

# A Study on Investigations Carried Out in Dams from the Perspective of Risk Analysis



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**Abstract** With the population growth, the Petrobras modernization REPLAN (Paulinia Refinery), the progressive region development and the shortage of resources from new wellsprings, there was a need to increase the water availability of the region of Campinas—SP and with that will be implanted two dams, one in the municipality of Quarry—SP and another in the district of Two Bridges in the municipality of Amparo—SP. The construction of the dams occurred for many reasons, one of which is to benefit many cities through water reserves serves to about 5.5 million inhabitants are that downstream of the reservoirs. These concepts, the present work AIMS to present all the criteria and principles that are related to the construction of the dams. Through research and consultations will be all the characteristics presented, direct and indirect information,

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# 1 Introduction

The construction of dams has always been paramount to the growth and development of mankind, from the oldest to which it is registered, such as Egypt, the Middle East, and India. Currently, concern about water resources involving quantity and quality has been accentuated due to drastic population growth and high pollution index, so the water has become a precious commodity and the construction of dams is a way to save her in order to have adequate human consumption without scarcity and quality [1–4].

The implementation of dams directly affects areas of major proportions, and thus end up being great potential works negative impact on the environment (flora, relief, and fauna), to the cultural environment (historical, artistic, archeological, architectural, heritage and people celebrations), artificial (towns, urban areas, villages) and labor (and material and immaterial that are necessary for the performance of labor exercises for humans) [5, 6].

These types of reservoirs are artificially made obstacles able to retain water for the purpose of industrial or domestic supply, navigation, irrigation, recreation, sedimentation control, and flood and are also intended for the production of electricity. For water supply dams it is a necessary follow-up, monitoring, and also its maintenance, it is one way to avoid any kind of accident that can occur and thereby ensure the proper functioning of these reservoirs. Such containers are made with different constructive techniques and varied sizes and this is set as required for the use, in the case of farms are generally used small clumps of earth and often large structures used for hydroelectric power supply and water supply, and between various other purposes are constructed from landfills or concrete [7, 8].

The amount of water that is stored in the reservoir will depend on the needs to be met. It should be set immediately after getting the planialtimetric survey of where they will be flooded by the dam. The main dam construction means are concrete arch, riprap, concrete, fill and gravity. These structures have further included the houses of power, spillways, discharge structures, and control units.

Brazil is the largest country in Latin America (in territorial extension), having approximately 209.3 million inhabitants, who live in 26 Brazilian states and the Federal District. Its states are divided into five regions (North, Northeast, Midwest, Southeast, and South), is the most populous southeast region, with approximately 80 million inhabitants, distributed among the states of Rio de Janeiro, Espirito Santo, Minas Gerais, and São Paulo. The state of Sao Paulo has about 12 million individuals. This high population concentration is due to large industrial and technological investments in these areas, thus generating greater financial circulation and consequently more chances of employment [9–12].

Located in the state of Sao Paulo, the Campinas region is made up of 22 cities (Americana, Artur Nogueira, Campinas, Cosmópolis, Engenheiro Coelho, Holambra, Hortolândia, Indaiatuba, Itatiba, Jaguariuna, Monte Mor, Morungada, Nova Odessa, Paulínia, Pedreira, Santa Barbara d ‘Oeste, Santo Antonio de Posse, Sumaré, Valinhos, and Vinhedo), 3,224,443 inhabitants, and total GDP (Gross

Domestic Product) of R \$ 142,301 million. This scenario has attracted more and more people to live and work in this region. However, with warming and public misconduct, many Brazilian cities have been suffering from water shortages at certain times of the year, especially when temperatures can reach 37 degrees Celsius. Based on this, there is a need to create dams to supply the entire population. Thus, in 2014 the process was started for the construction of the dams of the cities of Pedreira, Duas Pontes and Amparo, which when completed will be dependent on the Jaguari and Camanducaia rivers, which are located in the cities of Pedreira and Amparo, respectively [9–12].

With the construction of dams stands out as a major benefit, increased water availability for the population of the municipalities to be covered, which will require well in water security, since studies show that if you do not adopt such measures in 2025 about 7 cities entered for water resource vulnerability list [8].

Environmental and socio-cultural impacts of water projects of this size require a great preventive assessment, influencing the idea of design, formulation, and alternatives to the system, as well as in the design and detailed design. This assessment is extremely important both for environmental and social viability as economic, highlighting the impact studies, expropriation, flooding so that future problems directly related spending can be avoided. This assessment helps minimize problems, but not extinguished, it is inevitable that some of the forests are devastated for project implementation causing the loss of biodiversity, degradation of upstream areas caused by the flooding of the reservoir area, among other problems [13, 14].

Investigations based on geological studies are primary tools for dam analysis, mainly as a form of prophylaxis for future human, environmental, financial and health problems. However, due to the high costs resulting from this study often generates the negligence of large companies in the supervision of their dams. Based on this, the present study aims to perform an analysis of works related to the construction of these dams in order to detect possible failures during the process as well as to expose the possible damages and risks that populations face when there is negligence on the part of companies.

## 2 Methodology

This study was conducted by gathering bibliographic data in the literature on dams in Brazil, focusing on the water dam under construction in the Campinas region and the two largest Brazilian environmental disasters involving ore tailings dams. The results found are confronted with environmental, social and health issues.

### 3 Results and Discuss

The dam at the Two Bridges dominates site and reservoir are characterized by elongated mirrors, medium to high slopes (>15%) and local amplitudes below 100 m. The hills have rounded tops and straight slopes, south relief mountains, known as Serra dos Feixos. The well where the future dam will be installed cuts the Camanducaia River, characterized by stretches of rocks inserted in sandy soil, providing rapids in the east-west direction. Drilling tests were performed at the locations on the edge of the right SMDP probe 01, at a level of 1.60 m of residual soil followed by a change in the soil rock composite by micaceous clayey sludge that overcame resistance 40 strokes in the test SPT after 15.00 m deep [15, 16].

In the left margin, it was necessary to carry out three points polls for more precise information because there is greater instability in the soil. The 02-SMDP probe, located near the river, pierced a layer of 4.00 m landfill, followed by a 1.00-m alluvial layer comprising silt, sandy loam, with rock elements grayish-yellow in pigment. Further down, at approximately 22.00 m deep, there is a change in rock with silty-sandy texture micaceous. Continuing were performed on the left edge 03 and the SMDP-SMDP-04 polls, which is characterized in general by having layer of 1.00 m thick composed of colluvium bit sandy silt clay having small gravel; layer 5.60–6.00 m mature little residual soil sandy silt clay consistency and depth resistant 03–10 strokes; a ground-level shift of rock with silty-sandy texture micaceous found some rock fragments. The SMDP-03 and-04 SMDP found groundwater surveys the depth of 7.50 m and 20.00 m, respectively [15, 16].

In the report of the study pointed out that the quarry reservoir is inserted in a mountainous relief Elongated hills, and its average slope characteristics and high (>15%) and areas with ranges greater than 300 m. And it has shaped angular tops with ravines and slopes with rectilinear shapes. The axis is intercepted by sharp bends river Jaguari with portions of the bedrock originating tubing [15, 16].

During the surveys were carried out on the banks, both right and left, on the right edge was performed SMPE-01 and found layers of rock changes, micaceous clay and sandy silt clay micaceous. And by the results, it has resistance at SPT 40 strokes starting at 12.00 m deep. In the left margin, analyzes were performed 4, 02-SMPE polls the SMPE-05. The SMPE-02 probe was implemented on top of the rocky bed of the water body and provided with mylonite gneiss depth of 15.90 m. Since the SMPE-03 polls the SMPE-05, identified rock material layers (thickness varying from 1.00 to 4.50 m), silty clay-bit sandy soil, silt, clay and sandy micaceous the mylonite gneiss. The resistance values presented a gradual penetration to the depth reaching 40 blows to 15 m. In the investigation pointed rock masses that show medians and consistent changes at the top, passing the bedrock little changed in the final meters [15, 16].

## 4 Physical Impacts Analysis of Two Bridges and Reservoirs Quarry

With the introduction of Quarry and Two Bridges dam, according to Article 2 of CONAMA Resolution 349 (1986) to Directly Area Affected (DAA) is the place where will be implemented the project with its settled structures, access roads that may be increased produced or changed, with its unit procedures related to his work infrastructure. Therefore the Direct Area of Influence (DAI) is the region which will be reached directly from the impacts on the development coinciding with the (DAA) may have positive or negative interference. The quarry dam, in turn, affects the EPA (Environmental Protection Area) of Piracicaba/Juqueri-Mirim, the city of Campinas also has an affected area and the same is located on the left edge of the reservoir deployment. The APA of Piracicaba/Juqueri-Mirim, in turn, covers part of the left edge of the tank and all directly affected and influenced area [17, 18].

With the implementation of the quarry dam, Annex K will be flooded about 105 ha APA corresponding part of Campinas being flooded. Thus all the DAI, which corresponds to the left corner of the reservoir presented zoning in the management scheme, the Hydro Conservation area Jaguari, which its procedures is to ensure the preservation of sources and water, the Just as the recovery and protection of riparian vegetation, and permanent banning of pesticides and chemical fertilizers [17].

This application boundaries EPA and DAI, follows the same design of the study units for sub-basins and may require adjustments, it helps the planned environmental programs Pedreira dam act in proportion to the guidelines and the EPA region of objectives belonging to the Basin Jaguari. The introduction of the quarry will have a dam reservoir with an area of approximately 2.02 km<sup>2</sup> to about 82 ha overflow of the storage units. In this case, the conservation area of Campinas will have about 33 ha and the Piracicaba/Juqueri-Mirim have lost 97 ha. It tends to be noted that this total is added to a flood area of approximately 72 ha area corresponding to the overlapping of the two affected areas [18].

The EPA in Campinas will be affected by more than 105 ha which represent the sum of the areas of 33 ha reservoir and the area lost with limits applied to 72 ha. When added to the array of the tank, that area will have a total of 232 ha affected. In turn, EPA Piracicaba/Juqueri Mirim 169 ha has affected areas occupied by the quarry and reservoir 97 ha area is lost with overlapping boundaries 72 ha. When added to the array of quarry dam the entire length will have a total of 370 ha affected. In Table 1 is showed the affected storage units [17, 18].

The Two Bridges and quarry reservoir will occupy areas that are material goods, residential and agricultural activities that are called a small scale, mainly for self-consumption. In the case of the dam of Two Bridges, besides the presence of a small proportion of activity, there is also the presence of large areas where there is major business uses. In this case, there is the Farm Jaborandi industrial group Ypê which carries out large-scale poultry farming jobs. There is also the Agriculture Tuiuti (Shefa), which is a dairy, which will not be fully impaired. Since the establishment

**Table 1** Protected areas affected by quarry dam

Conservation Unit	Total area	Flooded area	DAA occupation	Total	Total with overlapping
Campinas	22.278	33	53	86	232
Overlapping area between conservation units	2966	72	74	146	–
Piracicaba/Juqueri-Mirim	287.000	97	127	224	370

Resorts, 4 Angels who works as a research laboratory and studies of animal vaccines and is a Research Center for Animals of Brazil will be completely flooded [18].

Regarding the commercial activities can point to the known “Ecological Reserve Mundão of Trails,” which develops tourism activities, relying primarily on the area and structure to track and camping near the river Camanducaia, the District of Arcadas, Amparo. Although titled “Ecological Reserve” is not protected conservation unit or established by law, unless that focus on permanent preservation areas and reserves. On the left edge of the river is located Jaguari the “Aunt Bar,” downstream from the dam quarry, which is likely to suffer interference by dam construction [17, 18].

There are also two small main dams that will be flooded. The river Jaguari is located the PCH White Monkey, with 2.36 MW of installed capacity owned by Electricity company and should be affected by the formation of the quarry dam and river Camanducaia, SHP Feixos, with 1.15 MW installed capacity of the Company Energy Wolf Jump Ltda, which will be hindered by the Two Bridges bus. In population surveys in areas to be occupied by the dam quarry and two bridges a total of 82 families were identified, of these 27 families are located in the area to be flooded quarry and 55 families in the dam Amparo [17, 18]. Table 2 shows the families living in the area that will be compromised by construction.

The compensation for expropriation can be performed in two ways: through payment in cash or government bonds (in urban environments or in the case of land reform). The impacts in rural areas with productive activity, considering the loss of areas dedicated to agriculture and forestry, will be enormous because these areas are in the direction of the dam spillway. The quarry dams and bridges two reservoirs should form with total area respectively of 202 and 486 ha<sup>2</sup>, the areas to be flooded effectively correspond to 181 ha and 463 ha and other areas are occupied by the river.

**Table 2** Families living in the area directly affected (DAA)

Families	Two bridges	Quarry	Total
Families interviewed	44	25	69
Family no information (*)	11	2	13
Total families	55	27	82

\* indicates without information about these families

In recent years the region near these rivers is increasing its population rate significantly, so has increased pressure on water demand, finally, states have adopted measures to be no lack of water at the time and in the future for the population and aimed at development of the region, thereby improving the quality of life of the population. The quarry reservoir is located near Highway John Beira, known as SP-095 and the town road Basil Vieira de Godoi, already the Two Bridges is close to the highway John Beira, also known as SP-095 and the highway Aziz Lian, also known as SP-107 [17].

The quarry dam is 3 km from the urban center of the city of Pereira and will be installed in the river Jaguar, located in the municipalities of Pedreira and Campinas, such reservoir will have an area of 2.02 km<sup>2</sup> and can store about 32 billion liters of water. Already the dam of Two Bridges is 8 km from the city of Amparo, and will be introduced in the river Camanducaia and will run until Ribeirão Pantaleon such a reservoir will have an area of 4.86 km<sup>2</sup> and can store about 53 billion liters of water [18].

Both dams are in regions with rapid economic development and population, and that was by agribusiness enterprises and large national and multinational companies in the region, so it has been the need to increase the water demand in the region.

## **5 Environmental Disasters in Brazil: The Mariana and Brumadinho Dams**

Actually in Brazil, when the word “dam” is said, it is associated with the word catastrophes, deaths, environmental crime, ecological disaster. This is because, on November 5, 2015, there was a breakdown of an ore tailings dam in the city of Mariana, Minas Gerais (Southeast Brazil). The Mariana tailings dam is owned by Samarco, which is managed by Vale S. A. and BHP Billiton. The disruption resulted in 43.7 million cubic meters of tailings dumped and a total of 19 deaths. The mud-covered a total of 663 km until it reached the sea in the state of Espírito Santo. In addition, the mud has reached the Doce River, which covers 230 municipalities that have their bed as a subsistence tool. According to environmentalists, the effects of tailings at sea will be felt for at least 100 years. One month after this catastrophe occurred, 11 tons of dead fish were removed in both Minas Gerais and Espírito Santo. Lives were taken, districts were destroyed and thousands of residents were left without water, homeless and without work. The rupture of the tailings dam (Fundão) in Mariana is considered the biggest environmental disaster in the country's history. Until the moment the region remains uninhabited and covered with mud. Many residents still receive government assistance. The feasibility of building a new district for the relocation of these families is studied [19–22].

However, isolation from communities and loss of access to health services can aggravate existing chronic diseases in the affected population (hypertension, diabetes,

kidney failure, tuberculosis, etc.), as well as triggering new deleterious health situations such as mental illness (depression). and anxiety), hypertensive crises, respiratory diseases, domestic accidents and outbreaks of infectious diseases. The increased incidence of pre-existing diseases in the region, such as yellow fever, diarrhea, and schistosomiasis may be a consequence of the medium-term disaster. In addition, contact with mud and water may lead to cases of leptospirosis [23].

On January 29, another tragedy struck the city of Brumadinho, Minas Gerais. This dam belongs to the Brazilian multinational mining company Vale S.A. As much as this breach has dumped a smaller amount of waste compared to Mariana, its social and environmental impacts have been as great. According to the National Mining Agency, the dam had no documentary backlogs, and was considered inactive, meaning it was not receiving any new tailings. The volume of excrement manure was about 12 million m<sup>3</sup> (1 m<sup>3</sup> equals 1000 L) and the speed of the mud reached 80 km per hour. At the time of the tragedy, security sirens should have been sounded to alert Vale workers and local residents. This, however, did not happen [19–22].

The mud, which contained iron, silica, and water, reached the Paraopeba River, which in turn negatively affected water quality, as this water present in the river presented risks. By the end of August 2019 (about 7 months later), 241 deaths and 21 people still missing are counted [19–22].

It is necessary to examine the presence of heavy metals in the tailings and their monitoring along these rivers to avoid the consumption and use of contaminated waters in the coming years. Heavy metal-enriched sediment can be remobilized to rivers with heavy rainfall, dredging and hydroelectric dam operation over the next few years [23].

It is important to point out that both environmental disasters were due to human failures, one of them based on a communication failure between the responsible companies, employees and city dwellers. Therefore, it is necessary to implement more modern communication systems that present low abstraction level, speed and low computational memory consumption [23–26], regardless of the operating system used by the company [27]. Moreover, it is important to invest in low cost, high accuracy medical methodologies that do not depend on specific equipment, so that the exams can be performed through a simple computer [28, 29].

## 6 Conclusions

By analyzing all the necessary procedures for the implementation of these dams, it was found that the project will benefit several cities in the region with the supply of water, which is recurrent shortages in drought times, and also will bring, all matters involving environmental impacts in the area, and the physical impacts that are associated with the expropriation of the owners of homes and loss of heritage sites to be flooded.

With work and the technical site, visit can understand the size and grandeur of the buses that aims to help society as a whole, and also comprehend and understand



the frustration of residents who are expropriating their homes because their lands were some generations of family heritage and for the construction of dams, but cannot observe reality broadly and understand that this project will benefit millions of people.

Since it is extremely important to build these dams even if it works with considerable environmental impacts in the affected area and physical impact on people's lifestyle directly injured with expropriations, but that in the future will benefit because there are no setbacks with the lack of d ' water, it will be one of the viable alternatives to the water crisis that is regular and that affects most municipalities that are downstream of future works, and as this will minimize the dependence of water coming from the Cantareira System to supply the region.

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