefore maximum beam size (width). Source: ACP 2004a, Niesten and Reid 2001, Sabonge pers. comm. 2004, Lloyd's List.

Of all the commodity sectors in international shipping, container shipping through the canal has experienced the most impressive rates of growth (www.pancanal.com). Indeed, it has been speculated that it is the growth in this sector that is really driving the economics behind the canal expansion (Wainio pers. comm. 2004). For containerships, vessel size is more generally discussed in terms of TEUs (twenty foot equivalent unit containers). The current locks restrict vessels to a maximum size of 4000 TEUs (Panamax) or 13 containers abreast. The new locks will accommodate ships up to 8000 TEUs and 18 across (ACP 2004a). Containers are primarily used to transport consumer goods: electronics, food, clothes, and so on. Rates of growth in container shipping, then, are closely tied to, and dependent upon, rates of growth in international trade and the steady expansion of the global economy.

Although vessel sizes today continue to increase with some ships already exceeding 150,000 GWT, the ACP will likely decide to limit the maximum capacity of the new locks to this size (ACP 2004a). Beyond this size, economy of scale advantages begin to breakdown in that the additional costs of building bigger locks (financial expense, water recycling, costs of acquiring more water, etc.) begin to outweigh the benefits to be gained (Sabonge pers. comm. 2004). In other words, the ACP considers 150,000 GWT to be the optimum size of the canal based on the Law of Diminishing Marginal Utility. Additionally, the ACP believes, and shipping analysts seem to support this view, that vessel sizes simply cannot go too much bigger than this size (Stopford 2000). There is a limit to the size of ship that a port can accommodate and the benefits of size diminish as the ships get bigger and the collateral costs increase. It is felt that, worldwide, ports are just about reaching their maximum berth capacity limitations. Increasingly larger vessels will pose all sorts of infrastructural problems and require massive investments in port upgrading (Sabonge pers. comm. 2004).

2.5.2 Widening and deepening of canal channel and current Gatún and Alhajuela reservoirs to increase storage capacity

In 2000, the ACP began work on widening and deepening the Gaillard Cut – the narrowest part of the canal (ACP 2004). As the only section not wide enough to allow two-way traffic of Panamax vessels, the Gaillard Cut delayed vessel transit times thereby limiting the maximum number of transits possible each day. The project was completed in 2003 at a cost of $1.4 billion USD. Two-way traffic through the entire length of the canal is now possible.

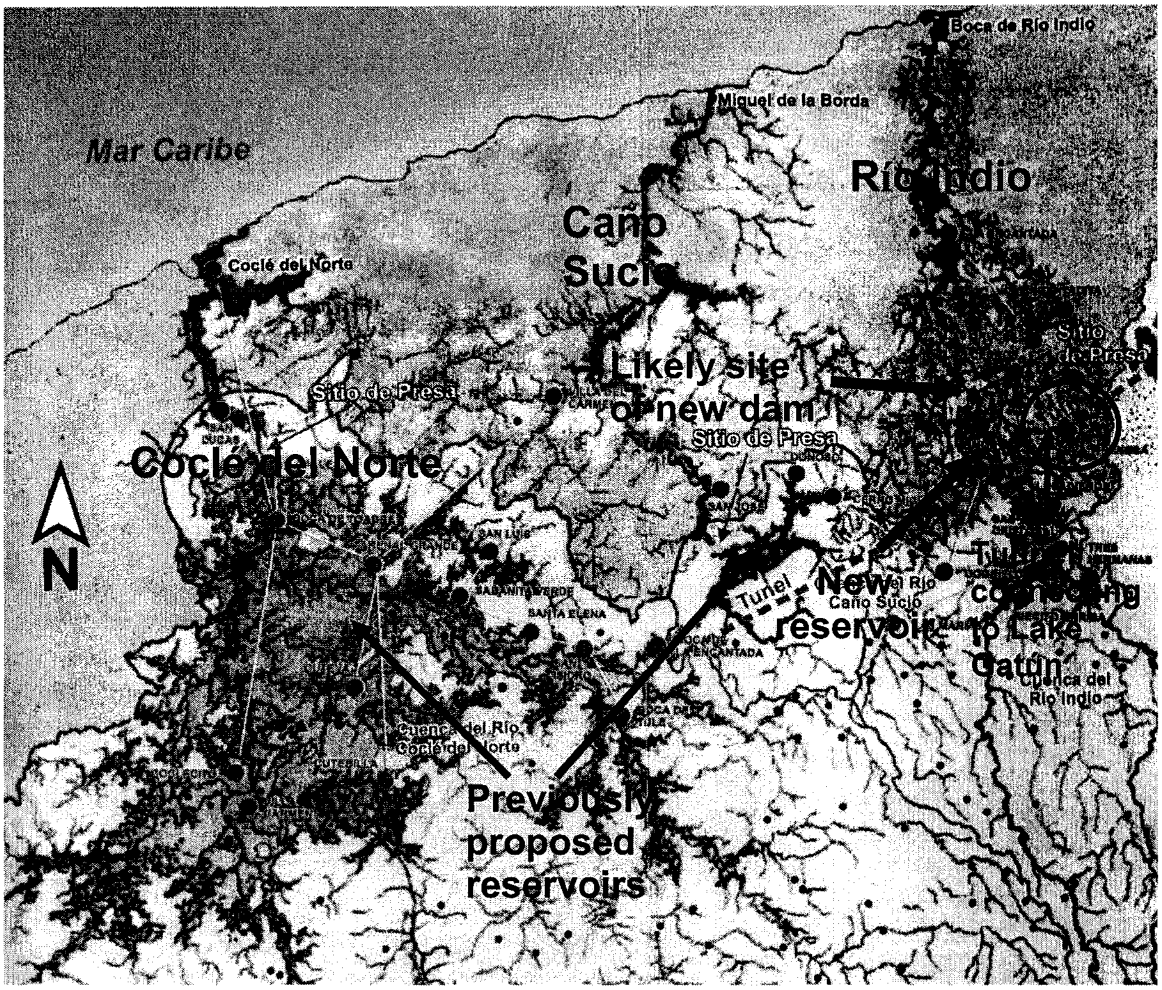
As a result of the Gaillard widening, not only did transit capacity increase, but as the Gaillard is connected to Lake Gatún, the water storage capacity of the reservoir has also increased. Virtually every year during the wet season, vast quantities of water from Lake Gatún must be released through a spillway in order to maintain a consistent water level of the reservoir (Vargas pers. comm. 2004). For example, over the last 15 years, an average of almost 130 billion gallons per year was released through the Gatún spillway into the Caribbean Sea (ACP 2004b). Should the lake level get too high, water could spill dangerously over the tops of the locks damaging canal operations and vessel safety. Most years, then, the canal watershed receives more water than it needs for current canal operations and urban requirements. The immediate problem is a shortage of storage capacity. Lake Gatún and Lake Alhajuela do not currently have the capacity to store all the water they receive. For this reason, canal expansion plans will likely include massive dredging operations to deepen the storage capacity of the current reservoirs. Increasing the reservoir capacity will help to alleviate this problem and provide a more reliable water supply to the canal year round.

2.5.3 Rise in the level of the Lake Alhajuela (Madden Reservoir) to further increase storage capacity; resultant flooding of additional inhabited lands

Another method to increase storage is to raise the level of the reservoirs. As explained, the maximum height of Lake Gatún is strictly limited. This is not the case, however, for Lake Alhajuela. One of the studies being prepared for the ACP is an assessment of the viability of raising the level of this lake (Castro-Ríos pers. comm. 2004). This will result in the flooding of inhabited land around the lake (extent unknown) but may reduce the need to construct new dams on other rivers.

2.5.4 Construction of a new dam most likely on the Río Indio – the river closest to Lake Gatún – with a reservoir size of 4500 hectares (45 km^2) and the subsequent diversion of water to supplement the canal via tunnels connecting the new reservoir with Lake Gatún

Even with an increase in storage capacity, there will still not be enough water to operate a new set of post-Panamax sized locks (Vargas pers. comm. 2004). For this reason, it is likely that the ACP will propose the construction of at least one new dam and reservoir. The Río Indio is the most frequently cited location for the new dam; however the Río Cirí Grande and the Trinidad have also been mentioned as possible sites (de la Guardia, Hanily, Manfredo pers. comms. 2004). If constructed on the Indio, the dam is speculated to be built at the community of Limón de Chagres (Map 2.2).

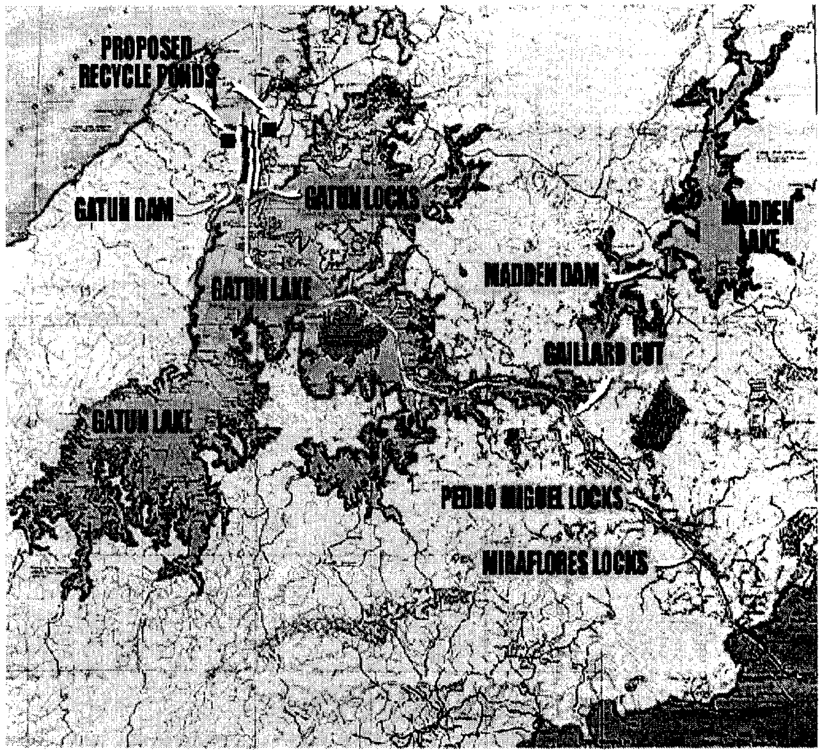


Map 2.2. Location of possible site of new dam on the Rio Indio at the community of Limón de Chagres and speculated size of new reservoir. Map also shows location of previously proposed reservoirs on the Coclé del Norte and Caño Sucio rivers that are no longer being considered. Source: Hughes 2002.

The new dam will provide enough water for an additional 15 lockages per day (de la Guardia pers. comm. 2004a). At current rates of water consumption per lockage (52 million gallons), this is roughly equal to an average of 780 million additional gallons of water per day to be drawn from the Río Indio. The 80m dam may also include a hydropower installation with a speculated capacity of 25 megawatts (Niesten and Reid 2001); and its reservoir is reported be no greater than 4500 hectares or 45 km² (de la Guardia pers. comm. 2004a). Water will be diverted from the dam via tunnels connecting it to Lake Gatún. Flow out of the new reservoir will presumably be controlled on an as-needed basis such that it will act not only as an additional source of water for the canal but also will also serve to increase the total storage capacity of the canal water supply.

Even without the construction of new locks, the ACP is anticipating that more water will be required to meet increasing demands of a growing population and to act as a reserve supply to Lake Gatún during dry years (Vargas pers. comm. 2004). Recycling water will reduce the amount of additional water required, however it may also incur much higher operating costs due to the greater energy requirements. These costs will be passed on to canal users through higher tolls. Moreover, there is a limit to the amount of water that can be recycled because recycling water poses a higher risk of salinization of Lake Gatún, the drinking water supply for residents of Panama and Colón cities (de la Guardia pers. comm. 2004). Each time a ship approaches the canal and the first gate of the locks opens so the ship can enter, some salt water from either the Atlantic or Pacific oceans enters the lock along with the ship. This salt water becomes trapped in the lock chamber and, as the ship rises to progressively higher steps, the salt water also makes its way through the locks (although much diluted with each progressive step), eventually making its way into Lake Gatún – Panama City's drinking water supply. The salinity of Lake Gatún will increase, therefore, the more its water is recycled through the locks.

Proposals have been submitted to the ACP for the construction of these water recharge facilities. For example, a proposal submitted by WPSI Inc. includes placement of recycling ponds at the Atlantic side of the canal that would recover 650 million gallons of water per day in the first phase and approximately 2.5 billion gallons per day in the second phase (AJGB Intl.). The Pacific end was determined, in this proposal, not to be feasible due to the socioeconomic impact caused by the alignment of the pipeline, which would have to cross several roads, communities and existing canal facilities (Map 2.3).



Map 2.3. Shows the location of proposed water reclamation/recycling ponds on the Atlantic side of canal. Source: AJGB Intl. 2001.

2.5.5 Relocation of farmers in the area to be flooded by the new dam

The number of campesinos to be relocated from the Río Indio in the event of dam construction has been widely speculated. The Coordinadora Campesina contra las Embalses (CCCE) continues to maintain that as many as 10,000 or more campesinos will be moved (Hernandez, F. pers. comm. 2004), while the ACP has suggested it will be closer to 3500 (Mítre pers. comm. 2004). The exact number will depend upon the final demarcation of the reservoir limits. Available land in the region is at a premium and many campesinos are extremely concerned they will lose their land without compensation (Hernandez, F. pers. comm. 2004). Most of the area has been deforested and is already being used for agriculture or cattle grazing.

For their part, the ACP claims that any person to be relocated by the new dam will be adequately compensated should they have legal title to their land. To this end, a land-titling process in the canal watershed has been initiated under the direction of the Panamanian Ministry of Agricultural and Livestock Production (Spanish acronym

MIDA). However, many campesinos have not participated to date and do not plan on participating in the land-titling process. Reasons for this are varied but seem primarily to stem from either a complete lack of trust in the ACP or a deliberate refusal to participate for fear of validating a process that they feel will inevitably lead to the construction of the dam (Aperador pers. comm. 2004). The CCCE have made it clear that they are opposed to any canal expansion project that includes a new reservoir or the forced relocation of any person without consent (Hernandez, F. pers. comm. 2004).

While the ACP insists they will have a fair and compensatory relocation plan, they have thus far refused to reveal it saying that all details will be released at the appropriate time. Their reticence to engage in open discussions about something of such fundamental importance has only served to heighten and confirm campesinos fears that the ACP is not to be trusted. One ACP employee indicated that two areas west of the Río Indio but still within the boundaries of canal watershed – the Rio Caño Sucio and the Rio Abajo – are being considered as possible relocation sites (Mitre pers. comm. 2004).

2.5.6 Deforestation and massive excavation of lands on western side of the canal to build new canal lane

In constructing the new locks, a completely new channel is to be dug. It will be a colossal undertaking, the likes of which have not been witnessed since the original construction of the canal and requiring an estimated 10 years to complete. Massive quantities of earth will be excavated, although the exact amount has yet to be disclosed. While the new lane will be a separate channel, it will operate along side the current canal and will still use Lake Gatún as part of the transit. Excavation will take place on the Pacific and Atlantic sides of the lake. Ships will be lifted to Lake Gatún just as they are now where they will transit across the lake to be lowered by a separate new channel on the other side. Impacts associated with the construction of this new channel include the deposition of vast quantities of wet and dry materials, loss and fragmentation of habitat, increase in erosion rates, alteration of drainage, change in sedimentation rates, and removal of vegetation cover (Louis Berger Group 2004).

2.6 Summary

We have seen in this chapter how the construction of the Panama Canal was a monumental undertaking that has helped to shape the modern history of the country. The canal is a defining feature of the Panamanian identity and its national psyche whose economic significance to the country cannot be overstated as we shall see in the next chapter. The route across the Panamanian isthmus was vital to global economic development even before the construction of the canal; and over the course of the 20th century, the canal has played a critical role in the growth of global shipping and international trade, one that continues to this day. Indeed, the time and cost of transportation through the canal affects commodity prices around the world. Against this backdrop, we have reviewed some of the likely recommendations for the modernization and amplification of the Panama Canal. It must be reiterated that none of these plans has yet been confirmed by the Panama Canal Authority. However neither are they mere speculation. The information presented here is based on the results of extensive interviewing with key employees within the ACP and on previous reports from highly credible sources such as the Proceedings of the Universal Congress of the Panama Canal in 1997 and the Report of the Tripartite Commission for the Study of Alternatives to the Panama Canal. In order that it is well understood what is at stake in the decision making process, Chapter 3 will consider the importance of the canal to Panama and how the proposed expansion plans as described here present formidable opportunities and risks for the country's future. It is within this context that an assessment of the project's viability based on an analysis of optimum economic scale can be carried out in Chapter 4.

Chapter 3: Risks and Opportunities of the Panama Canal Expansion

3.1 Introduction

A comparative assessment of the potential costs and benefits of the canal expansion would be merely speculative before full details of the plans are announced. The considerable uncertainty surrounding the canal authority's plans may, at this stage, render any attempt at an accurate appraisal of costs and benefits irrelevant if it is based on unfounded assumptions. In this third chapter, I instead consider some of the risks and opportunities that an expansion of the Panama Canal presents. It is necessary to understand fully the possible consequences in order to appreciate what is at stake in the decision making process. How important is the canal to Panama? What is at stake for the country? What are some of the blind spots in the decision making process? What might some of the possible consequences of expansion be? These questions are crucially important not only for assessing the viability of the proposals but for understanding how economic growth can exacerbate social and environmental problems – or even create new ones – when scale considerations are ignored. My analysis here assumes that all the details described in Chapter 2 will be included in the proposals. Although these details rely upon my own best judgment, they are substantiated by extensive research and analysis. I conclude the chapter by considering some of the consequences of *not* expanding the canal but continuing business as usual.

3.2 Economic Considerations

The Panama Canal is an extremely important part of the nation's economy. Having generated gross revenues in 2003 of USD$921 million (a 15% increase over the previous year), the canal directly contributes 6%-8% to Panama's GDP and an estimated 20% in indirect revenues (Niesten and Reid 2001; Arosemena pers. comm. 2004; ACP 2003a). Almost $300 million in profits were turned over by the ACP to the Treasury of the government of Panama in 2003 (ACP 2003a; Arosemena pers. comm. 2004a). One of Panama's largest employers, the ACP alone employs almost 9000 workers not including employees of the Panama Ports Company, Panama Railway Company, and other canal-related businesses. In 2002, the ACP paid out over $300 million in gross salaries and wages and an additional $40 million in employee benefits (ACP 2002). Employment is likely to rise considerably as a result of the PCE, particularly during the construction phase.

3.2.1 Cost Projections

Cost projections have been made for the Panama Canal expansion project ranging from $2 billion to upwards of $12 billion USD (Alfaro 2004; Hughes 2002; Proceedings 1997; Niesten and Reid 2001). The Tri-Partite Commission of 1993 estimated the cost of a third set of locks to be between $5.4 and $8.5 billion (Comisión de Estudio de las Alternativas al Canal de Panamá 1993). As Panama's population is only 3 million and its annual GDP a mere $12 billion USD approximately, even a modest $6 billion price tag amounts to roughly half of the nation's GDP. In the United States, a project of a proportionally equivalent magnitude would cost in the neighbourhood of $5 trillion based on 2003 US GDP figures (World Bank 2003). Understandably, some observers have identified the economic feasibility of the project to be perhaps the most significant obstacle to its implementation (Manfredo 2004; Wainio pers. comm. 2004; Paredes 2004). By any measure, the scale of the initiative is immense and is made more so given Panama's relatively small population and size of its economy. With Panama already burdened by a public debt of more than $9 billion, Niesten and Reid (2001) estimate that an $8-$10 billion price tag would put Panama in the 10^{th} worst position in the world for debt to GDP ratio. Should the people of Panama be solely responsible for financing the canal expansion? If so, how will they pay for it?

Without necessarily being opposed to the project in principle, some have suggested outright that Panama simply cannot afford to go it alone (Niesten and Reid 2001; Manfredo 2004; Paredes 2004). Moreover, it has been argued that Panama should not be assuming the considerable financial risk for a project that will bring considerable benefits to other countries and the international maritime community. Various financing schemes have been proposed to raise capital and ease Panama's debt load. These proposals include ‘frontloading’ whereby shipping companies pay for future transits in advance (Miguez pers. comm. 2004; Reid pers. comm. 2004), or a scheme in which beneficiary countries such as the USA, China, or Japan grant interest-free loans to Panama (Reid pers. comm. 2004; Manfredo 2004).

3.2.2 Debt Servicing and Financing

In their study of some of the economic considerations of the canal expansion, Niesten and Reid (2001) conclude that revenue gains from the project may not offset the costs of building, maintaining, and financing the new infrastructure. The conditions under which profitability requirements would render the expansion plan unviable are predicted to occur if the cost of debt service exceeds the additional income to be gained. Even assuming conservative estimates of project cost ($4 billion) and an interest rate of 7%, Niesten and Reid predict that net gains *must* exceed $300 million per year merely for interest to be paid on loans each year. If the rate of interest and the project costs are higher (i.e. 9-11% interest rate and >$7 billion total cost), the authors predict that the increase in revenues needed to offset these costs will have to be as much as $650 million per year or more, an increase deemed unlikely even under the authors’ most optimistic revenue projection scenarios.

Moreover, at a cost of $4.3 billion and a 7% interest rate, the authors calculate that interest costs alone, just over $300 million per year, will consume all, perhaps more, of current net income from canal operations. Should the project costs or rate of borrowing be higher, interest payments will be even more substantial. Leaving aside payments on the loan principal for the moment, transit tolls will have to be raised just to offset the interest payments on the loan according to Neisten and Reid. In 2003, transits through the canal generated gross toll revenues of approximately $665 million dollars or just over $50,000 per transit (ACP 2004b). Daily transits numbered 36 on average; however the maximum capacity of the current canal is said to be 47 per day. Assuming the canal will be operating at maximum capacity as is predicted by 2012, the ACP may still be forced to raise tolls by as much as 80% to offset interest payments according to the authors. Recent toll increases in 2002 of 8% and 4.5% (ACP 2004) were met with considerable hostility by the shipping industry (Nelson 2003a).

Niesten and Reid (2001) estimate that the expanded canal "would leave no additional – and possibly less – government revenue to invest in the economy or otherwise benefit the Panamanian population" (p. 1). Even if interest payments can be covered by toll increases and assuming no payments are made on the loan principal itself until the project is completed, profits currently being generated by the canal will no longer be available to the government for spending on other initiatives, at least until project completion. In 2003, net ACP profits were just under $300 million of which all was transferred to the national treasury of the government of Panama for use in general revenues (ACP 2003a; Arosemena pers. comm. 2004a). To estimate the length of time these revenues will be unavailable, Hughes (2002) assumed a total project cost of $6 billion and considered 4 future scenarios with differing rates of growth in the shipping industry and differing interest rates of debt servicing. The most favourable option with the highest annual growth rate (3%) and the lowest interest rate (6.5%) resulted in a calculation of 29 years before the debt would be completely amortized. However, a growth rate in the shipping industry of 2.1% and an interest rate of 9% yielded a calculation of 60 years before the debt would be paid off.

For their part, the ACP insists that the project will be less expensive and paid off much faster than their critics charge (Miguez pers. comm. 2004, Sabonge pers. comm. 2004). The ACP's Director of Corporate and Market Planning for the ACP, Rodolfo Sabonge, while refusing to disclose the exact figure, insists that the total cost of the canal expansion will be much less than has been speculated. Moreover, he claims that, whatever the final cost, the ACP is currently debt-free and their plan will ensure debt amortization in less than 15 years. As evidence, he points to the Gaillard Widening project completed in 2002 which, at a cost of $1.4 billion, has been completely paid off using ACP revenues alone.

Francisco Miguez (pers. comm. 2004), the ACP Coordinator of the Panama Canal Master Plan Team, contends that financing schemes such as those mentioned above will offset the need for debt financing. The ACP claims not only to have a plan to meet interest payments during the project construction phase, they will continue to be able to pay dividends to the government of Panama throughout the entire duration of the venture. Moreover, once the project is complete and the debt is paid, a substantial increase in canal revenues can be expected (although this projection has yet to be made public). A 60% increase in revenues after the completion of the new locks was projected at the Universal Congress of the Panama Canal meetings in 1997; however this figure may be even higher should tonnage through the canal eventually double. The costs of operating the canal with a new set of locks can also be expected to increase.

Despite these claims, Rodolfo Sabonge has admitted that "other countries are not interested in paying for the canal expansion" (Stares 2000). Moreover, an article as recent as May 2004 in the on-line maritime and transport publication Lloydslist.com cited ACP sources in reporting a $6 billion project price tag – a figure within the same range as those quoted by critics of the expansion (Nelson 2004; Hughes 2002; Niesten and Reid 2001). Even if the ACP Master Plan estimates the project costs to be in the $2 billion range, a recent study by Flyvbjerg et al. (2003) cautions against accepting such figures at face value. In their extensive analysis of numerous megaprojects around the world (>$1 billion), the authors concluded that "the cost estimates used in public debates, media coverage and decision making for transport infrastructure development are highly, systematically and significantly deceptive" (p. 20). They found that cost overruns of 50 to 100 percent to be common and overruns above 100 percent not uncommon. This is not to suggest on this evidence alone that the ACP should not be trusted; however, it would be wise to approach their cost projections with a healthy degree of skepticism.

As for increases in revenue following expansion, they will depend to a large extent on future trends in global shipping and trade and the demand for the new locks, trends which, according to the former director of planning for the U.S. Panama Canal Commission, are very difficult to predict with any significant degree of accuracy over the long term (Wainio pers. comm. 2004) (see section 3.5 below). Even Rodolfo Sabonge stated during the Universal Congress of the Panama Canal that "the usefulness of long-term (traffic) projections is relatively short" (Proceedings 1997). The economic benefits of an expanded canal may therefore be a matter of speculation at this stage; nevertheless, the ACP claims to have considered in their Master Plan all possible shipping and trade scenarios for the future.

Financing remains a formidable obstacle and one that will not easily be overcome without a sound and convincing business strategy on the part of the ACP. Without financial assistance, how much will revenues need to increase in order to offset payments on principal and interest while still contributing to the Panamanian economy? How long will it take to pay off the accrued project debt? How much will revenue increase once debt has been fully paid and the new locks are operational? Due to its enormous projected costs, a hastily made decision could prove absolutely disastrous to Panama's future economic health. The stakes involved are high and, for this reason, the decision on whether or not to proceed is, as Panama's new president Martín Torrijos has stated, "the most important of the (21st) century" for the people of Panama (Thompson 2004).

3.3 Social Considerations

3.3.1 Background Information

As it seems the most likely location for a new dam, I chose the Río Indio watershed as the site for the field work component of my investigation. Originating in the province of Coclé in the heart of Panama's interior, the Río Indio flows north towards the Caribbean Sea through a heavily deforested and intensively cultivated region of the western Panama Canal watershed or Región Occidental (ROCC) (URS – Dames & Moore 2003).

Field work was carried out in two communities in the watershed that, according to the ACP's original plans, are to be flooded by the new reservoir on the Indio: Limón de Chagres and Boca de Uracillo (see Appendix 4 for maps). Both towns lie along the banks of the Río Indio, each an approximate 1 hour walk from the other. If built, the new dam is widely expected to be located in Limón and markers have already been placed along the river at the exact location of the construction site. Field work involved meeting with community members on an informal basis in their homes over a total period of 2 weeks to discuss their feelings about the canal expansion and the possible inundation of their lands, as well as more general conversations regarding their community and family histories, means of livelihood, problems facing their communities, and so on. There were no formal questionnaires or surveys used as this study is not strictly speaking a social survey and it was therefore felt that questionnaires would not be necessary to meeting project objectives (see Appendix 1 for a summary of the interview methodology utilized).

Limón de Chagres and Boca de Uracillo are both small communities, only a few decades old, with populations in 2000 of only 113 and 92 individuals respectively (ACP 2003). Limón is accessible in the dry season only (December to April) with a 4X4 vehicle by way of a poor, dirt road. Boca de Uracillo has no road access. Both communities are accessible year round by foot, horseback, or cayuco (dug out motorized canoe) but, by these means, travel to other towns can take many hours. The land surrounding the communities has been heavily deforested to make way for agriculture and cattle ranching. Those living in these and other communities in the region are known in Panama as *campesinos* (peasant farmers) and are extremely poor even by Panamanian standards. Their homes are generally little more than one or two room concrete structures with dirt floors, no running water or electricity (figure 3.1). Meals, usually cooked over open pit fires, consist of staple foods such as rice, yuca, eggs, plátanos, and occasionally meat. Both towns have schools for young children; however, as the teachers do not live in the communities, they are sometimes unable to come when weather conditions or other problems make travel difficult. After 6^{th} grade, students must leave their home communities to travel to larger centres for secondary education. Many children cannot make the journey for financial or other reasons and therefore do not advance beyond this level. There is one shared public phone in Uracillo but no phone in Limón. Both towns have medical clinics but they are without attendants or adequate supplies. Medical emergencies can be extremely serious given the difficulty and time required to travel to the nearest town with sufficient medical facilities.

Fig. 3.1. Typical homes in Limón de Chagres and Boca de Uracillo.

Population increases in the ROCC over the last several decades have reduced land availability and intensified land use pressures. Land conversion between 1983 and 2000 has been dramatic. Low elevation dense forest (<200 m) has been reduced by 57% while pasture has increased 83% and land for agriculture 68% (ACP 2003). In the near future, only small patches of forest are predicted to remain, primarily in the Coclé de Norte watershed. Principal land uses today are mixed or permanent agriculture, and cattle ranching. In the Río Indio region, pasture and agricultural fields now account for 63% of the total land cover while only 2.7% is low elevation forest (ACP 2003).

As might be expected by the changes in land cover, the ROCC is characterized by the development of economic activities principally dedicated to cattle ranching and agriculture, activities that account for 64.9% of income in the region (ACP 2003). Agricultural products, grown both for subsistence and for the market, include coffee, bananas, plátanos, rice, corn, yuca, ñame, sugar cane, pineapples, and oranges. Farming technologies tend to be unsophisticated and the use of insecticides and pesticides on crops is limited. Beef, pork, and chicken are also produced and sold mainly for the markets in Panama City and Colón. Fishing is not a significant source of income but is not uncommon for subsistence purposes.

The average annual income of the ROCC is a mere $155 per capita which is an astounding 21 times below the national average of $3063 (Contraloría General 2000). On average, 61% of this income is spent on food (ACP 2003). A socioeconomic report for the ACP in 2003 concluded that "the economy of the western region of the (canal) watershed is small, without dynamism, and extremely poor...A large concentration of rural poor live in fragile ecosystems that do not support either intensive agriculture or many people" (URS – Dames and Moore 2003).

3.3.2 Potential Social Costs

As details regarding the exact size and boundaries of the new reservoir are not yet publicly available, the number of people to be displaced is still a matter of speculation. One employee of the ACP has said unofficially that the reservoir will be no larger than 45 km^2, slightly smaller than Lake Alhajuela (de la Guardia pers. comm. 2004a) and another claimed that no more than 3500 campesinos will be displaced, possibly to the Caño Sucio region of the watershed (Mítre pers. comm. 2004). Campesinos living in the region and the Coordinadora Campesina Contra las Embalses (CCCE) claim that the ACP has thus far been unwilling to discuss any details regarding the new dam or how people might be impacted (Hernandez, F. pers. comm. 2004). When meetings have been held with local communities, ACP officials talk in general terms about the sustainable development of the region but will not reveal details of the canal expansion plans. The ACP on the other hand reiterates that, should a new dam be required, they will comply with internationally recognized protocol for openness, transparency, and public participation (Miguez pers. comm. 2004). However, at this stage they say there are no formal plans and, therefore, there is nothing to discuss (Vallarino pers. comm. 2004). As plans ultimately may not include the need for a new dam at all, to discuss such a possibility would be irresponsible and would generate needless anxiety, according to the ACP.

But the campesinos are *already* anxious. Those interviewed expressed grave concerns about their future and their frustrations in trying to obtain information from the ACP (Hernandez, O., Madrid, Oballe, Rodriguez pers. comms. 2004). They claim most of the land in the region is already being used and there will be nowhere for them to go should they be displaced. While agreeing that the region needs to develop economically, the campesinos claim never to have seen any benefits from the canal and are skeptical that they will do so in the future. They are not necessarily opposed to an expansion of the canal; they simply do not want to lose their land. Without land, they say, they have nothing. It is their life, their history, their means of survival. Most have never lived in the city and have no desire to do so now. They claim the ACP's reticence to discuss their intentions has only heightened fears and distrust.

3.3.3 Social Benefits? Panamanian Economic Development

Part of the ACP mandate is to "produce the maximum sustainable benefit from our geographical position...and thus contribute to the prosperity of Panama" (www.pancanal.com). Indeed, ACP Administrator Alberto Aleman has stressed that any expansion of the canal must first and foremost bring benefits to Panamanians (Thompson 2004). Could the canal expansion contribute to economic development in Panama and help to improve the lives of people such as those living in the Río Indio region?

Economic benefits of the canal expansion could include a long-term increase in the canal's revenue stream which could contribute to the capital available to the government for socioeconomic investment. The ACP has also suggested that the construction of a dam will bring infrastructure to the region such as better road access, clean and abundant water, and electricity (de la Guardia pers. comm. 2004). Moreover, the construction phase may offer quality employment opportunities to campesinos.

With a per capita annual Gross Domestic Product of $4020 USD, Panama appears at first glance to be one of Latin America's richer nations (World Bank 2004). While there is indeed considerable wealth in the country, income disparity in Panama is among the world's highest, second only to Brazil in Latin America and only marginally better than South Africa (World Bank 2000). 37% of the population lives below the poverty line, over half of these in extreme poverty. In addition, fully half of all Panamanian children live in poverty.

The geographic distribution of poverty in Panama is pronounced. Of those living below the poverty line, 77% live in rural parts of the country. Among their most pressing requirements, campesinos living in Limón de Chagres and Boca de Uracillo identified the urgent need for adequate health care facilities and treatment, electricity, school repairs, a regular teacher, a potable water supply, a phone line (Limón), and road improvements (Madrid, Oballe, Hernandez, O. pers. comms.).

Despite the apparent severity of poverty in Panama, meeting such demands may not be particularly costly. A recent World Bank assessment of the country, claimed that "...it is estimated that the minimum annual cost to bring all poor Panamanians to the poverty line represents roughly 5% of gross domestic product (GDP)" (World Bank 2000; p. 21). In 2001, GDP in Panama was $12.1 billion. Using this figure (presumably the GDP in 2000 was even lower), this amounts to a minimum investment of roughly $605 million (or a mere 2 years of ACP net profits based on 2003 revenues) to alleviate poverty in Panama. Bear in mind that the Panama Canal expansion may cost more than 10 times this amount promoted with the explicit objective to contribute to economic development in Panama. The World Bank report concludes,

> "The analysis clearly shows that disparities in education are the key causes of poverty, malnutrition, and inequality in Panama. *Investing in the education of the poor is also the principal lever for helping the poor lift themselves out of poverty in the long run*" (italics added) p. 40.

Viewed strictly as a strategy for economic development, then, the canal expansion raises many serious questions in regard to whether it is the most appropriate course of action in helping to achieve economic development – particularly for the country's poorest. However, as we saw in Chapter 1, because economic growth and an increasing GNP tend to be equated with improved well-being, the need to create growth can sometimes become an end in itself, rather than the best means by which to promote public welfare.

3.3.4 Land Titling

According to the World Bank (2001), the distribution of land holdings in Panama is one of the most skewed in Latin America. In 1999, those living below the poverty line account for 2/3 of the rural population yet own only 1/3 of the land. The poor have even less access to titled land: of the agricultural land that is fully titled, the poor have legal title to a mere 16% of it. There is a high concentration of private land ownership while the majority of the population occupies small parcels of land owned by the national government (IADB 2002). Only 1/3 of all owned agricultural land in Panama is legally titled and most of the communal and collective landowners have no titles. According to the Inter-American Development Bank (2002), the current widespread existence of informal land tenure represents "a significant impediment to investment and national development" (p. 2).

To address some of these issues, the government of Panama has developed a Poverty Reduction Strategy in which land tenure security is a fundamental objective. A land titling process called PRONAT (Programa Nacional de Administración de Tierras) was developed with the assistance of the World Bank and is currently being carried out by the Panamanian Ministry for Agricultural Development (MIDA) in an effort to designate land ownership and regularize land tenure across all of Panama. Partially funded by the ACP, land titles in the canal watershed will facilitate compensation and land purchasing should a resettlement program be commenced. However, the Coordinadora Campesina is opposed to any forced relocation of peoples from their land due to inundation resulting from the construction of new reservoirs, regardless of compensation being offered by the ACP. Many campesinos are conscientiously objecting to the process on the grounds that either their participation could be viewed as a tacit endorsement of the expansion proposals or they simply do not trust the ACP to compensate them fairly. Although the cost to title land is only $6 per hectare, many currently occupying large land holdings simply cannot afford even this amount. For example, titling even a 50 ha piece of land would cost $300 or roughly two years income for the average income earner in the region (Contraloría General 2000). As many believe the land titling is no guarantee of compensation anyway, many would just as soon forego the cost (Hernandez, F. pers. comm. 2004). The ACP has thus far declined to discuss how and to what extent campesinos would be compensated should it become necessary.

3.3.5 ACP Social Programs in the ROCC

By its constitution, the ACP is responsible for the protection and conservation of the water resources within the legal boundaries of the canal watershed (Organic Law of the ACP 1997; www.pancanal.com). Realizing that economic development within the region is essential to the protection of water resources, the ACP is committed to the sustainable development of the watershed; however this objective is not specifically part of its mandate (Sanjur pers. comm. 2004). To this end, ACP social teams have visited approximately 120 communities in the western watershed (ROCC) and organized several workshops to discuss current socioeconomic and environmental challenges facing residents of the region. The canal authority is also working with non-governmental organizations in the ROCC such as the Centro de Estudios y Acción Social Panameño (CEASPA) and Fundación Natura in developing programs to improve nutrition and to advance conservation priorities. Other ACP initiatives currently underway include a reforestation program, environmental education, and the development of a plan for water management and sustainable development. According to the ACP's director of community relations and social programs, Amelia Sanjur, the authority believes they have a responsibility to contribute to economic development in the watershed regardless of whether there is an expansion of the canal or not. In their view, the protection of water resources and conservation in general is closely related to human development.

3.3.6 Inter-Institutional Commission for the Canal Watershed

The Inter-Institutional Commission for the Canal Watershed (CICH is its Spanish acronym) was established in 1997 expressly for the purpose of coordinating the efforts of government agencies and the Panama Canal Authority for the conservation of the region's natural resources. The Organic Law of the Panama Canal (1997), which created CICH, stipulated that the organization be established for the main purpose of integrating the efforts, initiatives, and resources for the conservation and management of the watershed and promoting its development (www.pancanal.com). Although CICH is funded by the ACP, it operates independently within the organization and has already launched pilot studies in two subsidiary watersheds within the ROCC designed to guide the promotion of sustainable development and conservation (CICH 2003). CICH also coordinates meetings between various stakeholders to discuss issues pertinent to conservation and management of the watershed. Stakeholders include representatives of communities in the region, non-governmental organizations, government agencies, and the ACP. Given its responsibilities, it is almost certain that CICH will be involved in the process of public consultation with regard to canal expansion. It is important to note however that, to date, neither CICH nor the ACP has carried out any such consultation or solicited any public participation in deciding the future of the canal.

3.3.7 Summary – Social Considerations

The social costs of the canal expansion are likely to be felt disproportionately by campesinos living in the regions to be flooded. The lack of dialogue between the CCCE and the ACP is regrettable and may present serious difficulties to the credibility of the project and its subsequent implementation. The declaration of the first meeting of Dams Affected Peoples in Curitiba, Brazil in 1997 resolved to oppose "the construction of any dam which has not been approved by the affected people after an informed and participative decision-making process" (International Rivers Network 1997). This resolution follows similar declarations regarding public participation in resource management decision making from the likes of reputable organizations such as the IUCN (World Conservation Union) and The World Commission on Dams (WCD) (Guijt and Moiseev 2001; Bugincourt, 1987; Renn et al., 1995; WCD 2000). The WCD's Report *Dams and Development* (2000) explicitly grants rights for dam-affected peoples, arguing that no project should proceed without the consent of those who are to be impacted. Although citizen involvement has widely been acknowledged as a potential solution to the problem of poor decision making (Renn et al. 1995), the ACP has yet to seek public engagement in the decision making process.

3.4 Environmental Impacts

3.4.1 Current State of the Canal Watershed

The Panama Canal lies in the heart of one of the world's most biologically diverse areas. Identified among the world's top 25 hotspots for conservation priorities (Myers et al. 2000), southern Central America is one of the richest regions of bird diversity in the world (Stolz et al. 1996) and Panama has as many plant species per 10,000 km^2 as any place on earth (Barthlott et al. 1996). Two-thirds of the country falls into either the highest or the high priority category for biodiversity conservation and Panama also serves as an important biological bridge between the continents of Southern and Northern America, facilitating the migration of many species (Heckadon-Moreno 2001; Hughes 2001; World Bank 2001).

Comprised of three major watersheds – the Coclé del Norte, Caño Sucio, Indio – the vast majority of the 2131 km^2 Region Occidental (ROCC) is less than 1000 meters above sea level and is characterized by primarily by modest relief, gentle hillsides, and river valleys. The geomorphology of the region includes areas of relatively flat coastal plains, low hills (20m-200m), and higher hills generally between 200m-600m elevation. Most of land surface within the ROCC (65%) is dominated by fields and pastures. The remainder is comprised of forest fragments, mainly at higher altitudes (ACP 2003). Although agriculture is widely practiced, soils are of generally poor quality. They tend to be compact and derived from hard volcanic basalts or porous and light with limited productive capacities, and are better suited to grazing and wood production. Climate in the ROCC is classified as tropical humid characterized by very high levels of precipitation (approximately 3294 mm annually), average monthly temperatures between 25°-27°C, a temperature difference of less than 5°C between the warmest and coldest months, and a distinct dry and wet season (ACP 2003).

According to a comprehensive assessment recently prepared by the Smithsonian Tropical Research Institute and the Louis Berger Group for the ACP (ACP 2003), the western canal watershed, where the dam and reservoir will be constructed, has lost 65% of its original forest cover. Fragmentation of low elevation forest is extensive with only small, mostly unconnected fragments remaining. Habitat conversion from forest to pasture is continuing at a steady rate (4% of total land area in the last 5 years). The report characterizes the state of remaining lowland forest as being in danger of disappearing and mid-range forest as vulnerable. Some species have been locally extirpated due to loss of natural habitat and remaining lowland fragments are not sufficiently large for most species to survive or to maintain existing ecological processes. In the relatively near future, only small patches of forest are predicted to remain, primarily in the Coclé de

Norte watershed (ACP 2003). High and low elevation forest may be reduced an additional 92.8% in the next 20 years while land for cattle ranching is expected to increase 71.2%.

Despite the ecological degradation, species diversity of the western watershed (ROCC) is still reasonably high. For example, 13% of the Panama's floral species are found in the watershed, a region that represents only 2.8% of the country's total land surface (ACP 2003). Similarly, 28% of the country's freshwater fish species are found there. The ROCC still provides a number of valuable ecosystem services. Rivers such as the Indio, for example, provide services that include supplying nutrients for freshwater fisheries, habitats that sustain biodiversity, recreational values, transportation on the river, maintaining microclimatic stability, fish spawning grounds, salinity balances for productive estuaries, and sediments to deltas (Figure 3.2).

Freshwater functions	Ecosystem Services in ROCC
Soil moisture for biomass production, transpiration, decomposing and recycling of organic material and nutrients in terrestrial ecosystems	Nutrients for freshwater fisheries Water purification Habitats that sustain biodiversity Recreational values
Rainfall, plant, micro- and soil organism interactions in terrestrial ecosystems; oxic and anoxic environments in wetlands	Transportation on river Maintaining microclimatic stability Genetic diversity Fish spawning grounds
Groundwater and run-off recharge into lakes and rivers	Water availability in soils for plant production Recharge of ground water Carbon sequestering
Moisture feedback in tropical forests; occasional water holes in dryland areas, and water generated structural patterns that trap seeds and initiate plant growth	Waste assimilation Wildlife diversity Insect control Productive agricultural land Moderating floods/droughts
Interactions between dry/wet periods	Salinity balances for productive estuaries Sediments to deltas

Figure 3.2. Examples of freshwater functions for ecosystem services in ROCC (modified from Folke 2003). Ecosystem development is preconditioned by freshwater; the biota self-organizes around freshwater flows and ecosystem services are generated.

3.4.2 Possible Impacts

The extent of projected environmental impacts including species and habitat loss due to the canal expansion is not yet known as an environmental impact assessment has yet to be carried out (Miguez pers. comm. 2004). Nonetheless, environmental impacts are likely to include flooding, deforestation, excavation, dam construction, hydrological modifications, and habitat loss. Depending on the extent and location of the new reservoir, however, the project may also fragment part of the Mesoamerican Biological Corridor, an important stretch of unbroken habitat formed by natural parks and protected areas from Panama to Mexico (ANAM 1998; Hughes 2002). Although Panama is a signatory to the 1992 Convention on Biological Diversity which aims to preserve species and habitat diversity, the canal expansion could potentially conflict with its objectives (UNEP 1998).

As with any large-scale dam construction project, the environmental impacts of a new dam on the ecology of the canal watershed are likely to be significant. Ecological impacts associated with dams include the death of terrestrial plants and forest, death and displacement of animals, elimination of habitat, flow regime change, reduction in sediment and nutrients downstream, blocked migration of freshwater fish, impacts on floodplain riparian communities, loss of downstream fisheries, turbidity changes, increase in water nitrogen content, and changes in water temperatures (WCD 2000; Ligon et al. 1995). While efforts can be made to minimize some of these impacts, others such as habitat loss and species displacement are difficult to mitigate. Changes in river flow will influence the aquatic biodiversity of the Indio (see section 3.4.3 below) and Hughes (2002) speculates that the construction of a reservoir on the Indio could lead to a significant loss in terrestrial biodiversity due to the fragmentation of habitat. It is also possible that the displacement of thousands of campesinos could lead to intensifying land pressures and accelerating rates of deforestation elsewhere depending on where resettlement takes place.

Although little is known about the full extent of greenhouse gas emissions (GHG's) from artificial reservoirs worldwide, they are recognized as contributing carbon emissions due to rotting vegetation and carbon inflows from the catchment. As forests are slight methane sinks, conversion of forest to reservoir also provides a large methane source (Keller et al. 1990). Tropical reservoirs are particularly important sources because of the high amounts of organic carbon that can be flooded (Galy-Lacaux et al. 1999). Keller and Stallard (1994) estimated that Lake Gatún, with an area of 42,200 ha, is a source of 400-1800 kg/ha/yr of methane. Although the reservoir on the Indio would be more than 9 times smaller (4500 ha estimated), methane emissions alone could still be significant – between 1.8 and 8.1 million kg/yr based on Keller and Stallard's figures. The World Commission on Dams report on Dams and Development (2000) claims that up to 28% of the global warming potential of GHG's could come from reservoirs.

An expanded Panama Canal may also contribute to increased carbon emissions and other environmental impacts by facilitating changes in the shipping industry worldwide. Witness a recent comment by the executive director of the Port of Houston Authority: "I think that (canal expansion) is going to put a strain on the ports and all of us are going to have to start building terminals as fast as the environmentalists will let us" (Nelson 2003a). While a larger canal in itself will not likely lead to an increase in world trade, it will help to facilitate projected increases in global transport. As ships intended for routes that must transit the canal are currently constructed exactly to the maximum possible specifications of the locks, it seems reasonable to assume that the construction of larger locks will similarly result in the construction of larger, and more, vessels with higher carbon emissions. The China Overseas Shipping Company (COSCO), for example, has confirmed that the construction of new locks will be favourable to their business operations as they will be able to make use of their growing fleet of post-Panamax vessels (Cai pers. comm. 2004).

The success of the canal expansion is predicated upon continuing growth in trade and shipping (Proceedings 1997; Sabonge pers. comm. 2004). Seaborne cargo is projected to increase to over 7 million tons annually by 2025 from 5 million in 2000 – more than a 40% increase (Stopford 2000). However, during this same period, industrial countries are obligated under the Kyoto Protocol to cut their carbon emissions by an average of just over 5% below 1990 levels (UNFCC 1997). Although GHG emissions due to transport are exempt from regulation under Kyoto, increases in international trade have long been linked to a growth in carbon emissions (see Fig. 3.3) and GHG emissions from transport are one of the fastest growing contributors to climate change (Simms 2000). Although international trade has increased at a faster rate than carbon emissions in recent years (perhaps due to increases in fuel efficiency), the two are still linked. Currently transport accounts for roughly a third of all carbon emissions. Although

Panama is not a signatory to the Kyoto Protocol, the expansion of the canal may have implications for global efforts to combat climate change.

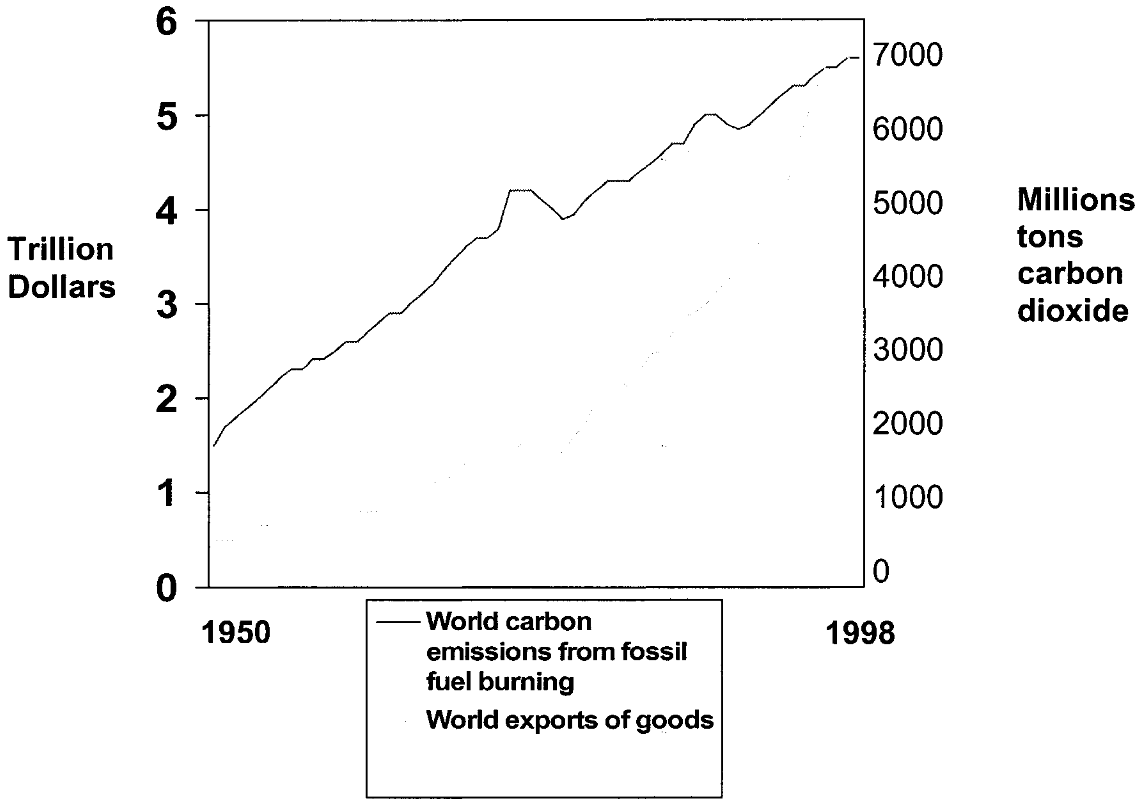


Fig 3.3. Relationship between global trade and carbon emissions. Source: Simms 2000.

3.4.3 Water

Implementation of the Panama Canal expansion will depend upon the acquisition of more fresh water and an increase in water storage capacity. Water supplied by Lake Gatún will not be sufficient should the canal be expanded and may not be enough even to accommodate increasing urban demands. Even now, the canal requires an enormous amount of fresh water, on the order of 52 million gallons for every ship making the transit, which is roughly equivalent to one half of total daily residential water consumption in Panama City (www.pancanal.com; Neisten and Reid, 2001). Each day of canal operations uses about ten days worth of the non-canal water needs provided by Lake Gatún. Niesten and Reid (2001) estimate a 40% increase in canal water use should expansion proceed; this combined with an estimated doubling of urban consumption by

2030 would raise water requirements by 31 percent in 2030 to an average of 4 billion gallons per day or over 1.5 trillion gallons per year.[2]

The amount of additional water usage in the new locks will depend on the lock configuration that is selected. A 3-lift lock with 3 water saving basins would require approximately the same amount of water that each of the current locks use (52 million gallons per transit). However a 2-lift lock with 4 water saving basins would use about 30% more water per lockage (Arosemena pers. comm. 2004). According to the ACP, a reservoir on the Río Indio is projected to provide enough water for a maximum of roughly 15 additional lockages per day (de la Guardia pers. comm. 2004a). Based on the current 52 millions gallons consumed per lockage, this translates into a maximum daily withdrawal rate of approximately 780 million gallons or 3 million m^3 per day from the Indio. As the streamflow average of the Río Indio is only 2.1 million m^3 per day based on data recorded between 1976-1995 (see Appendix 5), presumably this withdrawal rate is a maximum that would only be possible when the reservoir is at full capacity. Even so, at this rate it appears likely that under this scenario expansion plans would require a dramatic hydrological alteration of the Indio's natural streamflow regime. Hughes (2002) claims the water that the ACP will release below the dam will be equivalent only to minimum (dry season) flow levels which, during the rainy season, will represent a flow reduction approximately 10 times lower than its normal amount.

The ecological consequences of modifying hydrological basins can be significant. The alteration of river flow regimes associated with dam operations has been identified as one of three leading causes, along with non-point source pollution and invasive species, of the decline of some aquatic animals (Richter et al. 1997, Pringle et al. 2000). Rivers and riverine habitat have adapted over many years to specific qualitative and quantitative streamflow patterns (flow variability and flow amount). There are therefore limits to the amount of water that can be withdrawn from freshwater systems before their natural functioning and productivity, native species, and the services and products they provide become severely degraded (Richter et al. 1997). These limits are quantifiable and, using a

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[2] Water scarcity has become a real cause for concern in many regions of the world. It has been estimated that humans already appropriate 54% of fresh water runoff that is geographically and temporally accessible and this is projected to increase to an astounding 70% by 2025 (Postel et al. 1996). The dramatic modification of river systems by humans to meet this demand has led to the imperilment of many freshwater species, the decline of fisheries, and the drying up of river flows (Postel and Richter 2003).

water management analysis technique called the Range of Variability Approach (RVA), will be considered in detail in chapter 4 as part of an assessment of sustainable withdrawal rates from the Indio in comparison to projected withdrawal rates.

3.4.4 Environmental Benefits?

In light of the already considerable ecological degradation in the watershed, the ACP has claimed that the project, rather than intensifying environmental stresses, may actually help to alleviate them. In the words of the ACP's Director of the Canal Capacity Projects Division, "If something is built in the area, the watershed has to be conserved in order to guarantee the supply of water. This means that a program of sustainable development must be put in place. If nothing is done, the ongoing mutilation of the watershed will continue" (de la Guardia pers. comm. 2004a).

A recent report commissioned by the ACP as part of their canal modernization studies concludes that "the presence of the ACP in the region offers the possibility to stimulate...the integrated management of hydrological resources" (Castro 2004, p. 14). Another environmental assessment of the region commissioned by the ACP (2003) concluded that future growth in the region is highly dependent on external transfers. "Land use projections make necessary the development of policies to conserve natural resources through programs of sustainable development that will increase the quality of life" (p. 4-134).

If a new reservoir is built to serve as an additional water source for the canal, the ACP will indeed have a clear economic incentive to protect the surrounding watershed. The strip of intact forest lining the current canal is preserved in large part due to the canal authority's preoccupation with preventing excessive sedimentation in canal channels and with the deterioration of the drinking water quality of Lake Gatun (Condit et al. 2001). The ACP views canal modernization as an opportunity to contribute to the environmental protection of the region. By protecting the canal's water supply, the environmental conditions of the watershed will improve thereby contributing to long-term sustainability.

3.5 International Shipping

Projected growth in world shipping and shipbuilding provides a clear motivation for considering an expansion of the Panama Canal. World seaborne container trade is projected to grow to 71.6 million TEUs in 2005 from 61.5 million in 2002 – a 16% increase (figure 3.4) (Global Insight 2003). Approximately 60% of ships on order in 1999 were of post-Panamax dimensions (Niesten and Reid, 2001) and total tonnage of global shipping is projected to increase by 40% by 2025 over 1990 levels (Stopford 2000). A new canal lane will facilitate more transits of larger ships and subsequently higher revenues. Both the ACP and shipping companies have expressed concerns about the longer queue times likely to result once the canal has reached capacity in 2012 (Sabonge pers. comm. 2004; Miguez pers. comm. 2004; Cai pers. comm. 2004).

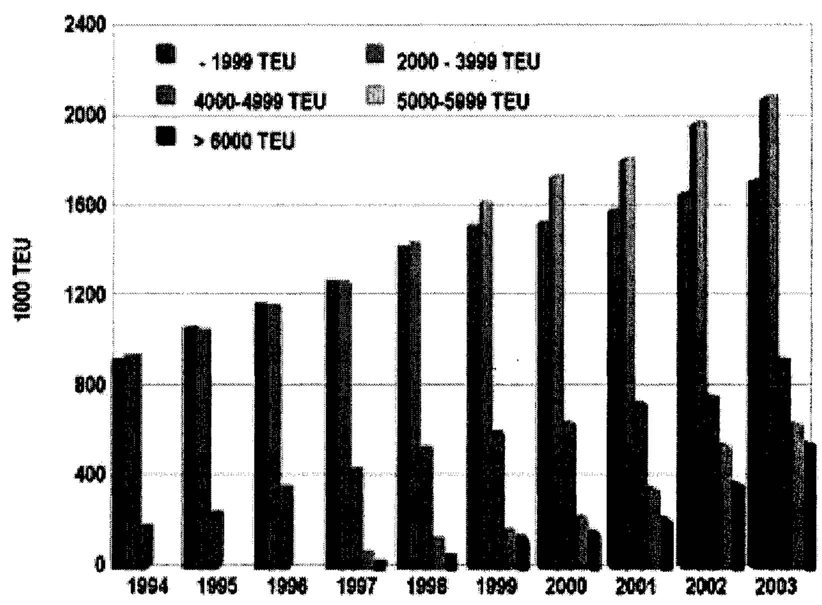


Fig. 3.4. Container fleet development by TEU class size 1994-2003. Current canal capacity is 4000 TEU's. Growth of both Panamax (and smaller) and post-Panamax vessels is increasing. Source: Institute of Shipping Economics and Logistics.

Current demand for canal services is strong and users have indicated they will welcome new infrastructure (Cai pers. comm. 2004). However, figures do not necessarily answer the question of whether growth in demand for transport via the canal is strong enough to justify the expansion. Although net container tonnage in 2003 increased 20%

over 2002 (ACP 2003a), Richard Wainio, ex-director of planning for the defunct Panama Canal Commission (the former U.S.-run ACP), claims that traffic trends must continue to go up for decades to make canal expansion worthwhile if it is to cost in the $10 billion range (Wainio pers. comm. 2004).

3.6 Alternative Trade Routes

At much lower projected construction costs than the Panama Canal expansion ($1.6 billion estimated), a Nicaraguan dry canal has been considered by the government of that country to compete directly with the canal in Panama (Rohter 1996). Two ports on either side of Nicaragua would be connected by 370 km of high speed rail to transport containers from one coast to the other. The Nicaraguan government has already granted a concession to Consorcio del Canal Interoceanico de Nicaragua to build the new rail route (Shaw 1998). Other such overland options have been or are being considered in Honduras, Mexico, El Salvador, and Colombia. The formation of high speed intermodal rail transport across the United States also represents formidable competition to the Panama Canal (Fonseca 2004). Clothing from China, for example, transported by way of ship to Los Angeles or Tacoma then by rail can appear on shelves in the eastern U.S. a week to 10 days earlier than if it had been shipped through the Panama Canal (King Jr. 2004). However, the overland option costs $1000 to $1500 dollars more per 40 foot TEU container than those shipped through the canal. And not insignificantly, due to global warming, the Northwest Passage through the Arctic Ocean is open a greater number of days each year and some scientists have predicted that it may be completely free of ice within 50 years (Campbell 2003). It is conceivable that this could become a legitimate, virtually year round transit option at no cost or comparatively low cost to shipping companies virtually eliminating the need to transit the Panama Canal for certain trade routes. For instance, the Northwest Passage will cut approximately 11,000 km off some routes between Europe and Asia.

As the Panama Canal Authority's corporate mission statement includes the objective, "to produce the maximum sustainable benefit from our geographical position" (www.pancanal.com), the project is likely to be partially justified as an initiative that will do just that: take advantage of the country's abundant water supply and geography, Panama's distinct competitive advantage if you will. However, shipping companies can easily use other trade routes in pursuing their own self-interest. While they generally view an expansion of the Panama Canal as a favourable development, the China Overseas Shipping Company (COSCO) freely admit that they will use whatever is the most cost effective trade route in the future (Cai pers. comm. 2004). Countries offering the most efficient, lowest cost transit options will likely succeed in attracting shipping business in the future.

The ACP could conceivably find itself in the position of trying to be cost-competitive with other trade routes, while at the same time keeping tolls high enough to pay the debt accrued by the expansion project. The 1993 Commission for the Study of Alternatives to the Panama Canal estimated that a 100% increase in canal tolls for all ships transiting the canal (including those not using the new locks) would be the optimum tariff to finance the expansion (Manfredo pers. comm. 2004). The Commission recognized, however, that such an increase would not be realistic. Indeed, recent toll increases in 2002 of 8% and 4.5% (ACP 2004) were met with considerable hostility by the shipping industry (Nelson 2003a). There may in fact be a limit to the tolls that can be levied in the new locks before other routes become more attractive to shipping companies; however Panama will be in an extremely difficult position, beholden to their creditors and therefore probably unable to lower transit fees. This could conceivably precipitate cost-cutting measures in other areas such as labour or environmental standards. Indeed, a spokesperson for the Futures Group, a corporation contracted to make recommendations for canal modernization, said at the Universal Congress of the Panama Canal in 1997 that financing the expansion means finding ways "to reduce the costs of operation. Maybe we have to look at the elimination of redundancies in the labor force; maybe look for ways to contract non-essential activities" (Proceedings 1997).

If the ACP is not to betray their stated commitments to high labour and environmental standards (the ACP is a member of the World Business Council on Sustainable Development and has signed the United Nations Global Compact Corporate Social Responsibility Initiative), the canal authority must then either cut costs elsewhere in order to maintain its competitive advantage over the long term or focus on providing a service that their competitors do not or cannot provide, namely an uninterrupted water route from port to port. The latter seems more promising. Although transnational shipping companies seek the lowest possible operating costs, they are also providing a service to their clients and are therefore concerned about convenience, safety, efficiency, and security (Cai pers. comm. 2004).

3.7 Possible consequences of not proceeding with the canal expansion

Should the expansion proposals be rejected by either the government or the people of Panama in a referendum, the ACP will be forced to revise their plans or perhaps even reject a canal expansion entirely. While this seems unlikely, it is worth considering some of the consequences of *not* expanding the Panama Canal but continuing in its current state.

Members of the ACP have stated repeatedly, and several studies have supported the notion, that the canal will lose some share of the global shipping market without a modernization plan (Sabonge pers. comm. 2004; Proceedings 1997; Comisión de Estudio de las Alternativas al Canal de Panamá 1993). While it is true that, without expansion, the canal will be unable to capture a growing share of the global shipping market and will soon be operating at maximum capacity, the idea that the canal will become increasingly obsolete in the near future is simply not borne out by the facts. Proceedings of the Universal Congress of the Panama Canal (1997) reveal that, despite the rapid growth of post-Panamax vessels, Panamax and smaller vessels are also growing in absolute terms and the canal will still be able to accommodate 70% of the global fleet in 2020 (see Figure 3.4 above). The former Panama Canal Commission Director of Planning stated during the conference that while recognizing the growth in post-Panamax vessels, there is also a strong growth in North-South routes that will not use post-Panamax ships in the foreseeable future (Proceedings 1997).

Pressed on the question of the canal's obsolescence, the ACP's Director of Marketing Rodolfo Sabonge (pers. comm. 2004) admitted that they do not feel the canal will stop being used anytime in the near future. In fact, he admits that, once reached, the maximum capacity will likely be maintained far into the foreseeable future. He emphasizes, however, that the canal is mandated to operate as a business that maximizes its economic benefits to its shareholders – the people of Panama. In this respect, the canal will, after a point, no longer have the capacity to expand economically and will, they fear, become a "boutique canal", with decreased global importance and only attractive to those shipping routes that must use it. Already, the canal has lost some of its market share in recent years according to Sabonge. It is in terms of economic growth that the canal will become obsolete. In Sabonge's words, "Not being able to grow is obsolescence, at least in this world…we need to grow economic activities to keep up with the rest of the world" (pers. comm. 2004).

Were Panama not to proceed with the canal expansion, all evidence suggests that the canal will continue to generate a constant revenue stream for some time to come. Net profits in 2003 were on the order of $300 million and the waterway is not yet operating at maximum capacity. Even if net profits remain fixed at $300 million annually, the canal alone could generate the minimum funds necessary to alleviate poverty in Panama within 2-3 years according to World Bank (2000) figures. Additional revenues thereafter could be directed towards water conservation and environmental protection initiatives in the canal watershed. These profits are virtually certain to continue well into the future whereas the canal expansion may put this revenue stream at risk, at least for some time. It is also worth mentioning once again the recent study by Flyvbjerg et al. (2003) which revealed that many, if not most, megaprojects (>$1 billion USD) around the world have been shown to underestimate costs and environmental/social impacts, incorrectly predict future demand, and overestimate social and economic benefits. Actual megaproject viability typically does not correspond with forecast viability with the latter often being "brazenly optimistic" (p. 136).

The ACP's concern of course is that current revenues will not be reliable over the long term without canal modernization because as queue times increase to transit the canal, other shipping routes start to become more attractive, thus chipping away at their bottom line. This may be so; however conclusive evidence in support of this claim has yet to be produced. The Panama Canal offers the only complete transit route across the Americas by water. The time and cost savings to be gained by not having to unload and reload cargo are considerable. Barring the construction of a new water route elsewhere (which seems highly unrealistic for the time being), Panama boasts a formidable competitive advantage. Given the potential environmental and social costs, as well as the sizeable financial risk involved, Panama may be wise to consider several alternatives for canal modernization. This seems unlikely, however, as the ACP has already confirmed that the forthcoming Master Plan will put forward only one proposal for the future of the canal (Miguez pers. comm. 2004).

3.8 Summary

In this chapter some of the potential risks and opportunities presented by the canal expansion have been explored. We have seen that the project presents formidable challenges that, depending on how they are managed, could either impede or contribute to Panama's future development and environmental sustainability. Viewed strictly as a strategy for economic development, the project raises many serious questions in regard to whether it is the most appropriate course of action – questions that thus far the Panama Canal Authority has yet to address. Canal expansion may present an opportunity to repay Panama's substantial social debt to its most disenfranchised; however it could also contribute to further marginalization and increased poverty. Similarly, environmental conditions in the western canal watershed may well improve should the project be carried out in conjunction with conservation and restoration efforts. However, ecological conditions in the region have likely been eroded already due to extensive land degradation. Should the inevitable impacts not be minimized, the risk of further deterioration perhaps to a permanently degraded ecological state will increase. The project viability, then, ultimately depends on what exactly the ACP plans to do and how they plan to do it. There exist methods to help guide their decision making process however. Determining the optimum anthropocentric or biocentric scale in advance may be one such method. Chapter 4 examines the project feasibility with precisely this objective in mind.

Chapter 4: Assessing Ecological Limits and Economic Scale in Panama: will the canal expansion be uneconomic?

> "Focusing on economic growth to eradicate poverty, disconnected or decoupled from the complex dynamics of the environment resource base on which growth depends...will not lead to sustainable solutions."
> - Folke et al. 2002, p. 439.

4.1 Introduction

We have seen in preceding chapters how the Panama Canal expansion is fundamentally an initiative that has arisen in response to a perceived need to foster continued economic growth for Panama and to maintain the canal's importance to global shipping. Yet when economic risks are considerable, the possible impacts serious, and the long term benefits uncertain, how is Panama to proceed?

This final section seeks to synthesize the information presented thus far. Much terrain has been covered. It is here that I will sketch out some of the crucial connections between discussions of economic scale and resource use. Four of Daly's principal arguments were presented in chapter 1:

1. **Optimal scale vs. optimal allocation** – Economic scale issues should be treated as fundamentally different from allocation issues.
2. **The economic system and the ecological system** – The economy is an open subsystem of a larger, finite, materially closed, non-growing ecosystem.
3. **National accounts** – Gross National Product (GNP) as it is currently measured is not a good indicator of economic activity or actual well-being and it does not consider how big the economy should be in relation to the biosphere.
4. **The Impossibility Hypothesis** – GNP as a measure of welfare has led to a concept of development that is impossible for all to attain. Levels of resource consumption in developed countries cannot be extended to the rest of the world.

These four points will be revisited again here and considered within the context of the plans for the Panama Canal expansion. If the final decision regarding the canal's future is to be fair, competent, and one that is socially and environmentally sound, the ACP must ensure that at least three important objectives are reached in addition to more obvious considerations of cost, risk, and market feasibility. First, the process followed in reaching a decision must be inclusive, open, and participatory; second, there must be reasonable and widely-accepted certainty that human and ecological well-being will increase as a result of the project; and third, the increased resource demands on which the project depends must fit within the capacity of the relevant ecosystem support base. While indications thus far suggest that the first objective has not been given sufficient consideration, it is the second and third that are of greater concern for our purposes here. How are we to be sure that the quantitative economic growth that will result from the canal expansion (1) will not overwhelm the ecosystem support base and (2) will lead to a qualitative improvement in overall well-being? Daly would suggest that setting the optimum economic scale of economic activity at the outset based on the regenerative and absorptive capacities of the biosphere and restricting resource and energy flows to these limits is one method by which economic development initiatives are more likely to improve social, environmental, and economic well-being while at the same time remaining within ecological limits. Chapter 4 will put this hypothesis to the test by employing a water management technique that is designed to do precisely what Daly advocates: set an ecologically-based limit to resource flows – in this case the hydrological modification of a river system – based on renewable biospheric capacities. Are Daly's ideas a useful contribution to local resource management issues? Is the Range of Variability Approach an appropriate policy instrument for use in determining optimum economic scale? Will the expansion of the Panama Canal be economic in Daly's sense of the term or will it contribute to economic growth that exceeds the regenerative capacities of the ecosystem? I begin with a description of the Range of Variability Approach.

4.2 The Range of Variability Approach (RVA)

4.2.1 What is the RVA?

In many ways the canal expansion project is an exercise in overcoming limits, not being bound by them. Vessel sizes are limited by lock constraints; maximum transits per day are limited by canal capacity; the minimum level of Lake Gatún is limited by ship drafts; efforts to relocate impacted farmers are limited by land availability (and by human rights); confidence in shipping and trade projections is limited to short-term time frames; and the cost of the project itself is limited by Panama's ability to pay for it. Perhaps most significant, however, are the limited water reserves available in the Panama Canal watershed.

We saw in Chapter 3 how the amount of water withdrawn from freshwater systems can affect their natural functioning and productivity, native species, and the services and products they provide (Richter et al. 1997). What kind of policy instrument could help to determine an ecologically acceptable level of water withdrawal from the Río Indio? Hydrologists and ecologists working in conjunction with The Nature Conservancy have developed a water management strategy called the Range of Variability Approach (RVA). The RVA is based on a growing body of research showing that the ecology of a river is best protected by maintaining the natural range of variation of its flow regime (Poff et al. 1997; Bunn and Arthington 2002; Richter et al. 2003; Baron et al. 2002; Richter et al. 1997; King et al. 2003).

River ecosystems have both qualitative and quantitative water requirements that must be recognized in order that they continue to provide the kinds of ecological services on which humans and other species depend. Freshwater management policies that do not acknowledge such requirements risk serious, perhaps irreversible, declines in their ecological productivity (Folke 2003). Research has shown that ecosystems may still maintain function and generate services for a time but, when faced with a sudden event, the system may experience a fundamental and often irreversible shift, usually to a less desirable state with a reduced capacity to supply life-supporting services (Holling and Meffe 1996; Gunderson and Holling 2002; Deutsch et al. 2003; Holling 1973; Scheffer et al. 2001; Elmqvist et al. 2003). For example, the construction of the Glen Canyon Dam on the Colorado River led to significant changes in the river's flow, sedimentation, temperature, and physical characteristics which in turn resulted in fundamentally altered natural food webs and the disappearance of many species including native fish (Postel and Richter 2003). In addition to the ecological damage, these transformations also eliminated many of the valuable ecosystem goods and services that humans relied upon. Flow modifications to many rivers in the United States, Britain, France, southern Africa, India, Canada, Scandinavia, and Australia have caused similar changes in physical habitat (which in turn is a major determinant of biotic composition), the habitat of aquatic plants, and the distribution and abundance of aquatic invertebrates. (Bunn and Arthington 2002).

Ecological resources have traditionally been managed mainly for economic output in the belief that a steady stream of resources can be provided indefinitely for human use (Peterson et al. 2003) and that any damage done can be reversed. But this is not always the case. Once a threshold is breached, ecosystems can be very difficult to restore back to previous natural conditions. Fishery collapse and permanent cultural eutrophication from nutrient inputs are two examples of this phenomenon (Baron et al. 2002; Jackson et al. 2001). By working to maintain natural streamflow variability, the RVA can help to inform about the risk of extreme hydrological transformations that might contribute to a catastrophic shift.

> *"The goal of ecologically sustainable water management will not be achieved until humans accept that there are limits to water use, and those limits are defined by what is needed by the natural systems that support us." (Richter et al. 2003, pg. 222).*

The natural flow paradigm is based on an understanding that aquatic and riparian organisms depend upon, or can tolerate, a range of flow conditions specific to each species. The species that are found in each river have endured adverse flow conditions, exploited many occasions of favorable flow, and have managed to persist in their native rivers over long periods of time. Until very recently in evolutionary time, the variation in river flows has been dictated largely by natural climatic and environmental conditions. These natural river flows have influenced the development of behavioral, physiological, and morphological traits in river species (Richter et al. 2003; 1997).

In the United States, the RVA has been used both to help restore the natural streamflow variability in already modified rivers and to speculate how best to mimic natural variability for rivers being targeted for some kind of substantial human intervention such as the construction of a dam (Richter et al. 1997). The RVA has been developed as part of an Indicators of Hydrological Alteration (IHA) software package designed to assist hydrologists and ecologists in evaluating streamflow data over a long period of time (20 years or more). As it is often difficult to determine which specific attributes of the altered flow regime are directly responsible for observed impacts such as the decline of a fish species (Bunn and Arthington 2002), the IHA characterizes a river's natural streamflow variation using a set of 32 ecologically relevant hydrological parameters and analyzes changes in those characteristics over time (see Appendix 2 for full list and descriptions of parameters) (Richter et al. 1996). These parameters are grouped into five general categories that represent five fundamental characteristics of hydrologic regimes, described here by Richter et al. (1996, pgs. 1166-67):

1. **Magnitude of monthly water conditions** – the magnitude of the water condition at any given time is a measure of the availability or suitability of habitat and defines such habitat attributes as wetted area or habitat volume, or the position of a water table relative to wetland or riparian plant rooting zones.

2. **Magnitude and duration of annual extreme water conditions** – the duration of time over which a specific water condition exists may determine whether a particular life-cycle phase can be completed or the degree to which stressful effects such as inundation or desiccation can accumulate.

3. **Timing of annual extreme water conditions** – the timing of occurrence of particular water conditions can determine whether certain life-cycle requirements are met or can influence the degree of stress or mortality associated with extreme water conditions such as floods or droughts.

4. **Frequency and duration of high and low pulses** – the frequency of occurrence of specific water conditions such as droughts or floods may be tied to reproduction or mortality events for various species, thereby influencing population dynamics.

5. **Rate and frequency of water condition changes** – the rate of change in water conditions may be tied to the stranding of certain organisms along the water's edge or in ponded depressions, or the ability of plant roots to maintain contact with phreatic water supplies.

Based on the IHA characterization, the RVA proceeds in steps that work to set, implement, and refine management targets and rules for each river with the fundamental concept being that the river must be managed in such a way that the value of each IHA parameter falls within its range of natural variation (Richter et al. 1997). Using the resulting information, the management team can then decide on the most appropriate RVA target. In this manner, the appropriate scale of modification is, as Daly suggests, a social decision based on ecological information but resulting from collaborative efforts across disciplines.

While the RVA may reduce the flexibility to manage river systems solely for economic benefits and other human needs, a decision can be made by stakeholders at the outset as to how much or how little modification is acceptable. How healthy do we want the river to be? Is some degradation of river health acceptable? Such decision making may present some conflict between competing water users when demand is growing rapidly and supply is limited. It is important to keep in mind, however, that by choosing this approach, water managers are setting a limit on the degree to which they will allow the river to be degraded. Water demands can then be met through traditional market mechanisms to increase the allocative efficiency of the resource and by policies designed to share water more equitably (Postel and Richter 2003).

4.2.2 Testing the RVA

The purpose of this exercise is not to perform a full hydrological analysis but to evaluate the technique as a potential policy instrument in helping to determine the appropriate scale of economic activity in relation to resource use. For this study, the IHA was used to analyze existing historical streamflow data of the Río Indio to paint a picture of the river's natural flow regime. Daily streamflow records for the Indio were provided by Panama's hydropower company, Etesa, who have operated a monitoring station at the community of Boca de Uracillo since the 1950's. Daily records between 1976 and 1995 were used for analysis as records both before and after this 20 year period had several unexplained gaps in the data (see Appendix 5 for raw data collected).

4.2.3 Results and Analysis

Daily flow values over the 20-year period (1976-1995) were used to calculate daily and monthly averages, thus providing a hydrographic depiction of the Rio Indio's annual average flow regime for this period (Figure 4.1, p. 70). The Indio is typically characterized by distinct wet and dry seasonal flow as well as several important high and

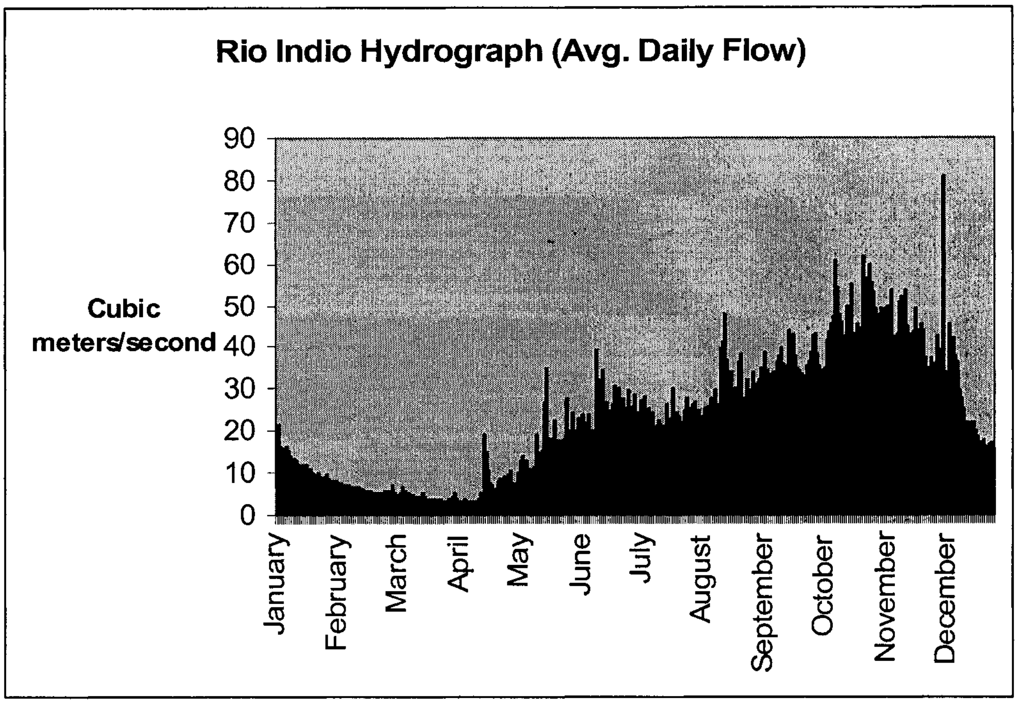


Fig. 4.1. Graph represents the average annual flow regime of the Rio Indio for the 20-year period 1976-95.

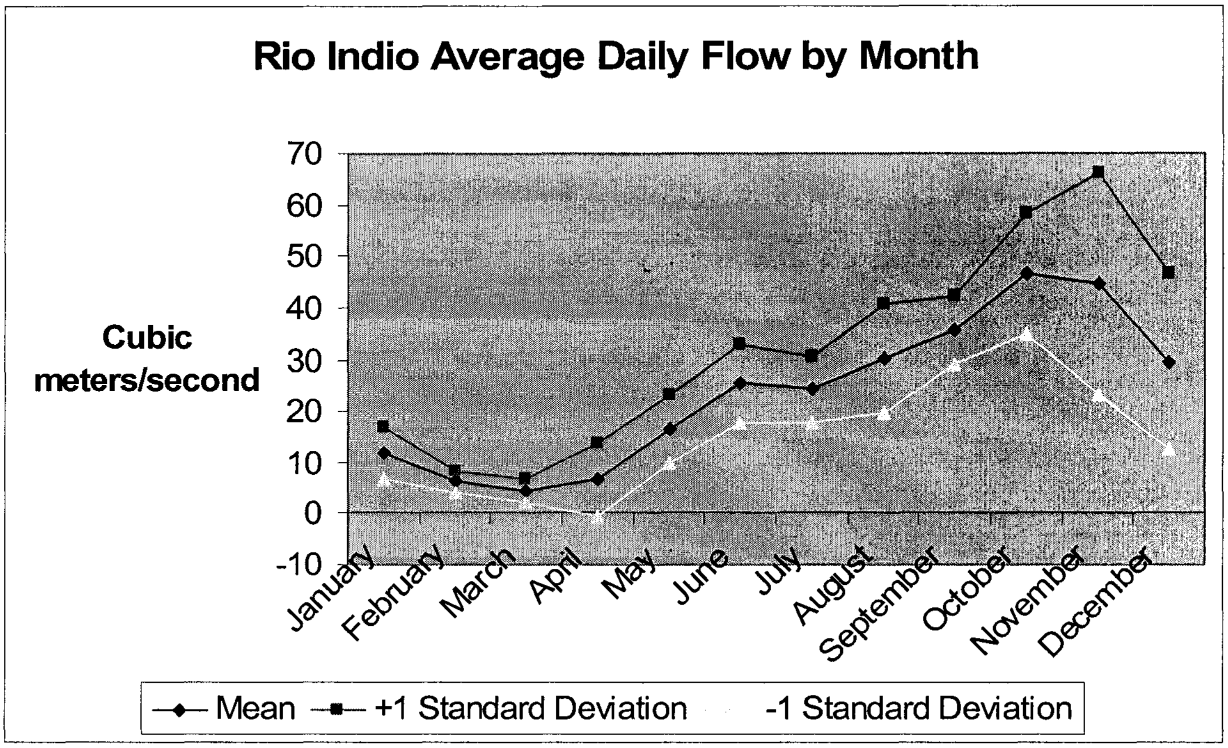


Fig.4.2. Graph shows the average daily flow of the Rio Indio by month for the 20-year period 1976-1995. ±1 standard deviation from the mean is also indicated.

low pulses, and peak/low flows. For the average monthly flow graph (Figure 4.2, p. 70), the mean given for each month is the average *daily* flow value for that month based on the period analyzed. A ±1 standard deviation was used to represent the range of ecologically acceptable flow modifications for this parameter. Within each month, flow releases would be required to fall within this range to meet the river's quantitative flow requirements. Additionally, variation of flow (high and low pulses, extreme events, single day maximums and minimums, etc.) must also be met to satisfy the *qualitative* attributes of the Indio's natural flow regime.

IHA analysis provided a characterization of the Indio's natural flow regime from which RVA targets for all 32 parameters were computed at ±1 standard deviation from the mean as recommended by Richter et al. (1997) (Fig. 4.3, p. 72). If, as its proponents claim, the RVA works to preserve the integrity of the entire ecosystem, these targets should correspond well with Daly's biocentric optimum point at which "other species and their habitats are preserved beyond the point necessary to avoid ecological collapse or cumulative decline" (1996, p. 52). The biocentric optimum point of economic activity in Panama must therefore not result in the modification of the flow regime beyond this recommended range. However, these RVA targets are only guidelines for decision making. Multi-disciplinary management would ultimately make the decision regarding how much degradation of ecosystem health, if any, would be acceptable. In addition to recommending management targets, the RVA includes subsequent steps that involve designing a set of management rules that will enable attainment of the targeted flow conditions and the implementation of an adaptive monitoring program designed to assess the ecological effects of the chosen management system. Only the initial RVA steps – IHA analysis and the recommendation of management targets – were undertaken for this study.

Fig. 4.3. Results of the Indicators of Hydrologic Alteration analysis for the Río Indio, Panama. Basic data used in the analysis were daily mean streamflows between 1976-1995 (see Appendix 5), reported here as cubic meters per second. RVA flow management targets are provided for all parameters. See Appendix 2 for detailed descriptions of IHA parameters.

			Range Limits		RVA Targets*	
			Low	High	Low	High
IHA Group 1	**Means**	**Standard Deviation**				
October	46.60285	11.74998612	30.77	72.1	34.85287	58.35284
November	44.55307	21.54928186	26.05	123.15	26.05	66.10235
December	29.53684	17.01896309	12.78	75.63	12.78	46.55581
January	11.93519	4.963915022	5.82	23.21	6.971272	16.8991
February	6.227019	2.249832775	4.26	9.95	4.26	8.476852
March	4.357347	2.272519981	1.81	11.77	2.084827	6.629867
April	6.642243	7.271891734	1.52	22.07	1.52	13.91414
May	16.50862	6.65948131	8.41	26.71	9.849136	23.1681
June	25.34953	7.463778327	15.35	45.6	17.88575	32.8133
July	24.22952	6.419323583	11.7	39.82	17.81019	30.64884
August	30.23192	10.50194104	16.59	48.47	19.72998	40.73386
September	35.63047	6.766004058	23.71	48.3	28.86446	42.39647
IHA Group 2						
1-day minimum	2.2	1.08	.75	3.24	1.12	3.28
3-day minimum	2.3	1.12	.8	3.75	1.18	3.42
7-day minimum	2.4	1.14	.86	3.79	1.26	3.54
30-day minimum	3.1	1.56	1.22	4.89	1.54	4.66
90-day minimum	4.4	1.6	2.06	5.61	2.8	6
1-day maximum	211.8	107.11	71.7	474.8	104.69	318.91
3-day maximum	138.6	47.72	71.56	224.53	90.88	186.32
7-day maximum	97.1	30.28	52.22	161.41	66.82	127.38
30-day maximum	59.7	19.54	40.12	124.63	40.16	79.24
90-day maximum	46.6	12.36	34.64	87.47	34.64	58.96
IHA Group 3						
Julian date of annual minimum	11.4 (Jan. 11)	16.12	-17 (Dec. 14)	39 (Feb. 8)	-4.72 (Dec. 26)	27.52 (Jan. 27)
Julian date of annual maximum	185.3 (July 2)	63.74	16 (Jan. 16)	248 (Sept 3)	121.56 (April 29)	248 (Sept. 3)
IHA Group 4						
Low Pulse Count	4.25	2.2	1	9	2.05	6.45
High Pulse Count	21.95	6.39	10	33	15.56	28.34
Low Pulse Duration	25.73	13.66	7.44	62	12.07	39.39
High Pulse Duration	4.42	1.39	2.4	7.25	3.03	5.81
IHA Group 5						
Fall Rate	-5.97	1.69	-10.07	-3.09	-7.66	-4.28
Rise Rate	10.88	2.9	5.44	16.29	7.98	13.78

*RVA targets were based on mean + or – 1 Standard Deviation, except when such targets would fall outside of range limits (range limits were then used).

As we saw in Chapter 3, the ACP is planning on diverting enough water from the Indio to provide for 15 additional lockages per day when the expanded Panama Canal is at maximum capacity (de la Guardia pers. comm. 2004a). This translates into a maximum rate of 780 million gallons or 3 million m^3 per day, whereas the daily streamflow average of the river between 1976 and 1995 was only 2.1 million m^3. Therefore, maximum withdrawal demands would exceed water availability in the river. Clearly, the expanded canal could only operate at maximum capacity when water reserves are sufficient, or by securing additional sources of water or relying heavily on recycling in the locks.

Even if water demands on the Indio do not exhaust the available supply, it appears likely that diversion rates will be sizeable. Hughes' (2002) prediction that the flow equivalent of only minimum, dry season base flows would remain year-round below the dam seems consistent with ACP planned withdrawal rates. This will represent a dramatic reduction in flow amount during Panama's 8-month rainy season. Such a drastic alteration in flow quantity will make it extremely difficult, if not impossible, to meet the Indio's quantitative and qualitative flow requirements described by the IHA parameters and RVA targets such as high and low pulses, floods, peak flows, timing, and extreme events.

Could the canal expansion be downscaled to stay within RVA limits? Although a full hydrological analysis and set of flow recommendations for the Indio is beyond the scope of this study, it is worth examining at least one set of RVA parameters – magnitude of monthly conditions (group 1) – to get some sense of what the RVA prescription might look like. In order to ensure that at least the minimum flow requirements are met on a monthly basis and that the annual flow regime continues to resemble its natural seasonal pattern, water withdrawals from the Indio are limited by the minimum monthly RVA targets listed above in figure 4.3 (Group 1). For example, in October each year, a minimum daily average of 34.85 m^3 per second or just over 3 million m^3 per day must be left in the Indio according to the RVA low target for that month. In March, by contrast, only 2.08 m^3 per second or 180,000 m^3 per day would be necessary to satisfy minimum flow requirements (figure 4.4).

Another way to look at the RVA flow prescription is to calculate the amount of water available to the ACP for withdrawal each month. Subtracting the minimum monthly RVA target from the mean for that month results in a calculation of the water available (in cubic meters per second). This figure can then be converted into cubic meters per day to provide an indication of the daily withdrawal limits for each month (Figure 4.4). For example, in October, 1.02 million m^3 of water could be diverted each day from the Indio, whereas in March only 200,000 m^3 would be available.

Month	Minimum flow requirements (million m^3/day)	Water available for withdrawal (million m^3/day)
January	.6	.43
February	.37	.17
March	.18	.2
April	.13	.44
May	.85	.58
June	1.55	.64
July	1.54	.55
August	1.7	.91
September	2.49	.58
October	3	1.02
November	2.25	1.6
December	1.1	1.45

Fig. 4.4. Table shows the minimum monthly flow requirements of the Río Indio and subsequent water availability for withdrawal based on IHA/RVA criteria.

Monthly withdrawals from the Indio that stayed within the prescribed RVA range set out by parameters in Group 1 would result in an annual flow hydrograph that resembled the -1 standard deviation line depicted in figure 4.2 above. However, the ACP would clearly not be able to withdraw enough water from the Indio sufficient for their planned 15 additional lockages or 3 million m^3 per day. In fact, there is not a single month where this amount of water would be available for withdrawal according to RVA criteria. Even in November, the month when water availability is highest, only 1.6 million m^3 daily could be withdrawn under this framework – roughly half the amount the ACP has said they will require (de la Guardia 2004a pers. comm.). Furthermore, it is important to bear in mind that even if water withdrawal amounts stayed within RVA guidelines, satisfying these quantitative parameters is not sufficient to maintaining the river's natural flow regime. Meeting the Indio's qualitative flow requirements that are described by the other IHA parameters in groups 2 through 5 (figure 4.3 above) is essential to maintaining the river's natural streamflow patterns of variability (Richter et al. 1997, Richter et al. 1996).

4.2.4 Problems with the IHA/RVA

Richter et al. (1997) recommend that the ±1 standard deviation be the default for setting initial RVA targets. However, they admit that this target is somewhat arbitrary as dependence of native biota on specific values of the hydrological parameters employed in the RVA has not been comprehensively substantiated with statistical rigor. The range of acceptable flow modification is still ecologically untested and will vary for each river (Poff et al. 1997). As critical ecological thresholds for various components are better understood, flow management targets should be adjusted in an adaptive fashion according to Richter et al. (1997). In their words, despite the necessity for further testing and analytical verification, "the RVA is our response to an urgent need to act in the face of considerable uncertainty" (p. 266). Testing the efficacy of the RVA is therefore an essential component of its implementation. Once a management system has been implemented based on RVA guidelines, Richter et al. (1997) recommend a monitoring and ecological research program designed specifically to assess the ecological effects of the management system. At the end of each year, the new streamflow regime must be re-characterized using the IHA and compared with RVA target values. These targets are to be refined based on ecological monitoring and research results.

There are additional problems with applying the RVA method in the case of the Río Indio. As discussed in Chapter 3, the Indio watershed has been severely modified over the past several decades. Much of the forest cover has been removed and this has likely influenced both the flow regime of the river, its temperature, level of sedimentation, and other important factors. According to Richter (pers. comm. 2004), the primary influence of land use changes is to alter the infiltration capacities of the soils, which usually translates into higher peak flows and lower base flows. In other words, flow data between 1976 and 1995 may not reflect the Indio's natural flow regime as it existed prior to human disturbance. Correcting this problem would require streamflow data before modification of the watershed which do not exist. In the absence of such data, the earliest records available would be preferable; however early flow data for the Indio is inconsistent and contains significant gaps. The 20 year period chosen for this study is the most reliable and comprehensive data set available. Although perhaps not ideal, it is well known that land use impacts on hydrologic regimes generally pale in comparison to impacts due to dam operations (Richter pers. comm. 2004). RVA analysis using this data set therefore provides a good point of departure for the Rio Indio, yet it is important to bear in mind that land use changes may have had some influence on flow conditions prior to the period analyzed. In cases where land-use changes may have altered the flow regime, hydrological simulation modeling or the use of normalized estimates may be used that are based on data from reference catchments with adequate record lengths, similar conditions of climate, surficial geology, and minimal anthropogenic effects (Richter et al. 1997). Such an approach would likely be useful in this case to improve the analysis of the Indio's pre-impact flow regime.

It is also important to emphasize that the RVA deals only with the issue of flow quantity and quality. While extremely important, temperature regimes, suspended sediment loads, the ability of aquatic organisms to move freely through the stream, thermal and light characteristics, organic matter inputs, chemical and nutrient characteristics, and biotic assemblages are fundamental defining attributes of freshwater ecosystems that must be given management consideration (Baron et al. 2002). For instance, there is no benefit in maintaining the natural streamflow regime of a river if it is being excessively polluted at the same time. While a dramatic change in river flow is one of the processes that could contribute to a catastrophic shift in a river ecosystem, other processes that might drive this shift include the simplification of terrestrial and aquatic environments, land-use changes, redirection of flows, and changes in water quality (Folke 2003).

Another limitation of the RVA is that it is only one of numerous different water management approaches and there is no consensus on the best technique. There are a number of scientific methods available to determine how much water should be left in a river to support a healthy river community. Each method makes different assumptions about what is most important to aquatic communities. The advantage of the RVA is that it considers the entire river ecosystem rather than only selected species. The RVA is not just concerned with maintaining minimum streamflows as are some other methods; but instead, it considers the entire range of streamflow variation and explicitly sets limits to flow modification. As such, it is an approach to flow management that appears to be compatible with Daly's ideas about ecological limits to economic growth. It should be stressed as well that maintaining the natural flow regime, as the RVA advocates, is a highly regarded approach that has been substantiated by considerable, credible research in the ecological literature (Baron et al. 2002; Richter et al. 1997; Richter et al. 2003; Poff et al. 1997; King et al. 2003; Bunn and Arthington 2002).

Finally, while the RVA provides a detailed description of a river's natural flow patterns and suggests management targets for flow modification, it does not give an indication of the ecological consequences associated with altered flow regimes. Understanding these consequences is essential for deciding how much modification is acceptable in any given situation. Other methods have been developed for precisely this purpose such as the DRIFT approach (Downstream Response to Instream Flow Transformation) which has been used by water managers in South Africa (King et al. 2003; Postel and Richter 2003). DRIFT explicitly identifies different degrees of ecological health that could be expected as existing flow conditions in a river are altered (King et al. 2003). The expected ecological conditions resulting from different water management scenarios are classified on a scale from A (negligible modification) to D (largely modified). A full description of DRIFT and other such methods is beyond the scope of this study; what is important is to recognize that the RVA is limited and is but one important part of the policy toolbox.

4.3 Ecological Economics and the Panama Canal Expansion

It is important that we now turn our attention to how tools such as the RVA can help to determine economic scale at a local level and contribute to Daly's primary objective: redirecting economics to serve the public good by contributing to qualitative development. To this end, we now revisit Daly's four arguments presented in Chapter 1.

4.3.1 Optimal Scale and Optimal Allocation

As we saw in Chapter 1, Daly (1996) believes economic scale issues are fundamentally different from questions of allocation and therefore require different policy instruments. Optimal scale is a macroeconomic goal that is not determined by prices but is a social decision reflecting ecological limits. Prices serve efficiency; income redistribution policies serve equity; scale requires some 3rd policy instrument – one that predetermines acceptable volumes of resource flows based on the renewable biospheric capacities of regeneration and waste absorption.

Results show that the RVA is a potentially useful policy instrument in limiting the hydrological modification of river systems based on ecological flow requirements. The range of targets made available by the RVA provides some flexibility to set boundaries at different points; however a firm limit is established at ±1 standard deviation from the mean for all 32 IHA parameters. This is the recommended point beyond which the system may begin to experience ecological decline. In this sense, the RVA targets on their own are likely more useful in helping to determine the biocentric rather than the anthropocentric optimum point to hydrological modification. While these terms are not used as such in a RVA analysis or for that matter in the ecological literature, the RVA takes an approach to river management that is consistent with Daly's definition of the biocentric optimum in that it sets out to preserve the entire ecology of the system regardless of a species instrumental utility to humans. It may also be possible to set an anthropocentric limit using the RVA but, as the RVA does not predict the ecological consequences of different flow modifications, it would have to be used in combination with another tool such as the DRIFT approach to river management (described above in section 4.2.4) to determine the point at which "the marginal benefit to human beings of additional man-made physical capital is just equal to the marginal cost to human beings of sacrificed natural capital" (Daly 1996, p. 51). As the DRIFT method identifies different degrees of ecological health that could be expected as existing flow conditions in a river are altered and links these to socioeconomic consequences for subsistence users of the river (King et al. 2003), it could in this case help to identify the point at which the marginal costs of lost ecological services due to sacrificed water and land resources in the

Indio equal or exceed the marginal benefits to be gained in the form of increased canal revenues.

Although RVA analysis, then, does result in the calculation of firm, absolute limits to flow modification, its recommended targets have yet to be statistically substantiated in the ecological literature. While this may appear at first glance to fail in our quest to set a clearly defined, defensible ecological limit at a local scale, Daly himself does not suggest that such precise, quantifiable limits are realistic or even necessary (Daly and Cobb 1994). On the contrary, he believes that while such limits likely exist, policies need not wait for the exact calculation of the optimum scale because this will require much interdisciplinary collaboration and will likely never be precisely defined. Ecological systems are exceedingly complex and their interactions not always well understood. Therefore it may not be possible to impose static resource goals on dynamic ecological systems because dependable plateaus may not exist (Gunderson and Holling 2002). There is an important interplay between social and ecological processes, and the variability in natural systems cannot be controlled (Holling and Meffe 1996). More important is the overwhelming evidence that the present scale of throughput is too large and therefore "policies must be adopted to reduce it" (Daly and Cobb 1994, p. 242). What we need then, in Daly's view, are policy instruments to assist in guiding such a reduction in scale. We can at best only specify a range of options with different safety margins and levels of risk each with its own projected socioeconomic and ecological outcomes to guide judicious macroeconomic policy and resource management decision-making. The RVA appears to be of some assistance in this capacity.

While water appropriation is a major feature of the Panama Canal expansion, it is not the only important consideration in determining project feasibility. RVA analysis may well be useful in setting limits to hydrological modification, but does this make it a useful macroeconomic policy instrument for determining optimum *economic* scale? We have seen in Chapters 2 and 3 that other impacts could include deforestation and massive excavation, fragmentation of habitat, massive social displacement, unmanageable debt burden, impacts from dam construction, an increase in greenhouse gas emissions due to the creation of a new reservoir and increased canal traffic, and defensive expenditures against the unwanted side effects of growth such as increased pollution of ports and the canal reservoir, or salinization of the drinking water supply. Just as there is a limit to river modification, the exploitation of other resources may similarly limited by ecological constraints. Even if hydrological modification remains within an acceptable range, these other costs cannot be accounted for using the RVA. Other policy instruments are required.

This limitation of the RVA highlights the need for a multi-disciplinary approach to economic scale issues. The ecological and human footprint analyses have demonstrated that it is the *cumulative* ecological impacts of human activity that are important in considering questions of scale (Wackernagel and Rees 1996; Sanderson et al. 2002). Even if canal expansion does not result in unsustainable water withdrawal rates, it could very well lead to other increases in the consumption of resources or the production of wastes such as carbon dioxide, thus increasing both the overall ecological footprint and the economic scale. The RVA is but one tool whereas measuring the optimum resource inputs to and waste outputs from the economy will require a host of policy instruments working in concert.

4.3.2 The Economic System vs. the Ecological System

Daly's second argument asserts that, as the economic system is a subsystem of a materially closed, non-growing ecosystem, it cannot grow beyond the scale of the larger system. The economic system should therefore be limited to an optimum scale of resource and energy throughflow. However, policies designed to stimulate economic growth such as the canal expansion do just the opposite: they work to *encourage* the consumption and depletion of limited natural capital reserves.

Could the Panama Canal expansion lead to uneconomic growth in Daly's sense of the term? In other words, will the project expand the scale of economic activity to such an extent that the well-being of humans or other species will decline? For our purposes, the finite larger system that provides services for the subsystem (the canal) is the canal watershed. The subsystem is limited, then, to the extent that it cannot grow beyond the size of the parent system: the canal cannot consume more water than is available in the watershed. Moreover, well before this point is reached, there is an anthropocentrically optimum point of water consumption and, still smaller, a biocentrically optimal point.

Beyond the anthropocentric optimum scale, the well-being of humans will decline with further economic expansion (uneconomic growth). Costs beyond the anthropocentric optimum may include decline in ecosystem productivity, loss of ecosystem services, unemployment, loss of livelihood, social displacement leading to intensified environmental and social pressures elsewhere. Beyond the biocentric optimum, although well-being for humans may continue to improve, we may well see ecological decline. Costs could include a loss of biodiversity, species extirpation, and habitat destruction.

We have seen that traditional cost-benefit analyses cannot accurately internalize all costs (Ackerman and Heinzerling 2004; Daly and Cobb 1994). Therefore, to reduce the likelihood that the canal expansion will contribute to ecological decline or uneconomic growth, policy instruments such as the RVA that work to limit the over-consumption of resources should be adopted. However, as it is the cumulative ecological impacts of human activity that are important in considering questions of scale, the canal expansion must not be viewed in isolation but rather as a part of total economic activity in Panama. A suite of policy instruments could conceivably produce a total resource and energy budget for all countries from which Panama would be given an allocation based on its population and resource abundance. We have already seen the beginnings of such a process with proposals to set limits and assign allocations to the emission of greenhouse gases, pollutants, and fisheries harvests among others. Once budgets are allocated, resource-saving innovation and ingenuity can work to increase efficiency of resource use but within the designated limits.

Economic scale should be limited at the national and global level out of recognition that scale questions are nested. Local ecological limits may well be overcome but only by impinging on limits elsewhere. For example, an expanded canal will require more water to move vessels through its new, larger locks. Increasing the amount of water diverted from other rivers to supplement the canal decreases the energy needed for water recycling in the new canal locks but increases the environmental and social impacts resulting from the construction of new dams and reservoirs and it decreases the available supply of natural capital (freshwater) for humans and other species. On the other hand, reducing the amount of water to be drawn from other watersheds increases the need for water recycling in the locks, thereby increasing the energy required to pump water upwards for reuse and also increasing the risk of salinization of Lake Gatún, the drinking water supply for Panama City. Either way, one problem is solved by creating another, and the total scale problem remains unsolved, having merely been shifted from one sector to another. Under a total resource and energy budget, Panama *could* exceed its water allocation in this manner but this would require withdrawals on its carbon budget which would force the country to make emissions cutbacks elsewhere thus keeping total economic scale within the predetermined acceptable range.

It should be mentioned that such a scheme does not make sense under a neoclassical economic paradigm because natural and human capital are assumed to be perfectly substitutable. In other words, the canal could simply use all the freshwater available in the watershed then use the human capital that had been created by the corresponding economic expansion to substitute another resource in its place, such as seawater or freshwater from even further afield. The human capital generated by exhaustion of the local freshwater resource would make it economically feasible to substitute the more expensive resource replacement. In this sense, the limitation is not water availability but cost. However, Daly has shown that natural capital, not labour or human capital, is the limiting factor of production in a resource scarce world. The amount of freshwater available is limited by annual rates of precipitation, not by our facilities to collect and store it. Even if sufficient human capital were generated by the canal expansion to make saltwater a economically feasible substitute for freshwater through desalinization for human consumption and by pumping it up to Lake Gatún for use in the canal locks, doing so would presumably require massive amounts of energy. In the absence of cleaner energy sources, fossil fuel depletion and carbon emissions would rise. Hence substitution of this sort once again does not solve the scale problem but simply moves it from one sector to another.

Although setting ecologically based limits to hydrological modification is a relatively straightforward exercise using a technique such as the RVA, other limits are not so easily quantified, particularly when jurisdictional boundaries are not well-defined. This could potentially create problems in allocating fair resource and energy budgets for each nation. Although Daly does not provide any guidance for dealing with such conflicts, he is opening a question that, if considered seriously, would fundamentally reshape humanity's relationship with the biosphere. The precise framework by which countries would be allocated resource and energy budgets is sure to be a complex process that will take many years to develop and will require much collaborative, inter-disciplinary effort. However, tools such as the RVA can be one element in building such a framework that is based on both our empirical knowledge and a comprehensive normative theory for the planet.

The RVA and other scientific tools would constitute the empirical component of the framework by helping to inform decision making of the ecological limitations to resource and energy consumption. A normative declaration will be necessary to decide, based on the empirical data, how much ecosystem modification or degradation is tolerable to satisfy human needs. Although such a moral theory does not yet exist, efforts are currently being made to develop a global stewardship ethic that rethinks human obligations to nature and to each other (Brown 2001; Singer 2004; Earth Charter www.earthcharter.org).

4.3.3 National Accounts

Should such a framework be developed and resource/energy allocations be successfully implemented in a fair and equitable manner, we still require better measures of well-being that consider issues of economic scale. It is projected that the canal expansion will lead to an increase in the size of the Panamanian economy (an increase in scale) (Proceedings 1997). We have seen in Chapter 3 that the benefits could include increased canal revenues, an increase in general revenue due to a projected increase in trade, indirect economic benefits for canal-related companies, employment benefits, the opportunity for social justice to those marginalized, and environmental improvement. Additional resources required to support this economic expansion will include more freshwater, land and habitat, fossil fuels, and possibly mineral depletion. Other resources may be inadvertently depleted as a side-effect such as soils due to increased erosion rates during excavation, vegetation cover due to excavation and flooding, local fisheries due to pollution, and biological resources due to habitat loss. Additional wastes resulting from the project will likely include carbon emissions, aquatic and marine pollution from increasing canal traffic, and the deposition of vast quantities of wet and dry materials for excavation. How much additional welfare will be gained from this increase in resource throughput and how can it be measured?

We saw in Chapter 1 Daly's proposed method for measuring actual well-being: The Index of Sustainable Economic Welfare (ISEW). The evaluation of proposals like the Panama Canal expansion is heavily dependent on the anticipated effects on economic growth; however Chapter 1 also described how growth, as measured by GNP, is not a good indicator of welfare, nor do we have good measures for the costs and benefits of aggregate growth. If it is improved welfare we seek in our economic policies and not just quantitative growth, we not only need better economic policies to improve welfare but also an improved means to measure it. The ISEW can help with the latter. This point needs illustration using qualitative hypothetical examples taken from the Panama case study.

Recall that the ISEW is a more accurate measure of welfare than GNP as it deducts spending that is not welfare producing and accounts for the creation and losses of all forms of capital by adding the creation of human capital and deducting the depletion of natural capital. Increased canal revenues, indirect economic benefits, and improved distributional equality would be added to the weighted personal consumption column indicating an increase in welfare while environmental and social costs described above would be listed under columns such as costs of water pollution, costs of air pollution, loss of farmland, loss of wetlands, increases in distribution inequality, and long-term environmental damage, and would be subtracted from total welfare (see Appendix 3).

While most projected economic benefits and social/environmental costs could be accounted for within the ISEW, other costs will be difficult to quantify accurately, particularly those that are not directly related to human welfare. Some assumptions can be made to estimate quantities that are immeasurable such as the costs imposed upon future generations by the depletion of water reserves or increased greenhouse gas emissions; however such estimates often rely upon traditional cost-benefit measures which we have seen to be deficient. Policy instruments such as the RVA and DRIFT could help to quantify a reduction in ecological and social well-being based on the hydrological modifications that are to take place; however as these tools are not strictly economic instruments, they are not designed to produce reliable monetary measures as is required by the ISEW. This is more a limitation of the ISEW as it is based after all on contemporary mainstream economic ideas that cannot easily quantify some costs. Daly and Cobb (1994) acknowledge this drawback but maintain that the ISEW still better reflects actual changes in well-being than does the GNP. Nonetheless, non-quantitative, non-monetary measures used in combination with the ISEW would help to provide a more comprehensive assessment of well-being, one that accounts for costs beyond the biocentric as well as the anthropocentric optimum scale.

Ultimately, a projected ISEW in combination with some other non-quantitative measure of well-being could be estimated under future scenarios that include canal expansion and others that do not. These could be contrasted to speculate on actual improvements in welfare over the long-term. To do so here would be merely speculative guesswork without knowing the details of the ACP's expansion plans. However, if Daly and Cobb's per capita ISEW calculation of the United States between 1950 and 1990 is any indication, there is reason to be sceptical about strategies designed primarily to increase GNP growth. We see that actual welfare actually declined slightly between 1970 and 1990 in the U.S. according to the ISEW while per capita GNP rose by almost 50% (Appendix 3). Panama is a poor country compared to the U.S. and economic growth may yet correspond strongly with improved well-being for many of its citizens. But the ISEW shows that the relation between economic growth and well-being is not perpetual.

Economic benefits from megaprojects such as the canal expansion in GNP terms may appear to be high at first glance but when real costs and non-quantitative costs are factored in, the *marginal* benefits may be nominal or even negative. Increasing social and environmental costs resulting from increased economic scale can negate any material gains brought about by economic growth. Increased marginal benefits in the form of improved – and accurately measured – well-being should therefore be the objective of prudent, ecologically sustainable economic policy. Policy instruments such as the RVA and DRIFT can help to assess possible changes in ecological health from both an anthropocentric and biocentric perspective while the ISEW can assist in actually measuring corresponding changes in welfare. As we saw in Chapter 3, improving well-being in the western canal watershed will mean addressing the need for adequate health care facilities and treatment, electricity, school repairs, a regular teacher, a potable water supply, a phone line, and road improvements. Meeting these needs should be *the primary objective* of economic development strategies in Panama. The canal expansion may not be the most practical or efficient means to achieve such goals.

4.3.4 The Impossibility Hypothesis

We have seen in chapter 3 that, without expansion, the Panama Canal will not have the capacity to expand economically and will likely have decreased global importance, remaining attractive only to those shipping routes that must use it. Already, according to the ACP, the canal has lost some of its market share in recent years and expansion therefore is needed for Panama "to keep up with the rest of the world" (Sabonge pers. comm. 2004). If the canal expansion is designed to help Panamanians move toward the goal of North American-style standards of living, Daly's impossibility hypothesis reminds us that, as the rest of the developing world also shares such aspirations, attaining it for all will be an ecological impossibility at current North American per capita levels of resource consumption and waste production. The resulting increase in *cumulative* economic scale will certainly overwhelm the regenerative capacities of the biosphere regardless of whether or not individual ecological limitations can be overcome. For instance, even if we were able to provide sufficient freshwater to all humans on the planet and for projects such as the canal expansion through massive infrastructure developments (dam construction, water transfer, etc.), we could simply be solving one scale problem (water availability) by creating others (non-renewable resource depletion, fossil fuel emissions, etc.). GNP would increase as a result of the economic activity generated by the infrastructure investments, but because GNP as an indicator of welfare does not recognize the dilemma presented by the impossibility hypothesis, genuine well-being may well be diminishing due to the depletion of natural capital, global warming, defensive expenditures, and so on. And this does not consider the water required by ecological systems to function which would further reduce the amount available to humans.

Tools such as the ISEW could assist in this regard by providing a better measurement of actual improvements in well-being. However, even if human well-being were to improve according to ISEW measures, we still may not know whether total economic activity was within sustainable biospheric limits. Ecological deterioration may well occur just as human well-being is improving according to the ISEW. In other words, the ISEW could permit continuing increases in population and consumption without necessarily solving the scale problem if individual ecological limits continue to be overcome either directly or by impinging on others. Were countries allocated total resource and energy budgets in the manner described in section 4.3.2 whereby a suite of policy instruments such as the RVA produces a total resource and energy budget (a fixed, optimal scale) for all countries based on the normative and empirical framework described previously, the cumulative scale problem could then be addressed. If one scale problem were solved by shifting it to another sector, a country would still be required to stay within its total cumulative resource and energy budget. Such an approach would almost certainly result in much-reduced ecological impacts and possibly a radical reduction in the inequitable consumption patterns that currently exist between developed and developing countries as rich nations would be compelled to live within the means of their resource and energy allocations.

4.4 Concluding Remarks

The results of this investigation indicate that Daly's work can be useful in helping to both limit ecological impacts at a local level *and* contribute to improved well-being when used in conjunction with appropriate policy instruments. However, on a case by case, project by project basis, setting either anthropocentric or biocentric limits to economic activity is not viable because local limits of one resource can be overcome by impinging on others. It is the cumulative impacts that are important and, because of this, we have seen that single resource management tools such as the RVA are limited in their capacity to help determine optimum local economic scale. It is crucial therefore that scale questions be considered by using these local resource management tools in conjunction with national and global resource and energy budgets that are determined empirically by the regenerative and absorptive capacities of the biosphere and guided normatively by a moral theory that sets out a comprehensive vision for a new and just relationship between humanity and the planet. Although it is a formidable undertaking, establishing a global ethic of this sort is not without precedent as evidenced by the Universal Declaration of Human Rights. As John Ralston Saul points out, "A reasonable number of non-economic and internationally binding treaties based on the primacy of ethics and the public good have begun to take form...They represent the beginnings of an attempt at an international balance in which the prism of civilization is neither naïve market economics nor national selfishness" (Ralston Saul 2004, p. 43). Further efforts are now urgently required to address issues of citizenship and stewardship within the context of appropriate economic scale.

Despite the promise of Daly's work in contributing to improved resource management, there may well be objections to his ideas. Perhaps most significantly, he could be criticized for making insufficient efforts to consider social costs as part of the optimal scale equation. We have seen in Chapter 3 how the Panama Canal expansion may lead to serious social impacts regardless of optimum economic scale relative to the ecosystem. To proceed with the project in almost any manner will be to incur social costs. However, insofar as social impacts are concerned, Daly follows traditional neoclassical economics by treating such costs as a problem of allocation and equitable distribution. The ISEW does take some social costs into account such as distributional inequality, defensive private expenditures, costs of personal pollution control, and loss of farmland. He stresses as well that redistribution policies have not been given nearly enough attention by economists compared to those designed to improve allocative efficiency. Policy instruments for attaining optimal distribution will include transfer payments and setting limits to income inequality (Daly 1996). As long as net social benefits outweigh the costs, these policy instruments could equitably compensate those who are to be impacted. This is not strictly speaking a scale problem however and is therefore not an oversight on Daly's part. Allocative efficiency and distributive equity (to a lesser extent) are already recognized by neoclassical economics as important issues;

scale on the other hand has been almost entirely ignored. Clearly, any discussion of scale must be carried out in combination with policies geared to ensure fair and participatory decision making, social justice, and equitable cost and benefit sharing. Just as local scale issues are nested and require a wider context, the relationship between the various branches of economics – allocative efficiency, equitable distribution, and scale – need to be defined better.

Pending such a resolution, useful policy instruments in ensuring social and distributive justice in Panama could include the IUCN's Sustainability Assessment Resource Kit (Guijt and Moiseev 2001), guidelines provided by the WCD Dams and Development Report (World Commission on Dams 2000), and Renn et al.'s (1995) influential work on achieving fair and competent citizen participation in decision making. Daly's point is simply that policy must also be guided by the knowledge that there exists both a biocentric and an anthropocentric optimum scale to economic activity, that traditional economic growth objectives have failed to recognize how the economic system is imbedded in the ecological, and that the goal of economic initiatives should be qualitative improvement in ecological and social well-being and not quantitative economic growth. Although this study has focused primarily on streamflow analysis, it is merely a point of departure from which to develop a suite of policy instruments that could work to redefine humanity's relationship with the planet based on both an ethical and an empirical framework.

While no final assessment of the Panama Canal expansion project can be made without knowing the full details of the plans, we can speculate from what is known that the project likely makes sense from a neoclassical economics perspective that encourages growth and resource throughput, but is not as feasible from the point of view of qualitative development which advocates less resource consumption and waste production as the key to true sustainability and improved well-being. These considerations strike to the heart of what is meant when we talk of development and sustainability. Why and for whom are megaprojects of this nature being carried out? Are they successful in improving human and ecological well-being as well as promoting economic growth? Do they fully account for all costs that result from the increased size of the economy relative to the biosphere such as the depreciation of natural capital, defensive expenditures, costs to future generations, biodiversity loss, and inequitable social impacts? Are they, in the end, economic?

It may well be that the assumptions of a future benefit stream, which is key to the viability of this project, may be based on flawed economic theory that is susceptible to collapse. If the theory itself is corrupt, as Daly believes it is, since it is based on incorrect objectives (growth not well-being), and if Daly and is correct about the reality of an anthropocentric and biocentric ecological limit to economic growth, then growth must be viewed as a cause of, and not a panacea for, both environmental and social deterioration. Perhaps economic scale in Panama has not yet exceeded ecological limits and further growth of this sort will indeed contribute to improved well-being for its people. Nonetheless, it is not at all clear whether the biocentric optimum scale in Panama has already been surpassed. If so, economic growth brought about by the canal expansion may well lead to further ecological decline even while human well-being continues to improve. By further expanding the scale of the economy relative to the ecosystem, the project is likely to add strain to already stressed local, regional, and global socio-ecological systems, and could have cumulative impacts apparent perhaps only in the long term.

Appendices

Appendix I

List of Interviewees and Personal Communications (alphabetical)

Interviewee	Organization
Alperador, Paco	Pastoral Social-Carítas Panamá
Alvarado, Luis	Director, ACP Environmental Division
Arosemena, Teresa	ACP Office of International Communications
Ashley, Uriah	Pastor, Catholic Church (Penonomé)
Cai, Meijiang	China Overseas Shipping Company (COSCO)
Castro-Ríos, Enrique	Documentary Filmmaker; Translator for ACP sub-contracts
Cedeño, Olegario	Campesino, Limón de Chagres
Cuschnir, Ariel	Director Coastal Programs, The Louis Berger Group Inc.
de la Guardia, Jorge	Director, ACP Canal Capacity Projects Division
Daly, Herman	University of Maryland
Elton, Charlotte	Centro de Estudios y Acción Social Panameño
Friend, Doug	Panama Ports Company
Hanily, George	The Nature Conservancy (Panama office)
Hernandez, Francisco	Coordinadora Campesina Contra las Embalses (CCCE); resident of Boca de Uracillo
Hernandez, Olegario	Campesino, Limón de Chagres
Hughes, William	Economist, University of Panama
Len-Ríos, Felipe	Journalist, La Prensa Newspaper (Panama)
Madrid, Mario	Campesino, Limón de Chagres
Merel, Celestina	Campesino, Limón de Chagres
Manfredo, Fernando	Former Assistant Administrator of the Panama Canal
Miguez, Francisco	ACP Coordinator of the Panama Canal Master Plan Team
Mítre, Martín	Engineer, Inter-Institutional Commission for the Canal Watershed (CICH)
Oballe, Fernando	Campesino, Boca de Uracillo
Reid, John	Conservation Strategy Fund, USA
Richter, Brian	The Nature Conservancy, USA
Rodriguez, Felice	Campesino, San Cristobal (Río Indio)
Sabonge, Roldofo	Director, ACP Corporate Planning and Marketing
Sanjur, Amelia	Director, ACP Community Relations and Social Programs
Vallarino, Oscar	Executive Director, CICH
Vargas, Carlos	Director, ACP Department of Hydrology and Meteorology
Wainio, Richard	Former Director of Planning, Panama Canal Commission

Interview Methodology

There were no formal questionnaires, surveys, focus groups, or standardized tests used during interviews as this study was not a social survey and it was therefore felt that such methods would not be necessary to meeting project objectives. Instead, interviews were simply conversations that were intended to provide a clearer picture of both the expansion plans themselves as well as people's feelings about the proposals. Interview methodology was distinguishable by two general groups of participants.

1. Campesino Interviews

Interviews with campesinos involved meeting on an informal basis in their homes to discuss their feelings about the canal expansion and the possible inundation of their lands, as well as more general conversations regarding their community and family histories, means of livelihood, problems facing their communities, and so on. Interviews were conducted during the course of 2 trips into the Indio region, each 1 week in duration and carried out in February and March of 2004. Length of the interviews would vary but usually lasted one half hour to one hour. I would first obtain oral consent to conduct the interview by explaining carefully and in detail the objectives of my research and the purpose of the interview. Assurance was given that information gathered during the course of the discussion would be used only for the purposes of my research and their names were not to be released publicly. A written project summary in Spanish was also provided which included my contact information. All interviews were conducted in Spanish and participants were free to decline the interview, stop it at any point, or refuse to provide their name or to answer any question. However, as it turned out, all interviewees participated fully without reservations. I am sufficiently competent in Spanish not to have required the services of a translator. Written notes were taken, however no recording devices were used. No compensation was offered to interviewees for their participation. All interview notes have been and will continue to be kept private and secure in my personal files to ensure the confidentiality of participants, particularly those who may have spoken out against the project proposals.

2. Other Interviews

Interviews with members of the Panama Canal Authority (ACP), NGO representatives, and others were slightly different. All ACP interviews were conducted by appointment in Panama City at the office of the interviewee during the period of January to June 2004. Again, recording devices were not used and only written notes were taken. Interviews were conducted either in English or Spanish and generally lasted 1 to 1.5 hours. Other interviews and personal communications (NGO members, University of Panama faculty, Panama Ports, Canal Pilots Union, private contractors, shipping companies) were conducted either in person, or by phone or email. In all cases, the purpose of the interview, objectives of the research, and dissemination of results were carefully explained at the outset. The nature of the questions and the topics covered varied depending on the interviewee. Confidentiality was less of a concern for these interviews as many of the participants grant interviews with the understanding that their comments represent the position of their organization and may be used publicly. Nevertheless, they too were given the opportunity to decline to be interviewed, refuse questions, stop the interview at any point, or decline the use of their names. Again, this was never a problem as all interviewees participated with full cooperation. The names of the interview participants will be used only for the purposes of this thesis and will not be made public without the express consent of the interviewee.

Appendix II

Indicators of Hydrological Alteration Parameters and their characteristics

IHA Statistics Group	Regime Characteristics	Hydrologic Parameters
Group 1: Magnitude of monthly water conditions	Magnitude Timing	Mean value for each calendar month
Group 2: Magnitude and duration of annual extreme water conditions	Magnitude Duration	Annual minima 1-day means Annual maxima 1-day means Annual minima 3-day means Annual maxima 3-day means Annual minima 7-day means Annual maxima 7-day means Annual minima 30-day means Annual maxima 30-day means Annual minima 90-day means Annual maxima 90-day means
Group 3: Timing of annual extreme water conditions	Timing	Julian date of each annual 1-day maximum Julian date of each annual 1-day minimum
Group 4: Frequency and duration of high and low pulses	Magnitude Frequency Duration	No. of high pulses each year No. of low pulses each year Mean duration of high pulses within each year Mean duration of low pulses within each year
Group 5: Rate and frequency of water condition changes	Frequency Rate of change	Means of all positive differences between consecutive daily means Means of all negative differences between consecutive daily means No. of rises No. of falls

From: Richter et al. (1996), pgs. 1165, 1167-68.

Group 1: Magnitude
The 12 parameters in this group measure the central tendency (mean) of the daily water conditions for each month. The monthly mean value describes the average daily flow in cubic meters per second for that month.

Group2: Magnitude and Duration
The 10 parameters in this group measure the magnitude of extreme (minimum and maximum) annual water conditions of various duration. For example, the 1-day maximum is the highest average single day streamflow recorded in a year. Multi-day maximums and minimums represent the highest or lowest multi-day average values occurring during a given year. For example, a 90-day minimum value of 4.4 cubic meters per second in a year means that this value was the lowest average daily flow value recorded over a continuous 90 day period for that year.

Group 3: Timing of Annual Extreme Conditions
This group uses 2 parameters to describe the Julian date of the 1-day annual minimum and maximum water conditions. The Julian date is a number representing the day of the year, 1 representing January 1 and 365 representing December 31 (except in leap years). For my purposes, I used negative values to calculate the mean and standard deviations for

the Julian date of annual minimums. This was done because the date of the annual minimum tends to fall in either December or January each year. These correspond to Julian date values of 1-31 or 336-365. Calculations using these figures would result in mean values in the 150-200 Julian date range which corresponds to June-August and is clearly not representative of when actual 1-day minimums occur. By using negative values for December dates (e.g. December 31 = -1 Julian date; December 20 = -12 and so on), more accurate mean and standard deviation values could be calculated. This was not a problem for the 1-day annual maximum as it generally tended to fall between April and September.

Group 4: Frequency and Duration of High and Low Pulses
The 4 parameters in this group include two that measure the number of annual occurrences during which the magnitude of the water condition exceeds an upper threshold or remains below a lower threshold and two that measure the mean duration of such high and low pulses. Hydrologic pulses are defined as those periods within a year in which the daily mean water condition either rises above the 75^{th} percentile (high pulse) or below the 25^{th} percentile (low pulse) of all daily values.

Group 5: Rate and Frequency of Change in Conditions
The 4 parameters in this group measure the number and mean rate of both positive and negative changes in water conditions from one day to the next. The rate and frequency of change in water conditions can be described in terms of the abruptness and number of intra-annual cycles of environmental variation and can provide a measure of the rate and frequency of intra-annual environmental change.

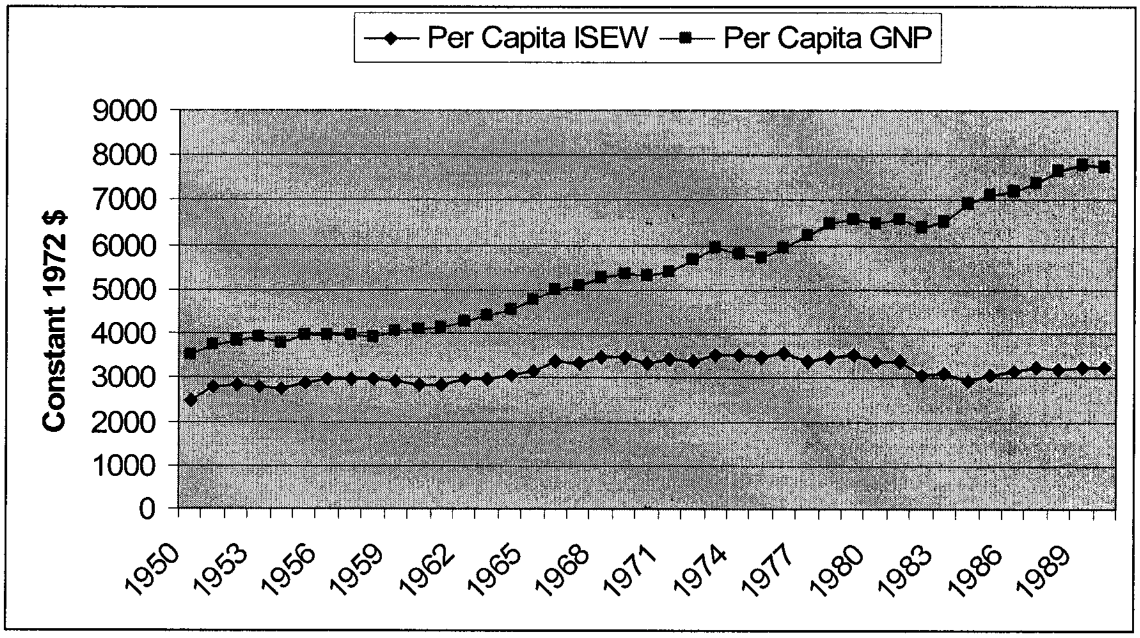
Appendix III

Index of Sustainable Economic Welfare – U.S., 1990 (constant billions 1972 equivalent dollars)

Personal consumption adjusted for income distribution	**$1,164**
+ Services for household labour	+$520
+ Services of consumer durable goods	+ $225
+ Services of highways and streets	+ $18
+ Consumption portion of public spending on health and education	+ $45
- Consumer spending on durable goods	- $235
- Defensive private spending on health and education	- $63
- Cost of commuting and auto accidents	- $67
- Cost of personal pollution control	- $5
- Cost of air, water, and noise pollution	- $39
- Loss of wetlands and farmland	- $58
- Depletion of non-renewable resources	- $313
- Long-term damage from nuclear wastes, greenhouse gases, and ozone depletion	- $371
+ Net capital growth	+ $29
+/- Change in net international investment position	- $34
Index of Sustainable Economic Welfare	**$818**

Source: Daly and Cobb (1994: Table A.1)

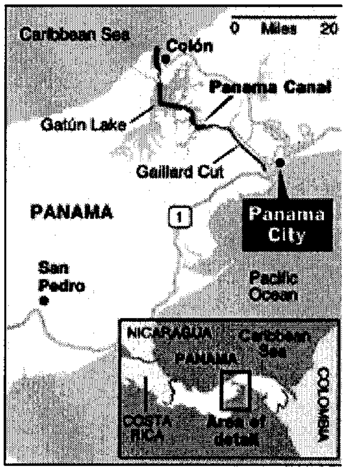
Per Capita GNP and Per Capita Index of Sustainable Economic Welfare (U.S.)

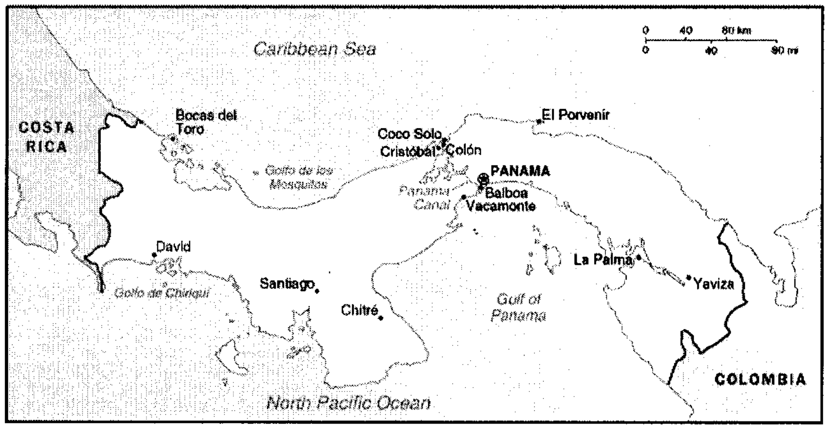


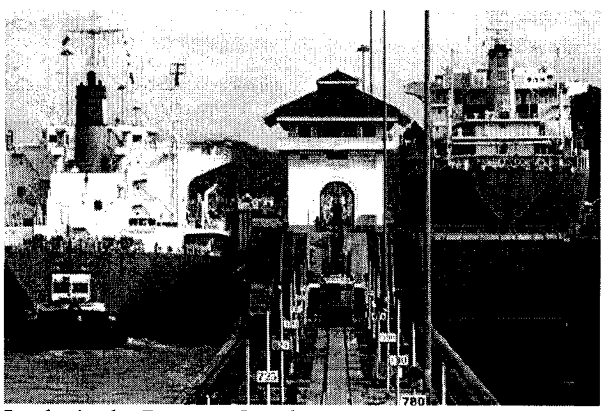
Graph compares growth in per capita GNP to the growth in the per capita Index of Sustainable Welfare (ISEW) in the United States. Actual welfare according to the ISEW increased only marginally from 1950-1990 and actually declined slightly between 1970-1990 in contrast to a steady growth in GNP during this period. Source: Daly and Cobb (1994: Table A.1).

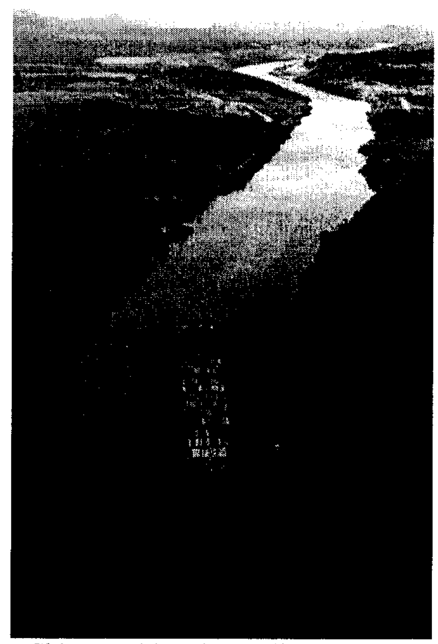
Appendix IV – Maps and photos

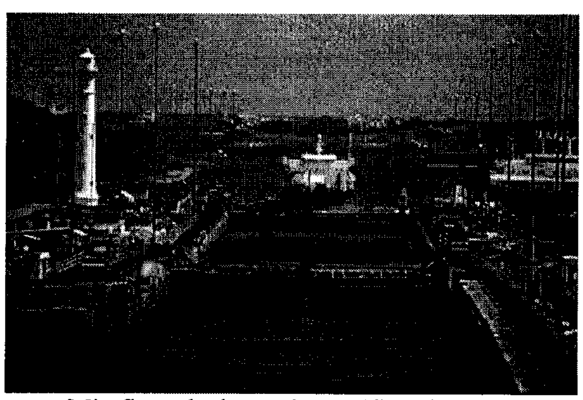
Panama and the Panama Canal



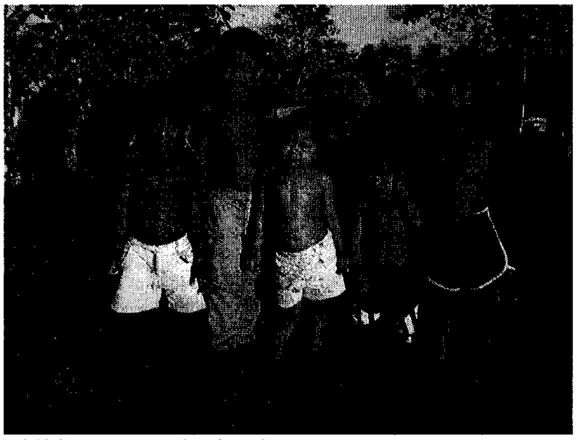



Locks in the Panama Canal


Ship transiting the Gaillard Cut in the Panama Canal


Miraflores locks on the Pacific side of the canal

Río Indio Region

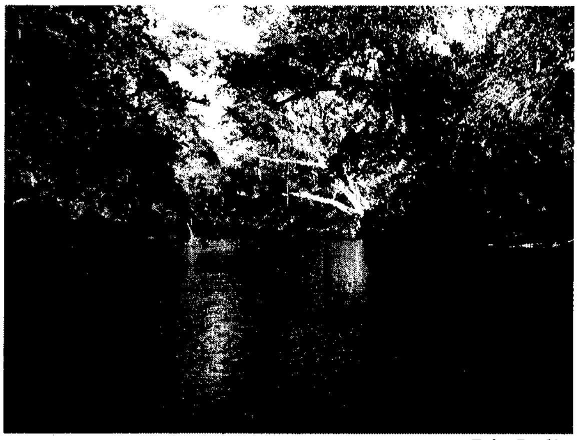

Children in Limón de Chagres


Cayuco on the Río Indio

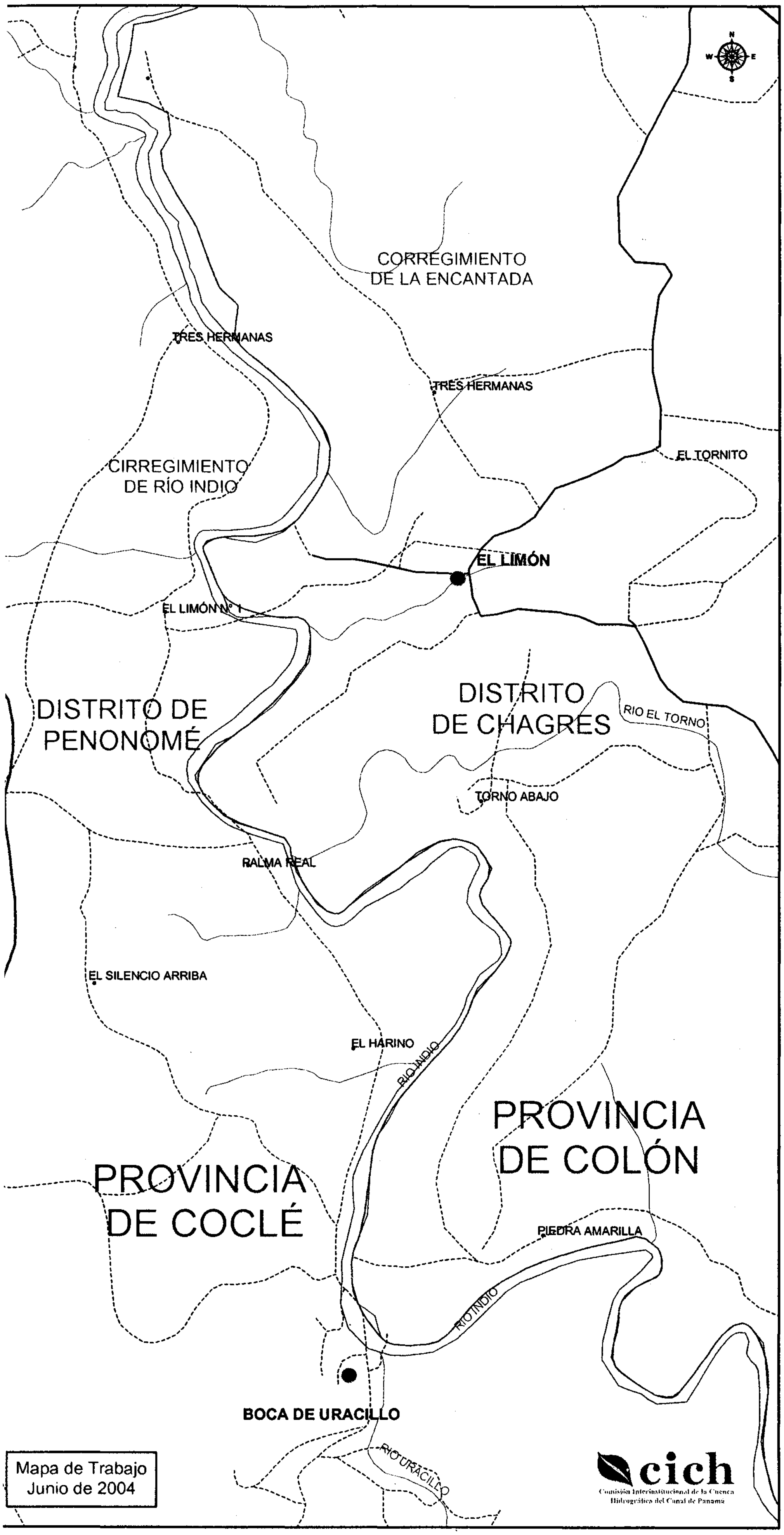

Slash and burn agriculture near Limón de Chagres


Cattle ranching in Boca de Uracillo


Deforestation near Boca de Uracillo


Río Indio

Cuenca Hidrográfica del Canal
Comunidades de Boca de Uracillo y El Limón



Leyenda

- Centros poblados
- Límite provincial
- Límite de distrito
- Límite de corregimiento
- Caminos
- Ríos
- Cuenca Hidrográfica del Canal

Mapa producido por la Comisión Interinstitucional de la Cuenca Hidrográfica del Canal de Panamá

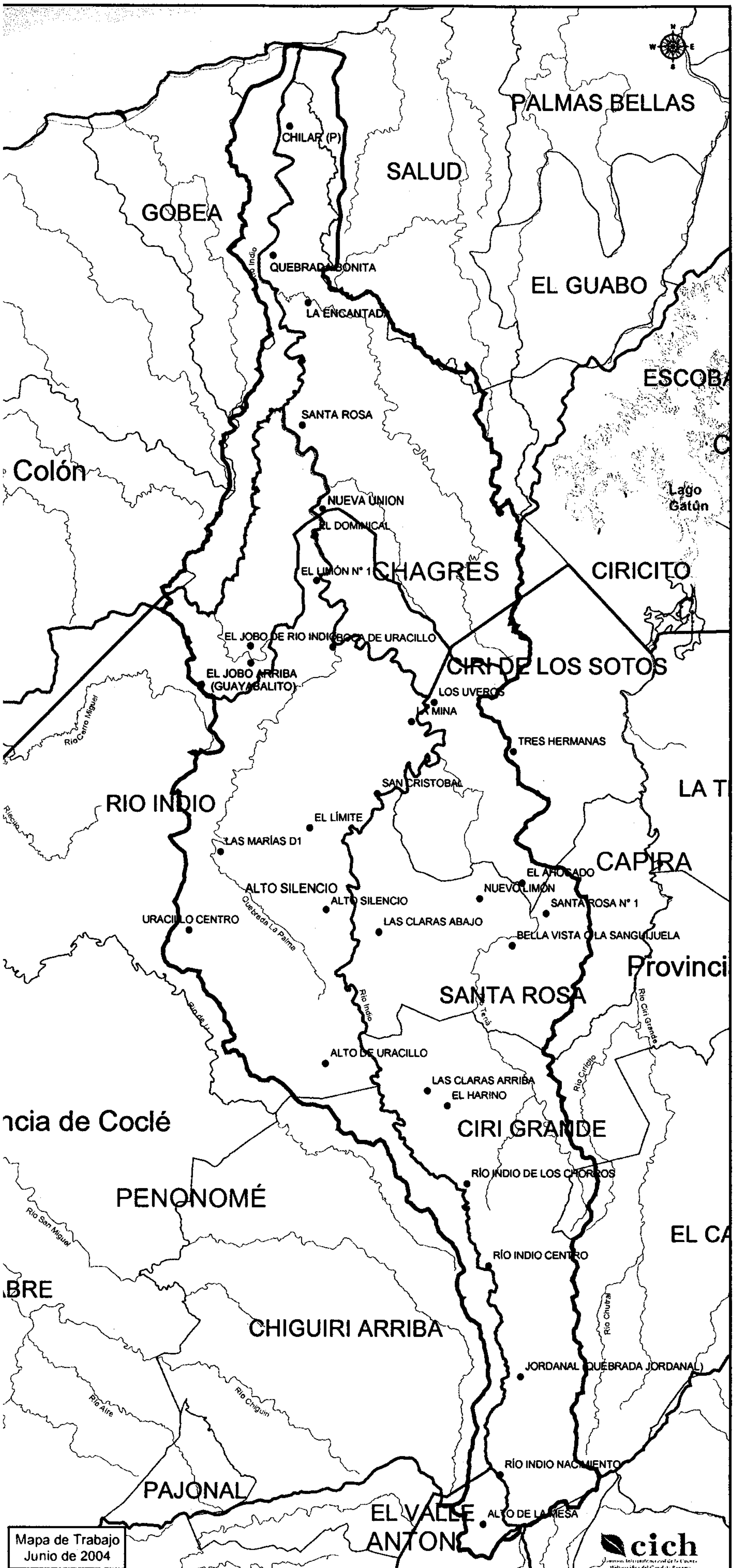
Fuente: Centro de Información Ambiental de la Cuenca
Comisión Interinstitucional de la Cuenca Hidrográfica del Canal de Panamá

Unidad de Sensores Remotos
Sección de Manejo de Cuencas
División de Administración Ambiental
Departamento de Seguridad y Ambiente
Autoridad del Canal de Panamá

Localización Regional

Instituciones Miembros de la Comisión Interinstitucional de la Cuenca Hidrográfica del Canal de Panamá

Cuenca Hidrográfica del Canal de Panamá
Subcuenca del Río Indio



Leyenda

- Límite provincial
- Límite distrito
- Límite corregimiento
- Ríos
- Límite de la Cuenca Hidrográfica del Canal de Panamá
- Límite de la Subcuenca del Río Indio

Mapa producido por la Comisión Interinstitucional de la Cuenca Hidrográfica del Canal de Panamá

Fuente: Centro de Información Ambiental de la Cuenca
Comisión Interinstitucional de la Cuenca Hidrográfica del Canal de Panamá

Unidad de Sensores Remotos
Sección de Manejo de Cuencas
División de Administración Ambiental
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Autoridad del Canal de Panamá

Appendix V

Daily Streamflow Data Río Indio 1976-1995 (in cubic meters per second)
Data collected by ETESA (Empresa de Transmision Electrica S.A.) – Boca de Uracillo Station
Each entry represents the daily streamflow reading for one day. Entries are in chronological order for each year (Jan. 1-Dec. 31). Years are listed across the top of each page and each month of data is separated by a horizontal line.

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
January																			
33.3	8.99	11.9	9.77	49.08	19.05	21.24	8.91	20.94	8.2	12.8	8.998	10.25	17	18.22	14.78	12.04	15.43	17.11	9.4
30.2	8.14	14.3	9.77	145.5	21.83	29.93	7.81	20.94	8.2	12.3	10.27	10.04	14.93	19.34	16.98	11.76	12.5	15.43	9.4
27.8	8.25	13.2	9.32	54	21.83	29.93	7.43	18.56	8.01	11.4	9.41	9.802	18.71	17.48	15.26	11.5	12.04	14.68	9
26.8	8.25	11.5	9.21	36.26	28.77	26.92	7.06	17.46	8.2	10.8	8.595	9.375	20.26	21.22	13.93	11.13	12.04	14.43	9
25.2	8.14	10.8	9.21	28.77	24.09	25.75	6.88	22.62	8.8	10.5	8.998	8.998	20.48	21.34	13.25	10.69	12.04	14.39	8.6
23.1	7.83	12	9.1	31.85	22.32	38.83	6.7	29.06	8.4	10.8	10.69	8.948	19.74	25.94	12.67	10.42	11.58	15.43	8.2
21.8	7.42	12.5	8.78	25.75	21.83	40.82	6.7	22.32	8.8	10	10.25	8.595	19.07	23.99	12.27	10.25	16.26	13.93	8.2
22.2	7.32	10.7	8.56	22.91	24.68	24.38	6.52	18.56	7.72	9.83	8.998	8.595	16.27	18.01	12.04	12.18	16.75	13.69	8.2
23.3	7.32	10.8	7.02	21.24	25.17	21.24	6.31	16.99	7.91	9.72	8.142	8.322	14.93	17.48	11.94	12.5	16.67	13.21	8.2
19.4	7.12	26.6	8.25	20.15	23.5	19.85	6.31	15.66	7.43	9.34	8.167	8.199	13.93	17.48	11.21	10.38	15.13	13.45	7.43
18.4	6.83	27.3	8.04	19.05	21.83	18.26	6.88	14.95	7.16	9	8.038	7.811	13.18	15.95	11.13	10.01	15.03	13.45	7.4
17.5	6.83	15.7	7.42	17.96	22.32	19.65	6.31	14.95	7.85	9.08	7.811	7.811	12.5	15.43	10.85	9.706	12.04	12.5	7.06
16.9	6.54	13.8	7.22	16.99	29.93	20.74	6.31	14.4	7.72	10.3	7.431	7.545	12.17	14.43	10.63	9.238	11.35	12.04	7.06
16.1	6.44	11.9	7.22	15.46	24.09	17.26	6.88	13.4	8.01	11.8	7.354	7.431	14.08	23.68	10.25	8.998	12.05	11.58	6.7
15.4	6.25	12.4	7.22	15.46	21.24	16.48	6.7	13.9	7.06	14.64	7.06	7.431	12.5	18.77	10.36	8.914	16.25	12.89	6.7
15.7	6.25	11.6	7.02	15.46	22.32	15.15	5.82	30.6	6.97	10.7	6.696	7.431	11.66	14.93	10.15	9.41	12.97	16.76	6.53
15.4	6.07	10.2	6.93	14.4	19.05	14.95	5.65	16.99	6.61	9.29	6.696	8.339	11.13	14.18	9.689	8.446	11.13	11.81	7.06
27.2	5.98	9.99	6.83	13.9	18.56	14.2	5.65	14.95	6.31	9.34	6.696	7.811	10.69	12.97	9.41	8.199	10.69	11.13	6.34
14.8	6.63	9.66	6.73	13.9	19.65	13.4	5.32	13.4	6.31	9.48	6.592	7.06	10.25	12.5	9.152	8.134	10.25	11.55	5.99
13.9	7.22	9.21	6.63	13.4	19.05	13	5	13.4	6.07	8.68	6.34	6.696	9.828	12.97	8.813	7.811	9.828	10.69	6.4
14.4	6.54	8.89	5.7	13.4	17.46	12.5	5	12.5	5.82	8.2	6.165	6.636	9.828	12.5	8.722	7.973	9.41	10.25	6.7
13.3	7.22	8.89	5.61	12.5	16.48	12.3	4.69	12	5.91	7.96	5.992	6.34	9.662	11.58	8.848	8.038	9.41	10.25	26.4
12.5	7.94	8.46	5.79	12	15.46	12	4.84	11.1	5.99	7.81	5.992	6.122	9.41	11.13	8.199	7.431	8.998	9.828	13.9
13.6	6.74	8.14	6.17	12	14.95	11.6	4.69	11.1	5.96	7.25	5.992	5.992	8.998	10.69	7.811	7.33	8.595	9.828	8.7
13	7.63	8.04	6.07	12	14.95	12.5	4.69	10.9	12.2	7.3	6.34	5.992	8.998	10.25	7.811	8.729	8.199	9.41	7.4
11.8	5.43	9.1	6.09	12	14.95	10.9	4.38	10.7	29.44	7.06	5.992	5.992	8.687	9.828	7.62	7.811	8.998	9.828	7.4
11.2	5.25	8.46	5.25	11.6	13.4	11.8	4.08	10.9	15.05	7.43	5.653	6.137	8.487	9.828	7.431	7.431	9.41	9.41	7.1
10.6	5.08	8.25	4.99	10.7	13.4	13.7	4.38	10.5	9.86	7.06	5.653	6.267	8.199	9.828	7.06	7.152	11.13	8.998	6.3
10.4	4.91	7.73	4.82	10.7	13	13.9	4.38	10	8.81	7	5.992	5.765	8.199	9.828	7.06	6.696	9.828	8.998	5.99

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
10.5	4.82	7.42	4.82	11.1	15.97	11.6	4.23	9.83	7.82	7.81	6.34	5.445	7.811	9.41	6.877	6.34	8.595	8.998	5.7
February																			
10.3	4.91	7.42	4.57	10.1	21.24	10.3	3.79	12.3	6.97	7.06	5.653	5.322	7.62	9.203	6.877	6.599	8.998	8.595	5.99
9.33	4.74	7.52	4.65	9.83	24.68	8	3.79	9.41	6.61	7.61	5.322	5.376	7.62	8.956	7.06	6.547	8.998	8.399	5.7
8.92	4.57	7.42	6.56	9.62	21.24	7.62	3.52	9.41	6.07	7.43	5.322	5.653	7.518	8.595	6.696	6.34	8.199	8.595	5.4
8.92	5.17	6.93		9	18.56	7.43	3.52	10.3	5.99	6.7	5.322	5.584	7.299	8.199	6.34	6.34	8.199	8.595	6.43
8.71	4.65	6.93	5.08	8.8	15.97	7.06	3.52	10.3	5.74	6.03	4.999	5.281	7.06	8.135	6.267	6.122	7.431	8.199	5.32
8.4	4.49	6.93	4.99	10.3	15.46	6.88	4.23	10.9	5.99	5.94	4.841	6.267	6.771	7.811	6.209	5.779	7.811	8.998	5.65
8.3	4.57	6.93	4.57	12.5	14.4	7.06	4.23	13.2	5.82	5.74	4.685	6.123	6.696	7.62	6.562	5.653	7.811	9.204	6
7.89	4.33	6.93	4.33	12.5	13.4	7.24	4.23	13.4	5.65	5.42	4.531	5.653	6.696	7.431	6.428	5.653	7.811	8.199	5.32
7.59	3.93	8.16	4.08	14.4	12.5	6.52	3.11	11.1	5.49	5.29	4.379	5.322	6.908	7.719	5.865	5.583	7.06	7.431	5.3
7.49	4.01	7.22	4.33	10.7	12.5	6.17	2.98	9.83	5.32	5.11	5.322	5.322	6.062	8.199	5.653	5.583	7.431	7.431	5
7.1	3.77	6.54	5.08	10.3	12	6.17	2.98	9.2	5.32	5	6.522	5.542	7.152	7.811	5.465	5.653	7.811	7.431	4.69
6.91	4.25	6.83	5.65	10.3	12	5.99	2.98	9.41	6.15	5	5.322	6.282	6.696	7.431	5.322	7.354	7.431	7.06	4.69
6.81	4.33	8.36	5.43	8.59	13	5.82	2.98	9.2	6.23	4.93	7.326	5.322	6.34	7.06	5.322	6.73	6.696	7.06	4.69
6.72	3.55	7.12	4.82	8.59	12	5.49	2.73	9	6.07	4.68	6.696	5.322	5.992	7.06	5.322	5.851	6.696	6.696	4.38
6.52	3.18	7.02	4.01	8	11.6	5.32	2.73	9.41	5.49	4.8	5.322	5.322	5.653	6.696	5.653	5.528	6.696	6.696	4.08
6.24	3.25	7.22	4.16	7.62	11.6	5.49	2.73	9.2	5.16	4.68	4.763	4.999	5.322	6.696	5.992	5.397	6.696	6.877	4.08
5.96	3.25	6.54	4.67	7.62	11.6	5.32	2.73	8.13	5	4.68	4.379	4.999	006.00	6.607	5.653	5.528	6.517	6.877	4.08
5.87	3.55	5.88	4.57	7.43	12.5	5.16	2.49	7.87	5	4.67	4.379	4.999	005.77	6.34	6.732	5.106	6.34	6.877	3.79
5.5	3.55	5.79	4.24	7.43	12.5	5.16	2.49	7.62	5.16	4.41	4.229	4.9	005.77	6.34	7.06	4.999	6.165	6.517	3.52
5.32	3.55	5.88	3.77	7.06	11.1	5	2.26	7.870	5.32	4.31	4.082	4.608	005.77	5.992	5.653	4.959	5.992	6.517	3.52
5.15	3.25	5.43	3.7	6.7	11.1	5.65	2.37	7.62	5	4.08	4.479	4.379	005.35	5.935	5.486	4.685	5.992	6.517	3.52
5.15	3.11	5.17	3.7	6.7	10.7	5.32	2.98	7.62	5	4.08	6.862	4.18	005.35	5.653	5.486	5.201	5.653	6.517	3.52
5.15	2.92	4.99	3.4	6.88	10.3	5.16	3.11	7.62	5.32	4.08	5.433	4.082	005.35	5.653	5.322	5.066	5.653	6.165	3.52
6.24	3.11	5.08	3.25	6.5	9.83	5	2.73	7.62	4.84	3.98	4.531	4.379	005.77	5.653	4.999	4.685	5.322	5.821	3.79
5.35	3.04	6.07	3.11	6.15	9.83	4.69	2.73	7.62	4.68	3.77	4.229	4.082	007.55	5.322	4.999	4.379	5.322	5.821	3.52
5.32	3.11	6.63	3.11	5.99	11.1	4.53	2.73	10.30	4.53	3.71	4.082	4.379	011.80	5.459	4.999	4.379	5.322	5.486	3.24
5.24	3.04	5.7	2.97	5.82	10.7	4.23	2.61	12.10	4.38	3.86	4.082	5.08	010.80	5.383	4.999	4.329	5.322	5.486	3.52
5.51	2.76	5.34	3.25	6.15	10.7	4.08	2.73	14.40	4.08	3.79	4.082	4.999	011.90	5.322	4.841	4.379	5.322	5.486	3.24
6.06				5.48				13.60				4.685				4.205			
March																			
5.15	2.43	4.99	3.47	5.32	9.62	4.84	2.49	13.00	4.08	3.51	3.653	4.082	008.15	4.841	4.999	6.267	5.322	5.486	2.98
4.97	2.43	4.65	2.97	5.32	9	5	2.26	10.20	4.23	3.75	3.753	3.794	007.50	4.685	4.795	5.322	4.999	5.486	2.98
4.71	2.26	4.49	2.76	5.16	8.59	4.38	2.26	8.63	4.53	4.27	3.712	3.7	007.17	4.685	4.776	4.685	4.685	5.49	2.98
4.37	2.26	7.57	2.69	5	8.4	3.79	2.26	8.63	5.49	4.04	3.515	3.549	006.33	4.685	11.99	4.685	4.685	4.66	2.98

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
4.03	2.32	9.43	2.43	4.68	8.2	3.65	2.03	8.13	5.98	4.01	3.244	3.584	006.33	4.379	46.86	4.685	4.379	4.379	2.98
3.87	2.37	8.78	2.43	4.68	13	3.52	2.03	7.62	5.66	3.51	3.244	3.515	005.96	4.379	28.16	4.379	4.379	4.379	2.73
3.71	2.26	6.26	2.37	4.68	16.99	3.38	1.82	7.87	4.82	3.24	3.515	3.289	005.77	4.379	10.25	4.379	4.379	4.082	2.73
3.55	2.08	5.88	2.49	4.53	22.32	3.24	1.82	8.38	4.92	3.24	3.244	3.244	005.23	4.379	7.811	4.268	4.379	4.08	2.98
3.55	2.14	4.65	2.43	4.38	21.83	3.24	1.82	7.62	5	3.18	2.983	2.983	005.23	4.379	6.696	4.082	4.082	4.082	2.98
3.63	2.14	4.57	2.49	4.38	24.09	3.24	1.82	7.62	4.76	3.09	2.983	2.983	005.51	4.379	5.992	4.082	4.082	4.082	2.98
3.24	2.08	4.57	2.49	4.38	14.4	3.24	1.82	7.15	4.53	2.98	2.856	3.016	005.23	4.519	5.542	3.794	4.685	4.082	2.73
3.16	2.14	4.49	2.37	4.38	13	3.65	1.82	6.66	4.38	2.98	2.731	2.983	005.23	4.519	5.214	3.794	4.999	3.794	2.49
3.32	2.08	4.24	2.37	4.38	13	3.38	1.62	6.66	4.92	2.93	2.731	2.919	004.73	4.379	4.999	3.794	4.685	3.937	2.49
3.16	1.98	4.24	2.26	4.23	11.6	3.24	1.62	6.44	5.49	2.73	2.489	2.731	004.48	4.292	4.756	3.794	12.52	3.515	2.49
3.02	1.82	4.01	2.2	4.08	25.75	2.86	1.62	5.74	4.84	2.84	2.489	2.731	004.22	4.082	4.685	3.688	15.53	3.794	2.49
2.95	1.66	3.77	2.2	4.08	14.4	4.17	1.62	5.30	4.08	2.98	2.489	2.731	004.22	4.181	4.531	3.515	8.215	4.082	2.49
2.88	1.66	3.62	2.26	4.08	11.6	4.38	1.62	5.30	3.87	2.5	2.554	2.609	004.22	4.292	4.379	3.631	6.34	3.794	2.49
2.81	1.82	3.62	2.03	4.08	10.3	4.23	1.92	4.87	3.79	2.93	3.033	2.66	004.22	4.082	4.229	3.741	5.322	3.587	2.92
2.75	2.32	3.25	2.03	3.51	9.62	4.08	2.73	4.87	3.65	2.73	2.983	2.731	004.22	4.685	4.082	3.515	4.999	5.788	2.49
2.68	2.2	3.32	1.93	3.24	9	4.08	2.37	4.87	3.51	2.83	2.983	2.731	004.11	4.817	4.052	3.244	4.999	9.948	3
2.61	2.08	3.18	1.93	3.24	9	3.97	1.82	5	3.45	3.38	2.983	2.731	004.22	4.999	3.794	3.244	4.685	6.009	5
2.61	1.82	3.11	1.82	3.24	8.59	4.08	1.62	5	3.24	3.04	2.983	2.489	3.794	5.486	3.794	3.184	4.685	4.685	3.88
2.48	1.61	3.7	1.82	2.98	8.2	4.17	1.62	5	3.24	2.73	2.856	2.489	3.515	5.992	3.794	2.983	4.685	4.379	2.61
2.3	1.51	3.4	1.66	2.98	8	4.26	1.62	4.69	3.24	2.49	2.731	2.574	3.515	7.431	3.794	2.856	4.999	5.994	2.49
2.24	1.47	3.32	1.87	2.98	7.81	4.17	1.42	4.69	3.11	2.49	2.609	2.489	3.515	5.003	3.794	2.731	4.999	9.54	2.26
2.12	1.42	3.25	1.77	2.98	7.81	4.08	1.42	4.53	3.18	2.37	2.489	2.256	3.794	4.685	3.601	2.731	4.685	7.645	2.03
2.12	1.37	3.47	1.61	2.86	8.2	3.68	1.42	4.38	3.43	2.42	2.489	2.199	3.937	4.685	3.486	2.731	4.685	5.322	2.68
2	1.88	3.33	1.56	2.98	8	3.52	1.42	4.38	3.45	2.49	2.489	2.19	3.67	4.531	3.244	2.639	4.999	8.699	4.1
1.89	1.93	4.53	1.77	2.98	7.81	3.52	1.42	4.38	3.24	2.49	2.371	2.256	4.082	4.685	3.244	2.68	4.379	14.57	3.32
1.78	1.88	4.25	1.66	2.98	9.2	3.52	1.62	7.06	2.98	2.28	2.256	2.256	3.515	4.229	3.113	2.639	4.082	9.139	2.98
1.67	1.37	20.6	1.61	2.98	7.62	3.52	1.42	5.16	2.98	2.66	2.256	2.489	3.244	3.515	3.048	2.731	4.082	8.8	2.7
April																			
1.67	1.32	38.5	1.61	2.73	7.06	3.38	1.42	4.53	3.24	2.89	002.04	2.256	2.98	3.515	3.368	2.609	3.794	8.799	5.4
1.67	1.23	8.56	1.66	2.73	7.06	3.24	1.42	4.23	3.38	2.98	002.04	2.032	2.98	3.515	3.654	2.489	3.79	7.653	6.9
1.57	1.18	6.16	1.99	2.73	6.7	3.24	1.42	4.08	2.98	2.98	002.04	2.107	2.98	3.244	3.146	2.371	3.794	6.7	6.5
1.57	1.14	5.8	1.82	2.49	6.7	3.24	1.42	4.23	2.98	2.73	002.04	2.459	2.983	2.983	2.983	2.256	3.794	7.253	5
1.67	1.14	4.82	3.47	2.49	6.7	3.11	1.42	4.08	3.31	2.63	003.32	2.256	2.983	2.983	2.969	2.256	4.082	8.599	4.4
1.67	1.09	4.24	11.5	2.37	6.7	3.24	1.42	3.94	3.38	2.65	009.50	2.097	3.113	2.856	3.733	2.256	3.794	7.431	3.8
1.95	1.05	3.93	3.7	2.26	6.31	3.24	1.42	3.79	3.38	2.26	004.55	1.924	2.983	2.983	3.743	2.185	3.515	6.674	3.45
2	1.09	5.55	2.69	2.26	5.99	3.11	1.42	4.08	2.98	2.05	003.18	1.819	2.983	2.983	3.146	2.18	3.515	8.595	3.41

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1.67	1.18	5	2.94	2.26	5.99	11.6	1.07	3.79	2.86	2.248	003.74	1.819	2.957	2.983	3.07	2.143	3.515	7.06	2.98
1.67	1.18	4.57	2.26	2.03	5.82	4.84	1.07	3.52	2.73	2.612	004.33	1.846	2.899	3.053	5.311	2.143	3.244	7.06	2.49
3.88	1.18	3.93	2.2	2.03	5.65	3.88	1.42	3.52	2.86	4.236	003.63	1.819	2.983	3.038	4.383	2.256	3.244	6.696	2.7
2.42	1.51	4.26	2.08	2.03	5.99	5.65	1.82	3.52	3.24	6.093	003.18	1.759	3.244	3.038	3.631	2.434	3.244	7.505	2.98
1.94	2.16	6.25	2.03	2.03	11.1	11.4	1.72	3.65	2.98	4.685	002.98	1.716	3.244	2.815	3.515	2.59	3.244	7.06	2.49
1.57	2.97	39.5	1.88	2.03	13.4	7.62	1.33	3.52	2.63	3.244	002.78	1.615	2.983	3.356	3.357	2.888	4.131	5.992	2.49
1.47	2.32	22.2	1.82	1.92	13.4	15.97	1.15	3.24	2.39	2.983	002.40	1.812	2.794	3.515	3.996	3.103	6.03	5.322	2.98
1.38	1.77	160	1.82	1.82	161.7	6.17	1.07	3.79	2.26	3.47	002.23	9.08	2.66	2.827	3.368	2.814	6.723	5.322	2.49
1.28	1.66	165	1.72	4.84	61.37	4.84	0.985	4.08	2.26	20.81	002.04	4.798	2.731	3.081	3.168	2.61	6.371	4.685	2.26
1.28	1.72	27.7	2.56	3.79	50.47	4.69	0.906	4.08	2.26	83.02	002.04	2.983	2.731	2.983	2.931	2.256	4.082	4.379	2.28
1.19	1.56	19	3.18	2.98	23.5	4.08	0.906	3.79	2.03	66.22	002.04	2.319	2.579	2.731	2.731	2.143	3.515	4.379	3.3
1.19	1.37	14.9	3.6	2.61	27.6	3.79	0.906	3.38	2.03	53.04	002.34	2.032	2.489	2.92	2.554	2.032	3.244	4.082	5.7
1.11	1.37	12.7	4.02	2.49	24.68	3.79	0.906	2.98	2.03	21.22	003.43	2.032	2.371	2.731	2.489	2.032	3.271	4.082	7.1
1.84	1.28	11.8	5.2	3.51	23.5	3.79	0.829	2.98	2.03	27.82	002.78	5.614	2.371	2.435	2.371	1.867	13.06	4.082	3.56
2.24	1.18	11.2	4.09	6.15	41.48	4.53	0.755	2.98	1.87	47.04	004.55	4.082	2.41	2.256	2.44	1.819	18.77	4.082	2.98
2.06	9.56	14.3	4.33	4.68	59.9	5.32	0.829	2.73	1.82	34.37	004.39	2.731	2.55	2.256	2.554	1.854	9.742	4.082	2.98
3.11	2.97	13.7	4.1	2.73	59.9	5	1.15	2.86	1.82	24.84	003.32	2.256	4.109	2.166	2.731	2.731	8.733	4.998	3.7
4.29	2.2	10.6	19.6	2.14	46.27	5.42	0.985	2.98	1.82	14.43	005.57	2.101	3.244	3.506	2.489	5.485	43.29	4.999	4.22
4.54	1.82	11.1	5.98	2.03	46.27	4.56	0.937	2.73	2.14	11.41	003.85	2.032	2.519	4.999	2.371	13.72	48.96	4.481	4.44
3.63	1.82	9.09	11.6	2.03	55.48	3.97	3.57	2.73	3.24	9.69	024.90	2.032	2.304	4.946	2.256	19.49	16.02	4.65	4.6
6.72	1.82	8.47	13.9	2.03	40.82	4.84	6.66	3.11	4.08	8.59	019.10	2.032	2.256	4.082	2.069	52.29	10.05	9.027	7
5.78	1.61	9.41	17.8	1.72	28.18	5.49	3.38	3.52	2.49	7.88	015.70	2.458	2.032	3.94	3.151	15.77	8.199	12.1	6
May																			
3.79	1.61	8.78	11.3	1.62	25.17	7.81	2.61	2.88	2.14	10.51	010.30	6.696	2.032	3.413	3.515	8.595	7.431	9.031	15.7
10.8	1.47	8.07	10.7	1.52	30.6	11.1	2.37	2.55	2.19	8.998	009.78	007.42	2.088	3.315	4.055	6.64	6.34	7.208	18.7
16.3	1.28	8.8	9.18	4.53	28.18	13.9	2.49	2.44	1.97	12.99	012.00	007.47	3.817	2.731	41.49	5.865	7.06	8.998	9.74
13.4	1.18	7.67	7.14	2.26	25.75	9.41	5.99	2.26	1.82	99.61	009.97	007.99	6.61	4.294	10.43	5.106	6.34	8.595	23.9
9.61	1.14	13.2	5.98	2.61	30.6	6.34	4.38	2.26	1.95	108.1	009.13	007.58	4.082	4.54	17.2	17.04	6.34	8.199	13
13.7	8.26	21.1	4.91	11.6	24.68	5.32	16.48	2.26	2.49	42.97	009.32	007.49	2.983	4.308	18.27	24.81	6.696	8.199	19.7
9.91	3.01	16.7	4.41	6.31	34.92	4.84	21.24	2.15	2.26	34.96	009.06	007.42	2.899	3.95	15.03	49.12	8.495	10.03	9.2
10.3	2.3	33.1	6.34	4.08	24.68	4.69	12	2.26	4.27	20.97	008.80	007.40	2.731	3.794	9.828	28.84	8.366	7.677	15.2
10	2.9	21.7	27.9	4.53	18.46	7.43	8.6	2.26	5.89	17	009.15	007.81	2.524	4.338	8.199	20.48	6.696	15.52	7.43
8.35	4.18	16.8	7.63	5.32	25.75	13	7.43	2.03	5.72	14.43	008.80	007.49	2.256	8.26	6.877	14.96	11.96	46.01	6.16
6.98	4.38	13.1	6.83	3.79	32.43	9.83	5.65	3.34	4.13	12.97	008.80	007.99	2.032	10.09	7.643	11.35	11.13	13.51	15.2
6.7	2.5	11.9	10.1	3.79	35.59	10.3	21.24	11	7.12	11.58	008.76	022.50	2.886	7.811	16.46	9.828	11.84	11.13	10.1
6.42	1.93	11.5	10.3	29.93	28.77	9.62	31.18	96.82	38.54	10.69	009.42	016.20	4.693	5.486	18.32	8.498	13.22	11.72	19.4

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
6.89	1.46	22.4	8.36	28.77	47.68	8.6	19.05	24.09	9.44	9.828	013.70	011.20	11.27	19.21	11.81	7.431	18.13	8.998	11.9
7.59	1.37	19.9	13	11.6	32.43	6.34	12.5	10.6	7.67	9.238	014.00	020.00	9.801	8.595	9.828	6.577	19.73	8.199	71.5
6.51	1.46	46.7	11.7	6.31	42.14	5.49	8.6	8.33	5.69	8.595	015.20	010.40	5.284	5.992	16.93	10.09	11.32	7.06	74.8
5.87	2.2	24.9	13.9	4.84	31.18	5.32	13.4	7.53	4.71	10.18	026.70	015.80	4.082	74.05	16.18	47.72	8.998	180.3	34.1
5.69	1.88	131	9.68	42.89	38.16	5.65	17.96	7.32	12.5	8.873	019.50	015.50	3.448	248.3	15.46	20.23	8.595	56.4	26.7
5.52	1.88	39.2	8.06	21.24	38.83	15.97	20.15	8.27	26.04	8.038	012.60	013.20	4.735	17.74	15.43	50.32	14.48	24.39	16.8
5.69	9.11	31	6.25	10.7	23.4	19.85	19.65	10.6	10.8	8.298	016.70	018.10	4.331	12.5	10.25	60.43	13.43	15.95	13.7
6.89	5	23.8	7.93	8.59	24.68	9.53	26.34	38.26	7.43	8.199	042.90	013.40	3.926	11.77	8.796	70.7	12.39	14.43	16.3
10.3	4.01	20.4	7.83	17.46	34.92	10.7	15.97	43.55	6.34	8.331	034.70	013.30	3.334	98.6	7.431	58.73	14.02	14.43	21
10.7	20	18.7	8.05	17.96	27.6	7.06	16.48	20.64	10.2	14.23	022.20	010.70	7.633	27.66	6.826	57.24	14.98	14.77	12.5
14.9	10.9	21	6.74	27.6	24.09	5.99	17.46	28.77	8.82	15.4	017.20	010.10	12.37	21.51	16.57	44.81	20.76	12.5	13.1
10.1	20.2	17.1	6.63	13.9	21.83	5.65	18.46	31.57	7.75	14.62	014.30	009.77	8.271	35.09	8.595	31	20.12	18.96	29.2
13.6	31.8	19.8	6.07	10.7	21.24	006.75	15.46	24.48	10.8	17.57	012.90	010.10	20.77	17.48	9	26.04	12.4	28.52	37.2
13.9	12.8	30.3	8.84	9.83	43.55	006.16	17.46	24.48	14.64	9.828	012.20	019.60	14.92	15.02	9.83	19.07	9.832	31.14	41.7
25.5	17	33.7	8.26	10.7	25.75	006.53	17.46	24.29	12.5	9.41	011.50	012.80	195.7	41.48	7.59	16.77	8.998	22.59	45.5
15.3	10.2	30.5	29.2	21.24	27.6	015.10	37.5	37.69	10	8.199	011.00	010.10	27.6	17	11.27	21.31	8.199	26.87	27.6
37.4	19.9	34.5	28.8	15.46	24.09	017.90	18.46	17.66	7.81	7.431	010.60	013.50	16.66	13.45	34.26	38.31	7.62	21.11	19.8
18.8	53.3	43.8	34.4	55.48	21.83	010.40	30.6	19.85	6.55	6.969	010.70	017.80	12.5	13.48	39.66	30.23	8.994	34.16	15.4
June																			
24.3	37.8	34.1	21.7	15.97	20.44	011.60	23.4	26.14	10.9	6.666	011.10	019.50	15.89	16.51	22.01	29.62	10.23	25.8	20.7
20.8	19.7	27.2	23.7	12.5	023.00	009.42	39.49	26.24	44.3	6.458	010.40	020.60	16.66	14.43	12.5	20.69	7.811	19.78	17
33.6	13	28.2	18.7	17.96	022.10	010.80	103.9	23.89	22.32	7.263	12.42	020.30	18.05	11.83	18.86	36.23	7.431	19.25	16.4
27.6	10.2	28.7	37.6	10.7	024.40	030.30	49.73	17.36	17.46	12.51	11.89	021.10	12.5	13.21	11.58	26.58	8.263	19.68	14.2
19.2	8.67	23.1	37.7	14.95	024.20	015.20	33.68	14.95	97.71	9.084	13.01	021.80	33.72	11.13	23.31	19.75	12.56	16.47	31.1
24	16.2	20	32.1	10.7	044.10	015.50	23.5	13.4	52.43	16.33	16.32	023.40	23.24	11.02	14.22	22.12	14.22	14.85	29.9
20	17.6	18.5	23.5	13.9	43.55	014.20	18.56	19.55	25.26	9.16	14.47	028.00	18.53	10.25	11.58	18.61	11.81	13.45	32.3
15.3	10.1	16.5	30.7	13	72.94	010.80	55.48	23.89	61.65	8.25	11.76	021.80	15.96	9.741	9.828	24.69	12.14	14.46	41.8
16.4	14.1	27.8	15.1	10.7	52.61	010.10	32.43	18.06	22.81	16.83	17.84	021.50	13.93	9.828	8.998	32.81	9.729	13.45	24.5
13.9	11	18.1	12	13	36.93	010.40	25.17	23.11	19.65	13.62	11.58	020.50	13.29	42.31	8.998	41.09	8.199	12.04	49.5
11.7	12.2	19.5	15.2	13	32.43	019.00	17.96	39.59	14.74	10.81	10.56	021.10	15.27	18.53	8.746	34.3	31.92	17.18	29.8
11.2	23.1	19.8	16.1	22.32	47.68	075.70	20.74	19.05	17.96	51.69	11.37	036.10	13.93	16.35	8.463	31.97	83	238.7	19.9
12	14.9	20.7	11.5	19.65	38.83	044.80	23.5	17.66	64.67	49.31	59.33	033.10	12.04	13.82	11.9	22.36	53.21	102.5	19.3
15.7	18.1	24	48.8	14.95	26.92	025.00	16.99	20.25	23.11	40.13	70.09	028.30	10.69	23.56	16.68	19.25	26.26	54.21	21
13.8	12.5	34.7	49.3	12	34.35	20.94	13.9	26.04	18.26	35.47	114.3	024.10	9.917	50.85	13.36	22.22	17.5	120.9	45.5
11.3	11	23.5	60.1	11.1	32.43	15.46	12.5	34.92	19.15	28.06	34.83	022.00	10.94	21.8	9.828	33.57	16.4	61.59	52.7
10.8	9.89	27.5	29.9	10.7	028.00	14.95	20.15	60.45	30.51	23.49	28.01	022.00	11.67	18.53	12.11	32.62	18.06	70.92	55.1

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
10.7	13.8	22.7	26.4	28.18	028.60	12.3	19.05	42.7	45.24	29.01	22.07	025.90	9.828	15.95	12.97	25.9	23.11	38.86	44.1
11.1	24.4	21.4	22.5	37.5	028.00	10.7	13.4	28.77	20.54	29.24	18.53	022.00	9.762	13.93	13.86	35.98	18.67	32.6	36.2
17.7	12.8	20.6	24.4	27.6	026.60	45.62	12	22.12	16.89	27.63	17.75	020.80	10.96	12.97	28.99	68.87	52.22	28.16	28.4
11.9	36	21.8	21.8	23.5	028.90	37.5	11.1	20.05	14.74	124.1	16.81	020.20	13.8	13.36	40.08	27.56	48.23	51.8	25.2
10.8	29.9	19.3	30.5	25.75	037.70	20.84	10.3	41.48	17.96	58.11	14.73	020.20	10.69	14.2	65.81	22.71	29.04	42.55	35.2
10.2	21.2	18.6		35.59	033.50	20.44	13.9	25.65	63.2	87.15	20.42	019.60	11.62	12.15	42.59	24.93	31.7	34.83	42.6
11.5	14.9	18.7	24.4	21.83	030.60	22.32	14.4	40.06	21.33	34.54	29.65	022.30	18.73	14.29	22.92	23.23	28.47	34.7	72.5
16.7	13.8	22.3	31.3	18.56	026.50	28.77	10.7	34.54	17.46	029.30	16.15	020.30	19.54	11.96	32.36	23.82	35	89.04	53.8
12.6	11.2	18	37.8	17.96	024.40	17.76	9.83	23.8	17.96	027.10	14.18	019.80	18.88	12.5	24.87	28.7	47.16	41.52	34.1
11.3	14.8	25.5	23.7	18.56	023.50	18.56	10.3	20.74	23.6	025.20	15.54	026.50	62.38	020.20	22.26	23.4	62.92	30.6	31.7
12.3	19.4	22.7	23.8	19.65	028.30	18.26	10.7	22.62	36.16	023.40	14.78	041.40	62.69	020.00	16.45	21.18	107.5	38.45	32.1
11.5	14.4	22.8	22	17.96	026.60	15.66	17.46	26.63	24.87	024.90	12.72	022.60	21.8	019.50	17.8	21.61	32.05	37.32	49.4
10.7	26.8	19.7	20.1	17.96	045.80	14.4	14.4	48.89	21.93	025.70	13.96	022.10	17.79	020.20	26.73	19.16	31.47	32.23	71.4
July																			
10.1	37.2	19.3	28.5	20.15	044.00	13.4	12	44.96	29.54	022.70	15.7	030.70	33.02	018.90	23.88	20.39	91.09	25.5	36.3
11.2	20	17.1	22.8	17.46	029.50	13.2	14.4	35.97	18.56	021.30	12.31	024.70	36.71	021.00	17.48	20.31	43.31	40.03	30
11	17	16	19.7	15.97	031.50	13.4	12.5	28.67	16.48	029.40	11.97	035.00	25.45	022.80	15.43	19.61	31.16	51.58	35.5
10.7	15.2	15.3	16.8	14.4	037.30	15.66	11.1	29.93	17.06	023.50	15.53	030.10	18.53	032.10	15.76	34.48	26.38	34.09	73.3
19.5	34.1	16.2	15.9	14.4	032.70	17.96	12	32.72	16.69	021.80	67.7	039.10	29.68	030.00	15.06	21.24	30.58	27.56	50.4
12.4	46.7	15.3	15.1	13.4	026.80	22.62	12	38.64	16.58	040.20	40.07	026.80	26.96	024.20	15.45	23.1	22.36	24.06	48.1
11.6	41.8	14.1	25.9	13	025.50	92.57	10.3	28.28	14.85	035.40	34.41	024.90	20.44	022.30	13.78	38.47	21.24	32.82	43
11.4	26.4	11.6	19.1	12.5	025.00	103.9	9.83	27.02	19.85	023.50	27.55	025.50	17.75	021.10	14.02	24.73	19.61	29.49	29.6
10.7	26.1	14.3	32.2	12	034.10	63.66	42.89	24.19	17.46	021.50	20.61	022.90	16.15	020.90	24.32	22.79	19.07	37.71	26
10.3	20.4	33.9	16.6	19.65	065.80	24.68	26.34	30.7	16.69	021.10	19.03	022.40	14.43	025.20	14.43	19.61	28.44	26.84	24.1
10.1	18.08	25	45.4	25.75	081.20	20.94	17.46	22.22	17.16	022.10	18.83	022.80	14.04	023.20	18.12	18.01	27.17	22.36	21.8
12.5	15.3	21.5	26.7	17.96	033.50	20.94	15.97	23.11	14.64	023.50	16.47	021.20	14.58	021.00	16.21	16.47	20.15	20.69	21.9
17.6	14.5	18.7	17.7	16.48	039.50	20.15	13	19.35	15.46	020.60	18.15	020.80	13.31	022.30	13.93	49.69	18.01	21.34	26.3
12.5	13.6	22.4	30.8	19.65	085.20	16.99	19.65	18.26	14.54	019.50	18.5	020.00	12.38	024.00	12.5	26.02	17.48	19.61	23.9
10.9	13	26.5	22.5	15.46	062.30	16.17	16.48	21.83	13.3	020.40	17.75	021.00	11.86	037.40	12.24	35.03	17.22	18.01	23.7
10.9	13.4	47.6	22.4	14.95	037.30	15.46	14.4	20.35	12.8	028.20	15.43	020.40	11.13	033.60	11.58	25.15	18.94	17	26
10	15	27.1	25.1	13.9	059.40	25.75	17.46	29.35	11.9	022.30	17.08	021.30	10.95	024.70	11.62	20.97	17	18.85	26
9.48	39	33.2	34.2	28.77	091.70	21.24	13	19.35	19.85	020.10	34.65	021.50	10.53	045.00	12.86	19.07	15.43	16.47	20.6
9.06	18.3	46.1	24	32.43	037.80	29.35	11.1	16.38	15.87	019.90	39.8	028.20	10.92	030.60	12.36	17.11	14.43	15.95	18.7
10	17.8	29.5	34.6	20.74	034.10	26.34	11.1	24.78	20.15	019.80	24.19	022.50	55.54	025.30	11.08	17.35	13.93	24.73	20.1
13.2	15.3	28.8	20.7	17.96	036.10	19.35	10.7	56.77	26.04	019.70	23.14	022.40	171.5	023.90	16.51	19.85	15.77	30.27	17.7
12.4	14.1	22.4	63.9	17.96	036.80	17.96	24.68	43.64	19.35	020.70	20.42	023.10	27.24	024.30	12.5	22.42	21.52	20.06	23.8

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
15.8	13.1	41.9	36.5	20.74	030.20	15.46	37.88	35.88	17.96	018.90	18.77	021.50	23.65	036.70	11.13	17.19	15.95	23.54	36.1
12	12.4	34.4	29.01	33.1	038.30	14.4	25.17	34.54	17.16	018.00	33.08	020.80	21.24	026.40	10.47	15.71	15.1	17.48	40.7
12.3	12.4	25.8	26.8	29.35	028.30	14.4	16.99	30.22	14.4	017.50	21.42	032.10	24.63	024.20	16.04	18.92	13.93	16.8	22.8
12.8	21.8	43.5	22.5	23.5	027.50	24.68	14.4	30.99	13.2	016.80	18.53	024.00	26.62	023.20	14.12	16.9	12.97	17.21	38.5
12.3	17.7	58.1	32.1	23.5	025.50	19.35	13	24.38	17.66	016.30	17	022.30	43.02	024.60	12.74	30.56	12.73	15.95	58.1
10.8	24.6	33.3	45.9	27.6	024.20	53.17	15.97	27.89	15.36	026.20	16.78	021.20	41.9	023.20	14.08	60.23	12.5	24.49	38.3
10	16	28.7	20.8	27.6	026.30	25.75	14.4	27.31	15.87	021.30	22	027.20	23.49	022.30	12.04	53.99	12.04	17.92	24.3
9.91	14.3	27.2	21.7	22.32	024.10	19.85	13	72.31	17.76	019.80	32.75	037.60	25.39	022.30	14.79	47.54	12.04	29.42	21.2
9.48	26	41.6	19	20.15	022.90	17.46	12	34.92	23.11	016.80	87.88	025.90	27.29	021.90	18.66	37.98	18.97	18.53	29.8
August																			
9.27	33	26.7	28.7	39.49	23.8	15.66	11.1	28.77	21.33	016.10	74.36	025.90	20.15	021.20	31.94	26.97	36.81	20.21	26.9
10.3	26.7	50.2	18.7	29.93	23.4	16.17	11.1	28.96	17.26	015.70	43.1	024.00	26.17	021.10	18.15	24.06	16.46	22.46	24.1
21.6	19.6	45.8	20.5	24.68	30.6	16.48	10.9	31.57	39.11	015.50	31	023.40	25.11	027.50	16.1	22.31	13.93	21.64	41.3
12.1	17.1	34.1	20.7	22.32	21.24	14.4	13.5	26.34	30.22	015.30	36.06	024.60	20.16	023.70	16.23	20.49	12.97	22.69	33.2
11.3	22.8	29.4	17.4	21.83	22.62	13.4	11.1	26.43	25.26	014.80	48.13	022.20	18.69	027.20	17.88	51.22	12.5	19.9	33.8
10.2	25.5	36	16.3	24.68	24.68	16.48	17.46	21.93	25.36	015.50	30.58	025.00	22.92	023.10	32.24	69.49	12.97	28.85	24.6
9.8	23.1	31.3	15.1	26.34	29.35	14.64	12.5	21.24	21.24	014.50	71.37	028.10	19.61	025.70	21.58	35.58	11.58	27.01	21.8
9.37	38.7	32.8	57.8	27.6	26.92	14.95	13	32.14	18.56	014.10	65.79	023.10	18.01	024.90	21.62	25.79	11.58	21.71	19.6
11.6	38.8	48.3	35.7	24.09	22.32	13.4	13.5	52.52	23.89	013.90	53.87	024.30	56.68	024.00	19.45	22.92	12.97	20.97	23.8
10	29.1	40	20	21.83	20.94	12.3	30.31	58.43	22.62	013.60	41.1	027.60	38.94	022.30	18.01	27.22	18.22	22.39	33.9
9.91	38.5	32.2	18.6	19.65	22.32	12.3	32.43	127.4	20.54	015.00	34.5	022.80	35.74	021.70	16.25	34.86	14.44	18.85	47.9
10.6	23.2	30	16.4	20.74	48.33	12	17.46	58.98	19.75	015.80	32.05	034.10	40.17	031.70	14.93	30.8	12.5	22.62	25.2
11.6	21.1	24.2	15.1	38.83	48.33	30.6	14.4	42.04	19.45	014.50	32.11	032.50	26.38	038.50	19.36	34.52	18.63	23.55	22.9
19.2	72.8	37.8	14.9	58.43	37.5	26.92	13	42.7	33.49	014.30	26.75	048.70	23.49	031.60	24.25	188.2	18.22	18.01	41.5
23.7	29.6	48.5	71.7	89.19	56.22	17.26	12	32.72	24.38	013.90	24.27	031.30	34.37	031.00	17.94	159.3	14.86	34.64	56.2
17.4	76.4	26.2	62.3	320.4	34.35	15.46	11.6	40.25	37.69	014.00	22.92	028.70	37.09	030.70	14.93	85.69	15.43	22.77	41.8
15.4	59.4	26.1	43.7	85.89	24.68	15.46	41.48	51.31	42.8	015.30	21.83	025.30	104.7	026.30	15.67	51.38	24.13	18.53	31
22.5	39.5	23.2	29.6	83.38	31.18	13.9	21.24	97.71	29.73	015.20	20.42	030.00	56.4	025.90	14.93	40.21	23.19	18.01	34.6
15.3	30.4	21.4	43.7	62.2	25.75	13	20.15	121.4	44.21	014.00	20.8	054.20	34.96	030.80	13.69	41.71	24.36	24.68	27.7
13.9	25.5	22	30.7	40.82	27.31	13	18.56	85.17	40.25	30.57	19.07	047.50	36.98	026.30	12.81	39.31	16.47	19.61	23.7
21.4	31.2	21.3	47.4	37.5	55.48	22.32	22.32	58.34	27.31	31.45	18.01	035.90	28.76	030.30	12.04	48.94	14.43	21.39	21.4
28.5	44.1	20.8	44.9	33.68	31.18	17.46	16.99	41.57	24.09	19.81	17.83	035.80	28.17	037.90	13.48	34.82	14.8	18.53	21.6
17.7	38.1	18.4	32.5	29.93	39.49	23.21	14.4	47.96	34.16	22.78	35.59	039.10	27.86	046.10	26.05	37.68	23.97	18.85	21.9
15	26.8	31.6	49	26.92	28.18	15.97	29.93	36.35	180.3	26.61	22.15	041.60	26.53	030.70	18.37	61.75	22.95	17.48	20.6
20.5	27.1	45.8	54	24.68	130	21.24	17.46	32.05	143.8	27.17	18.06	035.80	34.36	028.70	13.93	33.06	19.64	16.99	26
21.5	34.4	21.2	42.1	27.6	59.17	24.87	16.48	28.48	48.8	23.45	17.95	029.70	30	027.40	12.5	32.23	15.64	18.53	25.4

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
16.3	48.4	28	38.4	46.27	40.82	15.15	16.48	33.2	35.5	18.27	19.67	039.40	29.59	026.30	11.81	31.7	14.26	16.38	31.1
42.7	36.2	40.7	32.2	45.62	31.85	17.96	25.36	69.59	53.91	16.47	18.19	038.80	48.84	025.30	13.71	28.44	12.97	16.36	24.7
21.5	28.5	31.7	32.3	36.93	32.43	15.97	22.91	40.63	43.36	15.89	15.95	036.60	61.83	024.40	11.92	26.97	12.5	25.77	28.7
17.6	26.5	46.5	30.8	34.92	62.93	14.2	16.48	36.07	30.31	19.33	15.18	054.80	37.35	023.40	18.97	29.34	12.5	38.75	32.4
16.5	39.1	48.8	26.6	38.16	53.35	29.35	27.6	50.19	30.6	50.59	14.08	035.30	57.75	026.20	33.99	33.11	18.06	30.43	19.4
September																			
17.7	35.4	41.7	30.7	39.09	46.93	27.6	39.96	48.33	36.64	45.13	13.73	032.90	38.17	023.60	14.43	25.21	20.16	25.86	18
21.3	26.4	44	22	34.92	42.14	22.32	32.43	32.91	27.8	40.48	48.93	032.00	29.97	023.80	12.77	25.5	18.88	19.61	52.4
17.2	23.2	44.9	41.7	34.24	34.92	23.5	21.24	29.54	77.63	34.02	63.91	029.00	26.67	023.80	17.02	26.26	21.15	17.48	38.1
14.9	22.5	38.5	29.4	26.68	38.83	46.93	84.19	34.25	34.92	24.06	69.1	034.50	26.18	024.20	15.1	27.07	64.57	17	22.2
16	22.1	30.8	42.1	28.44	46.27	33.1	63.66	30.02	27.31	20.69	42.91	029.20	36.07	022.20	12.97	28.31	34.31	26.76	23.8
29.2	19.7	28.8	38.2	27.15	38.83	31.18	131.8	87.14	37.21	18.8	32.97	031.90	40.96	021.50	19.72	26.02	26.55	46.55	37
17.9	19.77	25.1	59.9	23.77	38.83	29.35	82.58	39.4	32.05	17.48	22.36	038.80	36.71	036.90	32.91	24.06	31.52	27.91	53.3
17.4	17.4	30.6	50.5	26.53	33.68	22.32	44.87	35.02	35.59	20.98	68.49	032.60	29.92	027.00	17.72	34.14	28.85	21.46	30.7
45.7	18.4	28.7	42.9	22.08	39.49	26.34	46.93	36.83	60.73	25.1	34.67	035.90	41.13	036.00	22.72	31.13	22.16	30.18	23.5
88.5	28.7	37.8	33	23.02	31.85	22.91	43.55	64.03	47.96	23.27	25.36	030.60	26.38	028.40	18.53	27.46	20.15	32.68	22.5
32.6	19.7	56.2	44.4	21.36	29.93	19.85	31.85	51.4	47.02	37.62	22.2	048.90	30.53	029.00	15.95	24.61	20.5	37.77	25.3
26.1	17.6	34.5	29.4	28.7	29.35	17.76	43.55	43.46	40.25	42.81	21.24	034.60	30.65	023.00	31.19	27.64	20.9	162.7	25.7
23.2	16.8	35.1	27.5	23.5	25.75	17.46	29.35	63.02	47.02	28.58	50.57	028.90	25.55	022.40	17	24.63	21.11	153.3	80.4
84.3	19.1	33.5	51.1	27.95	21.83	18.76	26.34	59.08	48.24	25.27	59.79	027.00	29.16	030.30	16.64	29.68	32.62	75.04	76.3
44.5	20.4	34.7	50.4	24.28	20.44	19.85	31.85	47.96	38.73	22.57	30.69	025.50	24.63	033.40	53.22	79.79	33.41	45.25	36.7
55	17.3	27.4	28.9	21.16	19.35	17.76	31.18	37.78	41.76	28.53	26.76	029.50	22.64	026.10	61.15	84.56	20.69	36.44	27.1
51.2	28.1	26.8	37.2	20.02	18.46	21.24	57.7	42.42	33.97	26.02	23.42	028.10	22.27	028.10	68.61	73.12	22.01	33.87	44.3
32.9	31.2	25.4	42.8	21.48	18.26	33.1	83.38	41.95	30.6	20.35	20.97	034.20	127.8	024.20	98.09	59.15	48.78	29.36	56.1
27.5	22.4	25.9	41.6	20.16	17.76	34.92	36.93	45.05	27.89	18.53	19.47	038.00	67.53	023.90	55.45	63.67	175.9	49.99	38.4
26.5	23.9	47	33.02	19.45	18.26	95.94	30.6	40.53	36.55	20.68	41.53	036.60	29.49	033.70	54.55	67.99	86.04	90.36	30.3
29	36.2	30.7	47.1	17.74	21.24	54	31.18	39.11	32.82	28.68	33.19	036.60	27.88	050.30	66.55	45.27	36.11	53.55	38.5
28.5	34.4	29.8	32	16.79	19.05	29.93	49.08	32.43	36.35	35.84	22.76	033.80	26.44	051.30	53.76	36.89	32.47	60.17	39.6
26.2	59.7	27.7	32.9	16.21	16.48	24.87	29.93	30.99	60.64	20.69	20.24	034.20	34.76	044.10	64.3	33.06	26.97	41.03	41.1
40.2	29.8	90.7	26.2	15.54	18.46	23.21	35.59	28.18	28.28	18.53	23.52	037.00	28.44	039.10	48.8	38.35	24.06	42.42	29.7
29.6	23.9	38.4	31.3	18.09	19.05	20.44	52.61	26.73	24.68	19.09	38.88	037.50	25.87	036.90	39.13	45.95	22.83	38.77	25.9
30.3	21	39.6	31.3	30.54	22.91	19.05	39.49	23.89	22.32	30.72	40.93	034.20	29.22	045.50	29.97	91.59	22.36	29.97	24.4
41.7	20.1	86.8	30.8	21.56	28.77	17.76	37.5	23.11	23.8	21.55	22.92	034.80	31.3	035.40	31.6	83.39	34.72	33.91	43.1
42	18.9	93.4	22.9	17.04	26.34	18.76	32.43	21.04	36.45	23.8	22.01	030.60	30.27	053.40	44.22	39.69	31.63	87.94	32.1
43.6	27.8	123	36.1	16.38	34.35	17.96	26.92	31.47	27.89	32.86	69.05	030.20	22.08	042.30	46.12	35.45	31.16	48.2	35.5
37.6	27.2	52.7	30.8	27.51	43.55	24.68	24.09	26.73	25.17	51.42	168.8	30.95	38.34	043.10	78.32	32.75	27.98	33.51	25.7

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
October																			
30.3	35.4	40.3	23.1	26.92	43.55	48.33	29.35	29.64	30.31	53.5	134.5	56.79	27.67	053.50	49.08	31.93	32.68	53.24	27.3
29.2	29.4	41.9	43.9	62.93	33.1	57.7	25.75	40.44	41.1	49.97	37.54	51.21	21.52	041.90	36.76	35.49	25.63	37.7	25
30.1	25.6	35	26.9	44.87	29.93	33.68	23.5	30.7	37.78	34.25	69.82	061.60	21.57	061.20	38.51	27.86	21.8	28.76	21.7
42	26.2	32	23.2	31.85	23.4	42.14	28.18	27.02	40.72	33.07	56.72	044.30	21.24	058.00	46.43	35.24	21.28	26.38	21.5
28.4	28.5	42.8	24.1	28.18	19.65	36.26	59.17	27.31	32.72	31.7	78.59	038.00	19.79	061.20	34.81	31.56	22.24	25.7	21.9
27.6	28.5	40.3	22.1	31.85	20.94	29.93	31.85	24.68	47.77	38.96	58.74	035.00	18.27	068.50	30.68	32.92	61.9	25.82	22.1
60.6	51.1	37.7	22.2	44.21	21.24	29.35	26.63	30.12	32.43	52.56	91.41	075.30	17.31	081.80	26.38	51.94	41.13	24.2	17.5
68	34.1	50.7	20.8	24.68	40.82	65.22	24.09	35.69	26.73	42.95	53.41	070.80	22.96	054.40	33.36	55.9	95.92	29.93	17.5
57.5	33.5	36.4	37	21.83	38.16	71.4	25.46	31.28	37.69	59.44	40.56	061.60	44.72	048.30	44.84	83.54	83.11	27.14	30.4
106	67.7	41.1	49	29.35	106.5	31.85	25.75	27.89	32.14	57.72	42.97	078.20	33.51	045.60	34.29	41.34	38.81	23.75	29.7
110	78.7	108	45.2	31.18	58.43	121.4	33.68	23.89	34.64	80.25	36.24	082.70	56.9	126.00	40.68	32.44	55.14	37.59	20.7
52.4	57.5	51.5	38.05	21.83	64.39	131.8	32.43	23.01	25.07	102.5	63.61	091.70	50.63	081.20	34.33	37.19	64.29	40.62	16.5
62	63.1	39.4	28.1	30.6	46.27	95.05	30.31	19.65	23.3	91.46	36.19	082.50	37.88	051.00	38.8	35.12	45.87	87.53	15.4
74.8	61.7	27.3	37.3	21.24	38.16	46.93	34.92	19.05	22.62	86.83	37.51	081.80	34.25	057.10	39.44	27.26	31.94	53.67	17.5
76.2	151	38.5	37.5	20.74	31.18	38.83	44.87	22.91	33.68	87.18	44.63	069.20	32.97	051.30	36.15	28.29	26.38	31.29	16.3
49.6	49.8	31.4	27.9	21.24	49.73	34.92	33.1	24.78	32.43	69.97	35.2	056.60	38.19	046.10	93.75	24.63	31.05	55.41	22.8
39.7	51.6	50.4	33.5	31.18	36.93	40.82	24.68	28.38	62.11	51.17	35.02	048.10	31.23	084.20	38.9	31.43	32.93	46.17	56.4
60.9	44.3	37.2	28.7	26.92	46.27	37.5	21.83	32.14	85.89	44.5	31.51	045.60	94.12	074.60	76.09	79.2	37.15	45.35	42.2
42	39.4	36.3	22.4	26.34	35.59	28.77	21.83	33.49	29.83	90.54	190.4	44.29	49.66	044.90	66.94	44.74	29.51	66.96	28.8
35.6	35	33.2	26.5	22.91	65.95	43.55	21.83	41.76	27.99	62.15	378.3	42.17	34.33	054.90	37.21	28.77	24.8	48.6	39.6
32.9	32.6	28.7	26.9	23.5	37.5	34.35	20.74	27.21	23.8	48.53	104.9	42.85	33.22	101.00	34.28	25.21	61.87	85.38	35.5
37.5	29.2	29.5	25.6	31.85	46.93	41.48	34.35	20.25	24.29	41.35	58.09	36.24	37.49	123.00	38.51	33.56	30.89	100.3	32.4
53.6	40.8	34.7	71.7	29.35	36.26	33.68	30.6	25.26	24.29	50.33	57.48	31.61	42.55	074.10	29.36	70.55	29.59	100.9	39.5
44	31.4	33.6	31.9	31.18	28.18	36.93	23.5	39.02	25.26	37.64	48.9	29.36	41.83	056.10	30.2	35.08	27.36	111.8	45.8
43.6	37.9	36.3	37.4	28.77	29.35	37.5	21.83	52.33	21.43	34.82	44.16	36.31	44.95	050.80	54.46	28.46	23.49	173.4	54.5
41.7	38.9	34.8	38.9	39.49	59.9	65.95	32.43	109.2	23.01	33.56	107.1	32.32	43.28	049.30	107	25.21	146.8	158.4	51.5
36	48.1	29.8	29.5	31.85	64.39	51.87	25.17	175.3	58.25	43.97	74.89	39.36	33.06	069.60	69.97	24.92	72.4	114.3	36.6
43	74.3	42.9	26.8	27.6	68.22	58.43	24.09	131.8	60.82	80.16	45.98	60.45	37.9	065.20	62.33	25.69	34.19	107.1	31.3
41.3	41.1	36	27.2	135.2	106.5	57.7	27.6	75.2	36.93	79.24	46.42	44.37	42.57	049.80	43.36	43.7	116.2	104.1	45.2
35.3	36.3	30.4	25.1	99.47	107.4	37.5	95.94	50.19	27.6	38.41	40.2	30.92	33.26	051.30	84.15	26.38	111.8	107	44.7
62.3	34.8	42.4	26.9	36.93	52.61	48.33	156.6	103.9	22.91	31.2	54.2	29.82	28.76	043.70	82.54	28.16	49.04	102.4	26.1
November																			
48.5	32	95.9	29.7	31.18	46.93	38.16	37.5	64.48	20.64	31.77	36.79	26.77	107.1	054.10	59.58	26.97	49.07	118.3	27.1
34.7	34.7	52.5	25.2	26.92	37.5	56.22	34.35	75.83	19.15	65.61	33.07	26.79	57.16	49.34	42.18	19.61	46.11	108.3	32.7
31.1	31.4	39.4	22.8	26.92	32.43	89.19	37.5	75.56	17.86	92.79	32.4	24.06	35.6	46.45	60.94	25.41	46.47	141.3	49.3

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
31.1	39.5	37.8	27.7	49.73	40.82	46.93	52.61	80.42	18.46	146.8	29.74	25.36	36.96	38.29	45.53	48.14	33.27	117.2	37.5
37.5	45.5	40.3	38.4	34.92	31.85	46.27	29.35	68.4	18.06	52.72	27.91	39.19	43.81	54.88	36.89	26.02	29.36	152.8	30
51.6	46.4	34.2	28.7	31.18	58.43	37.5	26.34	57.7	18.86	46.69	37.21	31.62	172.8	42.97	34.17	22.74	29.92	144.5	29
36.3	38.4	66	23.1	25.17	40.15	31.18	24.09	42.23	27.99	35.28	37.54	31.27	173.1	53.64	30.58	29.68	104.5	110.7	36.2
28.7	36	37.7	24.8	25.17	31.18	29.35	25.75	36.16	49.82	31.91	30.76	31.86	126.8	39.53	31.25	27.12	53.62	103.7	45.5
46	33.6	60.7	21	24.09	27.6	26.92	22.91	34.25	166	46.57	26.23	53.39	60.69	132.2	27.86	23.42	103.4	100.2	33.4
32.9	30.6	32.8	21.3	21.24	42.89	29.93	24.09	33.39	87.14	40.64	23.96	68.22	60.5	68.59	25.5	30.52	45.62	96.77	32.2
29.5	29.4	31.7	19.9	21.24	84.99	26.34	32.43	30.6	42.7	29.36	22.52	54.39	63.52	57.91	25.55	30.59	86.33	98.79	31.5
30.3	28.1	30.7	18.4	20.15	106.5	24.68	32.43	27.02	30.31	45.36	20.85	55.07	59.17	85.08	26.38	28.27	57.26	95.07	37.9
37.1	52.6	48.8	35.1	22.32	150.7	22.32	22.91	25.65	27.41	165	21.24	61.12	45.05	46.86	27.57	26.16	51.13	92.52	37.9
49.8	59.7	40.8	31.6	32.82	169.3	20.94	21.24	24.09	88.47	43.49	26.05	86.98	42.52	39.18	26.38	46.2	65.2	102.8	27.6
36.7	44.7	27.7	28.4	28.77	68.22	19.85	31.85	23.11	49.45	35.93	21.99	55.6	38.57	35.6	26.38	78.2	185.9	101.7	24.1
32.3	49.8	30.3	30.6	23.5	66.67	18.76	34.92	48.7	37.02	187.9	20.76	44.89	37.94	33.1	23.34	52.79	159.3	106	31.9
27.9	42.5	51	38.3	22.32	43.55	17.96	21.83	42.7	39.59	108.3	20.6	44.93	39.38	30.58	21.43	37.42	60.73	110.9	78.1
25.9	35.9	97.4	29.8	19.05	38.83	17.46	33.1	37.12	37.4	119.5	18.36	38.2	42.02	29.82	20.69	33.25	50.26	101.3	32.3
26.2	37.5	54.4	25.5	17.46	34.92	16.69	22.32	28.38	33.01	50.96	44.66	56.85	38.85	29.68	20.12	26.97	41.68	150.4	30.2
28.7	64.6	39.7	23.9	44.21	41.48	16.99	19.65	25.95	28.38	44.22	48.07	61.97	33.69	47.2	32.67	24.34	38.48	140.7	70.3
61.8	40.5	33	25.6	59.9	37.5	15.66	18.56	23.01	57.97	71.07	37.97	38.04	33.86	49.37	25.08	23.49	52.21	253.8	31.9
27.77	35.6	32	30.7	24.09	68.22	14.95	17.46	21.33	36.45	74.94	37.98	34.33	31.51	40.07	24.72	22.15	36.24	196.5	75
25.2	45	30.7	40.2	22.91	74.48	15.66	17.46	37.88	29.93	46.51	63.75	30.58	28.16	30.2	25.85	30.01	46.33	128	43.1
22.7	43.4	28.2	35	31.85	69.77	15.46	39.49	28.57	34.64	43.43	63.62	37.97	32.85	26.97	29.47	26.79	125.9	139.9	31.2
21.7	33.2	29.4	26.7	42.89	52.61	17.96	21.83	28.67	30.41	36.65	33	29.97	27.94	25.76	73.28	25.42	75.3	120.6	131
20.4	30	34.9	24.8	38.16	36.93	14.95	18.56	24.58	26.73	32.44	37	26.62	25.21	62.57	49.86	26.72	45.08	123.8	51.5
19.7	27.8	29.4	22.5	38.83	30.6	14.4	17.46	22.71	34.92	32.28	31.24	24.94	24.06	37.01	39.96	31.69	40.86	120.9	36.6
29	26.7	26.6	20.4	49.08	55.48	13.7	32.43	20.74	50.1	28.16	27.31	24.3	22.55	35.17	30.61	32.86	34.96	108.9	33.9
18.3	24.1	28.1	20.3	67.49	81.77	12.9	63.66	20.44	32.24	26.04	24.63	23.13	25.21	31.57	28.47	29.94	44.91	105.4	35.1
17.1	23.9	23.9	25.7	49.08	56.22	12.3	62.93	20.15	24.78	25.21	22.59	38.89	47.3	32.02	27.33	33.51	46.22	102.8	30.3
December																			
16.3	28.4	25.4	31	50.47	42.14	12	40.15	18.16	23.3	24.06	20.92	31.51	73.02	44.31	22.78	33.09	53.96	98.48	27
44.9	66.6	23.1	22.8	38.83	33.1	11.6	46.93	17.26	23.4	21.96	19.92	37.8	109.4	117.9	23.93	35.18	34.33	95.92	25.2
16.2	33.1	21.5	18.6	31.18	28.77	11.1	28.18	16.48	23.3	22.52	19.7	35.74	103.8	109.3	31.21	28.17	35.6	96.77	33.9
14.7	25.6	21.3	26.4	29.93	39.49	11.1	74.48	16.69	29.44	20.47	35.32	51.43	50.94	49.98	89.91	27.72	34.33	93.37	39.4
17.4	23.5	20.3	19.3	26.92	378.5	10.7	41.85	16.58	57.97	19.38	32.89	29.36	33.69	181.2	474.8	25.02	31.82	91.68	87.7
14.9	23.2	21.8	16.6	25.75	103.9	10.4	33.68	14.95	130.9	20.93	23.21	25.99	29.97	264.3	55.38	22.92	30.97	90	36.1
14.1	20.8	20.6	16.3	22.91	83.47	10.4	43.55	14.3	50.29	20.69	20.42	24.78	27.56	58.06	38.85	24.54	34.44	103.7	28.2
16.3	20.8	23.9	15.7	21.83	76.91	10.3	33.1	13.9	41	20.06	20.71	22.92	25.72	46.26	43.91	24.36	35.54	93.78	25.2

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
16	45	20.3	41.2	20.74	51.22	9.62	35.59	14.3	32.24	18.53	26.63	23.77	24.06	307.1	51.26	22.64	31	99.29	23.5
12.6	26.7	20.3	36.4	21.24	73.75	9.2	44.87	13.2	34.06	17.35	25.6	22.92	26.92	162.6	38.8	24.06	43.94	88.33	22.4
12.7	38.8	29.5	23.5	21.24	254.1	9	33.68	12.6	28.57	16.8	20.47	20.69	26.38	58.43	33.24	22.36	70.96	86.67	22.9
12.5	29.3	27.02	20.1	25.17	180.3	8.8	29.35	13.5	26.34	16.1	18.8	19.61	25.22	52.07	29.06	20.69	68.32	87.5	42.4
11.8	26.4	23.7	18.4	21.83	221.2	8.6	46.27	13.9	24.29	15.18	19.61	20.7	22.5	42.85	26.13	19.88	37.41	83.38	24.1
11.2	24.2	20.1	18.1	19.05	125.7	8.6	32.43	14.1	21.83	14.34	18.01	19.39	21.24	39.51	24.58	19.34	32.08	82.56	29.4
11	22	19.1	19.8	29.93	73.75	8.2	35.59	12.6	20.25	13.87	18.01	17.61	19.97	36.24	22.59	19.07	36.6	81.75	36.6
10.8	20.7	18.6	21.7	28.18	60.64	8.2	66.67	11.9	19.65	13.4	17.22	18.19	18.74	32.44	21.41	17.22	67.05	13.45	24.1
10.1	19.6	17.8	35.4	24.09	50.47	8.4	40.15	11.5	18.26	13.15	16.25	18.19	17.48	30.13	20.97	17	38.2	13.45	21.2
20.8	19.4	16.3	45.9	30.6	43.55	8.4	36.93	11.3	17.66	12.5	15.43	16.47	16.47	28.26	20.69	17.48	30.59	13.45	19.6
11.5	18.6	15.2	33.7	29.35	53.35	7.81	31.18	11.7	17.06	12.18	14.68	16.47	16.25	27.02	20.15	16.47	29.21	12.97	19
10.6	18.3	15.3	32.2	30.6	55.67	7.62	72.13	10.6	16.28	11.96	14.18	15.35	15.43	25.21	20.22	14.93	26.23	13.45	18
48.4	18.7	14.3	27	25.17	42.89	10.9	60.64	10.7	15.87	11.58	13.69	14.97	15.03	23.77	18.53	14.43	24.99	12.5	16.5
21.8	15.2	14	25.6	34.92	35.59	9.2	41.85	11.1	15.46	11.5	13.21	22.46	14.43	22.22	17.28	13.93	23.77	15.4	21
13.5	15.6	13.5	22.8	30.6	31.18	7.81	36.26	14.74	14.74	12.29	12.83	17.34	14.25	21.24	16.25	13.45	22.12	15.45	24.3
13	15.5	12.9	21.5	23.5	28.18	7.62	31.18	14	14.2	11.81	12.4	17	15.43	20.01	15.33	13.45	21.21	13.83	19.9
12	15.2	12.6	19.9	22.32	26.34	7.24	29.35	10.9	13.7	11.18	11.92	15.43	21.4	19.43	15.43	12.97	20.15	13.68	32.3
11.3	13.5	12	18.7	20.15	24.87	7.24	26.34	10.5	13.4	10.51	11.58	14.93	31.31	18.36	15.95	12.5	19.54	12.5	52.1
10.8	14.4	12	17.7	18.56	23.21	6.88	25.17	9.6	12.9	9.979	11.13	13.93	28.08	18.49	14.32	12.04	23.94	11.58	32.9
10.7	14.1	11.4	20.1	20.74	21.83	6.88	23.8	9.3	12.5	9.828	11.09	14.47	28.03	17.34	13.59	11.58	17.66	11.13	27.7
9.77	14.2	10.7	1.87	56.96	24.68	6.7	22.91	8.9	19.25	10.37	10.91	14.76	21.24	16.8	13.29	11.58	17.28	10.69	30.8
9.54	13.5	10.7	25.7	33.1	33.1	6.7	23.5	8.59	17.96	9.935	11.66	20.94	19.07	16.33	12.85	16.34	16.73	9.828	28.9
9.21	12.6	10.5	20.1	26.92	22.62	7.06	21.83	8.3	15.36	9.375	10.91	29.9	17	15.31	12.45	15.95	16.08	9.828	23.6

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