

RIO SÃO FRANCISCO TRANSBASIN DIVERSION NORTHEAST REGION, BRAZIL

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ABSTRACT

The Rio São Francisco rises in the Cerrado of the State of Minas Gerais and Goiás in the Central Region of Brazil fed by the runoff from orographic rainfall of the Central Plateau and Chapadas that divide this drainage from the Tocantins and Amazon Drainages to the Northwest. The river arises in the State of Minas Gerais in the Serra da Canastra at an elevation of approximately 1600 m. From there it winds 2,700 km north and east through the semi-arid lands of the Northeast Region of Brazil crossing much of the area defined as the Drought Polygon of the country.

The flows of this drainage provide the hydropower to fuel the industry of the region, the water to supply the growing fruit and vegetable production industry, the transportation for goods and services. This river system holds the key for the future of the region, but also represents one of the major potential sources of conflicts as the many developing demands for scarce water supplies within the Northeast of Brazil compete for the lifeblood of the river. These demands are not just limited to the riparian states of the river basin. The non-riparian semi-arid states of the Northeast have long coveted the waters of this river system and proposals for major transbasin diversions to the north and east of the drainage have been put forth for over 75 years. The emotional, environmental, political and economic struggles that such diversions proposals will spawn have just begun to emerge. This river system will be the subject of intense study, development and controversy during the coming century and the solution of these controversies will require the best technical and political minds the country has to offer.

The complexities of this system will require the use of the latest in computer and hydro-meteorological information technology to provide the decision-makers and diplomats with the information and tools necessary to forge compromises and to develop and prioritize the competing and, frequently, conflicting uses of the resources of the basin. The challenge of meeting the multi-purpose demands for the water of the river system in a sustainable and environmentally acceptable manner will tax the future thinkers and decision-makers to the limit. The equally important challenge of providing for these demands in a manner that does not threaten or destroy the unique ecology of the river and pollute its scarce and

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valuable water supply will require compromise, sound planning, political and scientific cooperation and a tremendous amount of effort, time and financial resources. The present proposal to divert flows from the Rio Sao Francisco amounts to proposed diversions of less than 1 % of the annual river flows. However, the diversion of these flows, originally proposed in 1900, has been vigorously opposed since that time by the riparian states, principally Minas Gerais, Bahia, Pernambuco, Sergipe and Alagoas. Of these, Minas Gerais and Bahia are extremely powerful from both an economic standpoint and a political standpoint.

In the last two years, the balance of political power and tradeoffs has changed to the benefit of the proposed recipient states through political coalitions. Consequently, this project is now moving on a fast track. From an economic standpoint, it has debatable benefits and strong impacts on the existing hydro-power system in the river system. This will be further exacerbated by recent energy cost increases in fossil fuels. The project, however, will probably never be judged by the economic standard as it is primarily a political project, reminiscent of the Central Arizona Project. From an environmental standpoint, the project is relatively benign with the exception of the impacts of additional growth created in the recipient states by the new water. The river downstream of the proposed diversion is highly impacted by large hydro-power dams and related hydro-electric power releases. Any flow impacts will be totally absorbed by the downstream storage systems.

This highly emotionally charged project, at a cost of over a billion dollars, promises to generate extreme political controversy over the next 10 years and beyond.

BACKGROUND

The Rio Sao Francisco rises in the Cerrado or steppes of the States of Minas Gerais and Goias in the Central Region of Brazil fed by the runoff from orographic rainfall of the Central Plateau and Chapadas or highlands that divide this drainage from the Toncantines and Amazon Drainages to the Northwest. The river arises in the State of Minas Gerais in the Serra da Canastra at an elevation of approximately 1600 m. From there it winds 2,700 km north and east through the semi-arid lands of the Northeast Region of Brazil crossing much of the area defined as the Drought Polygon of the country. The flows of this drainage provide the hydropower to fuel the industry of the region, the water to supply the growing fruit and vegetable production industry, and the transportation for goods and services. This river system holds the key for the future of the region, but also represents one of the major potential sources of conflicts as the many developing demands for scarce water supplies within the Northeast of Brazil compete for the lifeblood of the river. These demands are not just limited to the riparian states of the river basin. The non-riparian semi-arid states of the Northeast called the



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This arid area has suffered periodically with long and severe droughts that have decimated the economy of the Northeast and caused innumerable deaths and a persistent emigration of the rural people from this region to the urban areas of the South of Brazil with attendant social impacts, poverty and disruption of the culture. For example, in a major prolonged drought during the period of 1845 to 1848, more than 500,000 people of the Northeast died of starvation and health impacts from this severe drought.

The dream of supplementing the unreliable supplies of the region with a transbasin diversion project from the Rio São Francisco has recently moved closer to becoming reality at both the political and technical level. The National Ministry of Integration (MIN) has in the past two years, contracted a series of engineering studies designed to evaluate both the engineering and economic viability of diverting water to the Northeast states of Ceará, Rio Grande do Norte, Paraíba and Pernambuco (Setentrional Northeast). Although the riparian states of the São Francisco basin tend to be generally against any transbasin project, the number of Brazilian state that appear to be in favor of the project has been on the increase, as well as apparent approval at the Federal level within the administration, centered generally in the National Ministry of Integration.

The project has been faced with a number of key technical, social, political and economic issues over the last few years. This paper will attempt to address some of these issues along with the rationale being advanced by the project proponents relating to these issues.

TECHNICAL ISSUES

At the technical level one of the main concerns has been the hydrologic record of both the basin of origin and the recipient region, as well as the reliable assessment of present demands and rational estimates of future demands. This is key to assuring the riparian states that the project will have little adverse impact on their future water supplies. In addition, minimization of losses from the system, impacts on river morphology and optimization of the project to minimize pumping costs and maximize the use of "off-peak" energy have been analyzed.

The Rio São Francisco has a relatively steady hydrograph, with sufficient flow in most years to meet the presently proposed transbasin diversion as well as the present and projected uses within the basin and to support the extremely important hydroelectric generation within the basin. Supplemental water supplies to the Setentrional Northeast states from the São Francisco would help to optimize the efficiency of existing water retention structures in the region, allowing greater

drawdown with the assurance of the replenishment during wet years from this additional source.

The water supply studies of both basins have been based upon lengthy records of moderate reliability. While the impacts of climate change theories could change the available amounts, this is not considered to be quantifiable in any real sense and has been treated subjectively. Accordingly, the hydrological analyses done to date appear to be reliable and indicate that the future supplies of the basin of origin would not be adversely impacted by the presently proposed transbasin diversion.

With regard to demand questions, this area of analysis has been subject to a great deal more speculation. The growth estimates for the urban areas of the Setentrional states are based on past growth trends during a recent period of economic growth that far exceeds the past. The estimates for demand assume that this growth will continue as it has in the recent past, or in some cases, accelerate. The use of some of the transbasin water for municipal/industrial use in the metropolitan areas of Fortaleza, Ceara and Recife, Pernambuco has received less opposition but the demand projections have been questioned. In addition, assumptions have been made that all irrigable areas within the recipient basins that are amenable to the production of high value crops will be developed. This is important to the demand evaluation, as this type of agriculture is the only type that could afford the cost of the transbasin water in a sustainable manner. This proposed use of some of the water for high value agricultural irrigation has been strongly questioned. Project opponents have argued that the use of the same water for irrigation of similar crops in the Rio Sao Francisco Basin makes more economic sense. This argument has been countered by proponents, who claim that the water of the Rio Sao Francisco is from a Federal river and, under Brazilian law and is available to all Brazilian states and all Brazilian citizens. Further, the development of the arable land within the recipient states would create employment within the rural population that would stabilize these populations and diminish emigration to the South with its attendant problems. The demand figures developed from the MIN studies include both the projected M&I growth as well as irrigation. Sensitivity studies conducted by the MIN, have evaluated changes in the demand estimates with regard to the viability of the project. These studies indicate that variations in the development of demand would primarily affect the timing of the demand growth as opposed to the eventual development of the demands. This factor affects both the basin of origin as well as the recipient basins. This is presently under study by the MIN to evaluate staging opportunities for project construction that might provide more flexibility in matching supplies to demands within the project as demand develops. However, many components of the project are not amenable to staging and would have to be constructed at full capacity at the outset.

An extensive alternatives analysis was conducted to examine alternative supplies within the recipient basins as well as the use of conservation techniques to reduce or delay demands. Given the extreme shortage of water within this region during the cyclical droughts that occur, it is not surprising that the alternatives to this additional water supply result in inhibited growth, continued adverse impacts on the rural poor and an inability to optimize the operation of present and proposed water supply systems within the region. At best, the alternatives to this project just delay the inevitable need for additional supplies to the region.

As evaporation is extremely high in this region of Brazil, design of the proposed system to optimize the project efficiency has been a main concern. This is particularly of concern with regard to re-regulation storage reservoirs and terminal storage. The MIN has evaluated this and has optimized the use of such reservoirs. In the process, reservoir facilities that do not contribute a substantial gain in project yield were eliminated. The use of impermeable membranes under all concrete canal linings has been specified to minimize seepage losses as well as the use of pipelines and tunnels through critical areas. The original plan considered the use of natural drainage reaches to transport some of the diverted water. However, closer evaluation of many of these reaches indicated that losses would not be in the range of feasibility and that morphologic impacts on these natural drainages from the increased flows would be intolerable. As a consequence, the use of canals, pipelines and tunnels was chosen in most cases. Natural drainages will still be selectively used after careful analysis of the river morphology of the related reaches.

The project will not only consume energy for pumping, but will also divert water that is presently being used for the generation of hydroelectric energy at three large installations downstream. This impact has been the source of a great deal of controversy as the consumption of energy for pumping raises the variable operation costs of the project. In addition, the losses of energy that was formally generating energy downstream has been criticized. While the bulk of this energy is used in the Northeast, it is also transported to the industrial regions to the south. Potential use of the water after it passes through the generation system is minimal as it flows into the Atlantic Ocean downstream. This tradeoff has been carefully evaluated by the MIN as a part of the economic analysis and will continue to be a factor in the political debates that will be had as the project reaches approval stages. The cost of the energy lost was calculated into the over-all cost benefit analysis of the project.

ECONOMIC ISSUES

Key economic issues evaluated as a part of the project included the cost/benefit analysis but also the analysis of the energy forgone as a result of the project. Economic analysis regarding the opportunity cost of the project as it relates to other alternative investments that might be made by the Government of Brazil

such as highways, railroads, education or other uses of public funds has not been made. It is assumed that such choices will be made in the political arena as are most such decisions in most countries. The lack of such an opportunity cost analysis has been criticized by the economic community as are most uses of public funds. The internal rate of return for this project at a discount rate of 10% was preliminarily calculated to be 24.9%. The over-all capital cost for the project is estimated at 2.74 billion reais in 1968 values. Present rate of exchange is approximately 2 reais to 1 US Dollar. The impact of changes in the exchange rate on over-all project cost is under evaluation by the MIN on a continuing basis.

As was mentioned above, the opportunity cost of the loss of energy compared to alternative sources to generate this energy was not evaluated. This has been of concern to economists. The cost of the water to the user to fully recover the costs of operation and maintenance for the project, including energy, would be about \$R70 per 1000 cu meters. At the present exchange rate, this would be about \$US 35 per 1000 cu meters. This would be equivalent to a cost of about \$US 43 per acre foot delivered. For M&I use as well as for the irrigation of high value fruit crops for export, these costs are within reasonable ranges. The repayment of the capital cost of the project is not being considered as this project is considered an investment on the part of the Government of Brazil and the relevant states in order to provide an incentive for economic development and to alleviate the costly impacts of periodic drought within the region.

THE POLITICAL ASPECTS

As is the case with most transbasin diversions throughout the world, this project has been a major political subject. Since first proposed in 1847, the project has been debated within the political arena and has been inserted into the platform of political candidates, both on the pro and con side, for generations. Many candidates for office have used this project as a base for stirring up the emotions of the electorate. This has placed many political figures in almost irrevocable positions with regard to any compromise. It remains to be seen if these long held and emotional positions can be reconciled with any sort of political compromise to allow the project to go ahead. Unfortunately, if the project proceeds without such compromise and agreement, it faces a rocky road in the area of future appropriations for completion in the later years if political powers change, as they surely will. At present, it would appear that the project is moving ahead for a proposed construction contract by the Fall of 2001, provided that it does not get entangled in political stalemates once again.

THE PROJECT

The Rio São Francisco Transposição (Transbasin Diversion Project), as presently proposed, will have two major eixos or diversions. The first diversion will divert from the river just below the existing Sobradinho Dam at a point known as Cabrobo and will divert an average flow of 99 cumecs from the river through the use of a series of 3 major pumping stations, 15 regulatory reservoirs, 229 km of canals, 23 km of tunnels, and 3 km of aqueducts. The system is designed to deliver the water to the states of Ceará, including the capital city of Fortaleza, Pernambuco, Paraíba and Rio Grande do Norte. . The second major diversion will be from the existing Itaparica Dam and Reservoir located further downstream on the river, will divert 28 cumecs into a system of canals pipelines and reservoirs that will provide water to the States of Paraíba and Pernambuco and eventually to Recife, the capital city of Pernambuco. This system will include 6 pumping stations, 297 km of canals, 84 km of pipelines, 9.2 km of tunnels and 2.5 km of aqueducts.

The project will also include the construction of at least two intra-system hydroelectric plants with a total capacity of 52 MW. It is anticipated that additional studies will be made regarding other opportunities for generation to offset pumping costs within the project.

The total average diversion of the two eixos will be approximately 127 cumecs. The average flow of the Rio São Francisco into the Atlantic Ocean downstream is approximately 90 billion cubic meters per year. It is anticipated that the proposed project would divert approximately 1.5 billion cubic meters per year, or approximately 1.6% of the average flow of the river. The contemplated operational plan for the project would operate the system during wet years and during wet seasons of the year, thereby minimizing the impact of the diversion on the river downstream. It is also contemplated that the project would operate in a manner that optimizes the use of off-peak energy in order to obtain the lowest energy rates possible. The development of an operational model to be used for this complex project will be a major task.

The recipient states have the responsibility of the construction of terminal storage and the intra-state distribution and management systems. Some states, such as Ceará are well advanced in this process. However, other states will need considerable development in the water resources management area from both a physical and institutional standpoint in order to optimize the use of these new supplies when the project is finally in place.

It has been estimated that the project will take at least 5 years to construct. However, given the complexity of the project and the normal difficulties encountered in obtaining a reliable flow of funds from Federal sources, a more realistic estimate would probably be 10 years. This also assumes that future

political leadership will have the same level of support for the project that is apparently, existing within the present administration.

OPERATION AND MAINTENANCE

Also key to the project will be the institutional and physical framework developed for the continued operation and maintenance of the system when completed. The MIN is presently considering the use of a concession contract or direct operation and maintenance contract with the private sector to operate and maintain the project. The detailed plans for this have not yet been made available. The overall success of the project will greatly depend on the level of expertise and experience obtained for the long term O&M of the system. The determination and negotiation of tariffs for this water to be paid by the recipient states or their bulk water agencies has yet to be accomplished. It is anticipated that this effort should begin in earnest when construction begins on the project.

While the development of the long-term operation and maintenance framework for both the recipient states and the project itself are key, one other facet of maintenance is also extremely important. With projects of this complexity and length of construction time, it is doubtful that it will let as a single contract or that it will not face work stoppages for funding or other reasons. Consequently, it will be imperative that an institutional framework be established and adequately funded so that the various pieces of the project be adequately maintained and secured from vandalism and destruction by the elements as each phase of the facility is completed. This can be the responsibility of the general contractor until over-all project completion or can be contracted to an operation and maintenance contractor separately. In either case, a small but highly experienced team of maintenance specialists should be formed within the project implementation team that assure that this area receives proper emphasis and is not dropped through the cracks. The MIN is presently evaluating this aspect of the interim maintenance of the system as it is constructed.

ENVIRONMENTAL ISSUES

Brazil has strong environmental laws that are supervised by the Federal Environmental Agency, IBAMA. As a consequence, the project has been the subject of a rigorous environmental analysis and the preparation of an environmental impact statement or RIMA. This has been submitted for the project and is presently under review by IBAMA.

The impact of the diversion on the riparian system of the Rio Sao Francisco will be minimal as the major hydroelectric dams located downstream totally regulate the flow of the river. They, likewise, disrupt migratory fisheries and entrap natural sediment transported by the river. As a consequence of the minimal percentage of diversion of the total flow, it is not anticipated that the

impact of the project on the riparian system of the Rio Sao Francisco will be measurable. However, the impact of the project along the axis of the system will be more significant. With the length of canals and number of regulatory reservoirs, considerable environmental work was needed to evaluate the impact. It is highly probable that IBAMA will require the acquisition of native desert lands for preservation as compensation for the loss of such habitat and ecosystems to the project. It does not appear that any areas of cultural significance will be impacted, nor will any endangered fauna be impacted within the project area.

SUMMARY

The transbasin diversion of water from the Rio Sao Francisco or Transposicao do Rio Sao Francisco as it is called in Portuguese has been high on the agenda of the Northeast Region of Brazil for over one and a half centuries. The need for this project has greatly increased due to the economic development of the region and its trend toward the exportation of high value fruit crops. The political system, at present, appears to support the project and strong efforts are being made to inaugurate the construction of the project in the coming year. While the project still faces tough opposition, it appears ready for construction from a technical and needs standpoint. It remains to be seen whether the project, once started, can engender sufficient long-term support within the Brazilian political system in order to be completed in an efficient and timely manner. As has been the case in almost all transbasin diversions constructed in the United States, the intervention of other political priorities, changes in administrations and other unforeseen events seem to always delay and frustrate the most efficient completion of projects of such magnitude. The major projects such as the Central Arizona Project and the Colorado-Big Thompson Project are strong cases in this regard. Provided that it is even started, the Rio Sao Francisco Transbasin Diversion Project will take perseverance, patience and a lot of time to complete. By the time that it is finally on line, any overestimates in the demand curves for the project should have been well compensated for. This endeavor will require a great deal of diplomacy, political skill and technical skill to be completed and placed in efficient and sustainable operation for the benefit of the citizens of the Northeast of Brazil.