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# Environmental Basin - History of Billings Reservoir's Construction

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**ABSTRACT:** This article, as part of a doctoral research, discusses, based on a historical survey, the main aspects that contributed to the formation of the so-called – Greater ABC of São Paulo region, with emphasis on the urbanization process that radiated mainly during the 19th century from the city of Sao Paulo. In that context, two developments were recognized as inducing the transformation of the space – the railroad and the dam. For this study, its understanding was paramount to understand the various aspects that contributed to the territorial configuration of this important region of São Paulo, considering that this region is known for its economic and financial grandeur. However, when carefully observing the data referring to the arrangement of the municipalities that make up the greater ABC, as well as high HDI indices, one has the idea of a region that has achieved significant development, but the data and information found emphasize that this condition does not is homogeneously distributed, bearing in mind that there are socio-spatial inequalities among the seven municipalities in the region, which are materialized in various asymmetries stamped in the urban landscape of each municipality. In summary, it appears that this critical situation is the result of a wrong and incipient planning process that, among other aspects, led to an intense process of degradation of water bodies, in addition to intensifying situations of socio-environmental vulnerabilities.

**Keywords:** Urbanization; Watershed, Billings reservoir; spring protection areas, socio-environmental vulnerabilities.

## INTRODUCTION

With a land area of 58,280.32 hectares – 582.8 km², the Billings environmental basin is inserted in the southeast portion of the RMSP, bordering the Guarapiranga watershed to the west and the Serra do Mar to the south. Its geography defines a drainage system that encompasses the entire territorial area of the municipality of Rio Grande da Serra and partially the territories of Diadema, Ribeirão Pires, Santo André, São Bernardo do Campo and São Paulo municipalities. Its hydrological network is composed of a significant portion of springs located in the southern and eastern portions of the basin, close to the Serra do Mar escarpments, at maximum altitudes in around 900 meters. The opposite portion of the basin, north and west, is formed by a drainage network consisting of small watercourses, with a smooth longitudinal profile – characterized by a topographic difference of 50 m in the stretch from the source to the mouth (ROCHA, 2015).

An issue of extreme importance is related to the territorial configuration of the Billings reservoir basin. The concept attributed to the hydrographic basin is the one that delimits a territorial portion irrigated by a watercourse or a certain river network, generally recognized as referring to a primordial geomorphological unit, from which the dynamics of the surface flow of a water network is assimilated. drainage (CHRISTOFOLETTI, 1999). This fact justifies its adoption as a territorial unit with significant relevance in planning processes, especially those dedicated to environmental issues.

In the specific case of the Billings dam, the implantation of a hydrotechnical object is resulting from a large-scale anthropogenic action (WALDMAN, 2005; CUSTÓDIO, 2001). As such aspects are considered – its history and mainly the territory in which it operates raises its framing to the concept of environmental basin.

For Rutkovski (1999, p. 134), the environmental basin "by relativizing the physical space, making its limits more flexible, privileges the interrelationships at different levels, allowing a holistic/global and dynamic analysis of the situation when the focus is on the area urbanized – an anthropized space". In this sense, the same author highlights the importance of environmental planning when dealing with the management of water resources, so that it understands space not only as an ecological environment, but essentially as the locus where social, cultural, political and economic relations are established – "this is the space defined as an environmental basin" (1999, p. 134).

Complementarily, Leal (2003, p.74) adds that it is necessary to evaluate the specificities of each territorial delimitation "not considering only the natural limits of the hydrographic basin, but the use and occupation of the soil, the social organization and the integration of water and sewage reversal hydraulic systems". Thus, it is concluded that the delimitations of an environmental basin are not only physical, but socio-spatial, forming a space where the variables are mixed; however, they are still essential for possible resolution of issues involving the Billings dam.

## 1 THE IMPORTANCE OF BILLINGS FOR THE FORMATION OF ABC PAULISTA

The history of the formation of the so-called region – Greater ABC of São Paulo finds its roots linked to the urbanization process radiated mainly during the 19th century in the city of São Paulo. In that context, two developments were highlighted and recognized as inducing the transformation of space, as they progressively transformed their landscapes – the railroad and the dam (Figures 1 to 4).

Understanding the relevance of these undertakings it is essential to understand the various aspects that contributed to the territorial configuration of the Greater ABC[1] region of São Paulo. The arrival of railway lines in its territory created a connection network, based on the interconnection of the center of the plateau – from the capital to the port of Santos. The implementation of this communication route enshrines the role that the region would play in the formation of the metropolis and in the consolidation of the future industrial center. The images were inserted to illustrate and facilitate the initial context's understanding of São Paulo's urbanization process and its metropolitan region and the need to implement an entire infrastructure network, aiming above all at the production of electricity and water supply with the implementation of artificial reservoirs.

[1] Greater ABC – This region, today corresponding to the "Seven Cities", constituted in 1889 the Villa de São Bernardo. With the growth and population, economic and political development of the region, there were several dismemberments and the emancipation of the municipalities, the last of them in 1964. The old Villa de São Bernardo gave way to the current municipalities, Santo André, São Bernardo do Campo, São Caetano do Sul, Diadema, Mauá, Ribeirão Pires and Rio Grande da Serra. [...] these municipalities originally had a common history that remained deeply intertwined by their geographical proximity, their status as a "suburb" in relation to the metropolis of São Paulo, their polarization (population movement within the region), the emergence of a "work culture" typical of the region according to professor Luiz Roberto Alves, due to common problems such as floods, transport, issues related to the Billings Dam, among others. Available at: <http://www.chgabc.com.br/o-congresso.html>. Accessed on: Nov.20. 2014.

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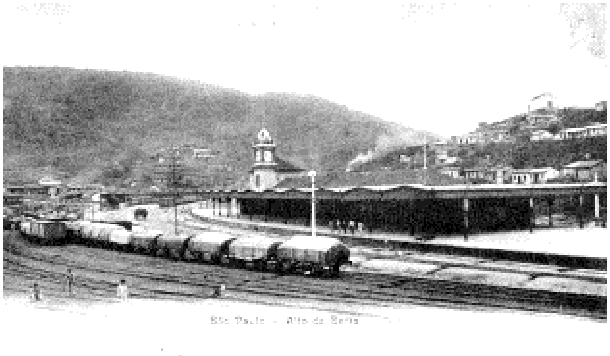
Figure 1 – Grota Funda Viaduct /1867

Source: Available at: <http://coisasdesp.blogspot.com.br/2015_03_01_archive.html>. Access in: Nov. 20. 2014.

Figure 2 – São Paulo Alto da Serra/ 1870



Source: Available at: <http://www.estacoesferroviarias.com.br/p/paranapiacaba.htm>. Access in: Nov. 20. 2014.

Figure 3 – Works on Raiz da Serra/1860

Source: Available at: <http://www.avilainglesa.com/spr.html>. Access in: Nov. 20. 2014.

Figure 4 – Railway Construction Serra de Paranapiacaba /1860

Source: Available at: <http://www.avilainglesa.com/spr.html>. Access in: Nov. 20. 2014

By carefully observing the scenarios related to the implementation of the railroad in this region – shown in the previous figures (Figures 1 and 2), it can be seen that the São Paulo Railway[2], also known as the English road, operated an irreversible transformation in the natural space, both under the social, economic, cultural and notably geo-environmental aspects, although with an inestimable environmental cost. Bearing in mind that the need to open a passage, define a route, necessarily implied cutting down woods and forests, and even adapting the relief – a destruction never

[2] In the middle of the 19th century, the state's large agricultural productions began to be transported on rails. Forest areas were cut down to make way for coffee plantations. Farms are being installed further and further away from the coast and transport on the back of animals is no longer sufficient for the distance and speed needed to transport cargo, demanding the implementation of this new transport system. Available at: <coisasdesp.blogspot.com.br/2015_03_01_archive.html>. Accessed on: Jan. 2016.

witnessed in the history of the great ABC (WALDMAN, 2005). In addition to altering the natural landscape, its effects were imprinted on the cultural landscape of the region, overshadowing the population contingent rooted in local history with the increasing introduction of immigrants. Thus, the implementation of the railroad constituted a determining factor for the ordering of the regional territory, either by replacing habits and customs, or by transforming the physical aspects of the local and regional landscape. Essentially, the introduction of mechanization as a transport and communication wherewithal to replace the modus operandi carried out by troops of donkeys – common figures in the landscapes of the time, caused a significant contrast when compared to the system implemented in the cities of Europe and the United States:

> The contrast between the old system and the new was much sharper than that seen in Europe and the United States, where railroads succeeded stagecoaches, which circulated on reasonable or even good roads. However, even the stagecoaches were unable to stand up to the iron train; what to say then about our donkey troops and our precarious paths! (LANGENBUCH, 1968, p. 142).

Obviously, railroads and troops of donkeys show different modes of socio-spatial interrelations, as the appropriation of the territory also differs, notably when compared to the aspects of adaptation to relief and topography. When addressing this issue, it is noted that, contrary to the route defined by the troops on donkeys, the railways, since the beginning of their implementation, have demonstrated their option for the floodplain areas due to the favorable conditions offered by these spaces in the definition of a route rectilinear, “as well as for railway compositions to reach the desired speed and, also, for the lower costs required for their construction and expropriation of land” (WALDMAN, 2005, p. 513). In general terms, the implemented rail system followed a logic that not only neglected the layout of the old communication routes, but also neglected the villages on the outskirts of São Paulo, directly and indirectly affecting the entirety of the pre-existing territorial structure (DEFFONTAINES, 2004; WALDMAN, 2005).

In this sense, it is concluded that, in addition to the numerous benefits attributed to the implementation of the railroad, the idea that allows relating it to the “maximum that it imposes, together with the tracks, the triumph of a new reading of time, capitalist and modern, supplanting the old traditional order” (WALDMAN, 2005, p. 515), giving his trajectory a mark left in the geography of the region.

If in times past this region was identified by green landscapes, covered by woods and forests, the scenarios presented in the early 1950s are little similar, with the growing urbanization driven by the railroad, new nuclei were formed following its route in a space where previously was occupied by the Atlantic Forest.

In this context, the region is progressively being occupied and its physiognomy is modified by the most diverse uses and activities of all kinds – a harbinger of a “land valuation process that would justify the argument by which urban land ownership is valued in the very process of production of land". city" (SEABRA, 1987, p. 19; WALDMAN, 2005). Although the reading of this whole process is quite complex, it is still a way to try to understand the geophysical contours that delimited the territory constituted by the great ABC, or the arrangement integrated by seven cities - ABCDMR[3] , located in the southeastern sub-region of the RMSP – territory where the Billings basin is located.

This region is known for its economic and financial importance, as it constitutes an industrial center of significant importance, both for the economy of the State of São Paulo and also for the country, where for a long time it maintained high levels of development and wealth. However, when carefully observing the data referring to the arrangement of the municipalities that make up the greater ABC, in which the presence of positive indicators resulting from the enormous industrial production, as well as high HDI indexes, is pointed out, one has the idea of a region that achieved significant development. Which is still a reality. However, it should be noted that this condition is not homogeneously distributed, considering that there are socio-spatial inequalities among the seven municipalities in the region, which are materialized in different asymmetries stamped in the urban landscape of each municipality.

Data presented in the IBGE Demographic Census (2010) indicate that approximately 2,551,328 inhabitants reside in the greater ABC, which corresponds to a percentage of 12.96% of the total RMSP and approximately 6.18% of the total population of São Paulo. The same survey pointed São Bernardo do Campo, Santo André and Mauá as the most populous municipalities in this territory, in turn, the highest demographic density indices are indicated in the municipalities of Diadema and São Caetano do Sul. Contrasting with this whole scenario, there are the municipalities of Ribeirão Pires and Rio Grande da Serra, since they are fully inserted in areas of protection for springs, they are the least populated.

In general terms, it is perceived that the region presents the old and worn out problems that afflict most cities in Brazil, especially those with greater severity that involve socio-environmental vulnerabilities in areas of environmental fragility, in this case, the water sources.

For Waldman (2005), the excessive urbanization process caused strong impacts on the Billings system and its surroundings, compromising the hydrodynamic cycles of its basin. For the author, from a geographic point of view, it would be very difficult to define a protection policy without considering all the dynamics that involve the entire ecosystem and the possible impacts resulting from anthropogenic actions, in particular those of a socio-environmental nature. From this point of view, it is essential to consider

[3] ABCDMR – Grande ABC is an acronym used from the 1950s onwards to identify a set of seven municipalities located southeast of the capital of São Paulo, constituting the Southeast Sub-Region of the Greater São Paulo Metropolitan Region (RMSP). It was created by Complementary Law nº 14, of June 8, 1973. Thus, in the acronym it is designated as (A) Santo André, (B) São Bernardo do Campo, (C) São Caetano do Sul, (D) Diadema, (M) Mauá, (R) Ribeirão Pires and Rio Grande da Serra, in a brief analysis, are considered municipalities endowed with intense social, economic and political dynamism.

that the spaces in which the springs are located constitute territories marked by an enormity of urban demands, with a marked overlap of social, environmental and political factors. In this sense, discrepancies prevail regarding the use and occupation of the land, in addition to those resulting from the different infrastructure networks for which the reservoir assumes a strategic role. From this conjunction of factors, different views emerge, which could be classified into four strands:

- They defend the need for rigorous application of legislation to protect springs;
- Defend the need for a conciliatory solution between the environmental and urban issues;
- Defend the repeal or revision of legislation in the interests of real estate agents.
- They defend the right of occupancy of watershed areas for lower-income population groups.

Given the breadth and complexity involved in this problem, a possible path that can ensure greater effectiveness in the preservation, recovery and maintenance of the protection areas for water sources, for which permanent preservation areas (APPs) become essential, or even , the vegetated strips, would seek to understand the essence of the city's production process and relate it to the living space of a significant portion of the country's population, bearing in mind that the urban and environmental issues are inseparable. From this approach, the core of the issue lies in recognizing the particularities of urban dynamics, in particular, of the social fabric that accommodates itself over physical space with broad specificities - which do not adapt to complex legal norms, but to the laws of nature.

## 2 THE BILLINGS IMPLEMENTATION PROCESS

The beginning of the urbanization process in the city of São Paulo at the end of the 19th century was boosted by the implementation of the railway network and, above all, the increase in coffee production, which contributed decisively to its industrialization. This period was marked by the significant increase in demographic rates, which were materialized in the expansion of the urban occupation area consolidated by the contribution of investments made in the infrastructure network, covering the public supply of drinking water and the electric power system.

The operationalization of this entire infrastructure network was verified in 1877, with the implementation of the canalization to supply the first water reservoir in the urban area, the Consolação Reservoir, executed by Companhia Cantareira de Águas e Esgotos, later in 1901 the first Light's[4] hydroelectric plant in the country – the Parnaíba Plant (SÃO PAULO, SMA/CEA, 2010).

In São Paulo and the metropolitan region, these initiatives made it possible to identify the origins of the deterioration of water bodies process by accentuating the

[4] Light – Serviços de Eletricidade S/A.

inadequacy and irregularity in the use and occupation of urban land in various practices, among them: the undue release of untreated waste into bodies of water, interventions in floodplain areas for the implementation of the road system, alteration of the hydrological dynamics of the rivers for the production of electric energy, as well as adoption of measures aimed at permitting land occupation for uses that are not compatible with preservation criteria of environmentally fragile spaces.

With this growth rate, the urbanization process intensified and the city enters the 20th century with a population four times greater, imposing the urgency of expanding the entire infrastructure network.

It is in this context that several public actions for readjustment occur, through the implementation of new reservoirs. For this purpose, the installations of the Cantareira System undergo expansions, as well as the taking of an important measure, expressed in recognition of the need to protect the remnants of the Atlantic Forest for water production, thus enabling the establishment of the Reserve of the Serra da Cantareira (SÃO PAULO, SMA/CEA, 2010).

In order to handle all the demand resulting from the urban development process that was operating at the time, Light, in the year 1906, began the implementation of the Guarapiranga Reservoir, with the aim of improvin the flow of the Tietê river and supplying energy to the turbines of the Parnaíba Power Plant, for later its waters to be destined to the attendance of the needs of public supply, becoming, around 1928, the most important source of supply of potable water.

However, due to the growing increase in demographic rates driven by the strengthening of the industrial sector, in can be seen in São Paulo in the mid-1920s, a period of drought that caused a 30% decrease in the supply of electricity, requiring further expansion of the system, which are implemented with the creation of new production structures in the neighboring cities of Pirapora and Cabreúva – Usina Paula Souza and Usina Hidroelétrica de Rasgão.

In this context, in 1922, the American engineer Asa White Kenney Billings arrived in São Paulo, with the mission of preparing studies for the implementation of the Serra Project[5], whose purpose was to produce electricity for the city of Cubatão. For its development, it was taken into account that the territory of the region where the city of São Paulo was inserted was an area of headwaters of rivers, where they are born and follow in a natural course towards the interior of the State; on the other hand, the Serra do Mar was an insurmountable natural obstacle towards the coast. In the face of such constraints, the Serra Project predicted that, in order to reach the volume of water

[5] Serra Project – In order to achieve the purposes defined within the scope of the project, it received the contribution of another engineer – F. S. Hyde, together they presented a technical solution for the dam to be built near the center of São Paulo and to be able to pour its waters towards the sea , the need to use the resources and potential of the region's geography, which was achieved, among other aspects, by taking advantage of a 720 m difference in level existing in the Serra do Mar.

necessary for the generation of electricity using the uneven, it would have to artificially reverse the flow of rivers and dam their waters, hence the importance of using resources and potentialities of the geography of the region, which was accomplished among other aspects, with the use of a 720 m difference in level existing in the Serra do Mar. Based on these strategies, in 1926 the first electricity generating unit, the Cubatão Power Plant, now known as the Henry Borden Power Plant, went into operation, which, through the damming of the waters of the Rio Grande and Rio das Pedras and their subsequent driving through tunnels, these were taken to the pipelines reaching sea level.

Still under this perspective, in 1925, in order to expand the energy production capacity of the Henry Borden Plant[6], aiming to meet the growing demands generated by the industrial center located in the vicinity of the Port of Santos, the construction of the Billings reservoir was approved by Federal Decree No. 16,884, which was completed in 1927 with the construction of the Pedreira Dam, executed for damming the waters of the Rio Grande or Jurubatuba – one of the contributors of the Pinheiros River, enabling the waters of the Billings Reservoir to be transposed through the Billings-Pedras regulatory dam to the power supply system of the plant. (SÃO PAULO, SMA/CEA, 2010).

In summary, for the implementation of the Billings Dam, an artificial lake was created by damming up the waters of the Alto Tietê basin and the unevenness of the Serra do Mar in order to generate electricity.

The implementation of the Billings Dam[7], the second major impact venture in the region identified as the major ABC since the 1950s, is characterized as a hydrotechnical object, the Billings system covers six of the seven municipalities that make up the ABC region, in addition to having the largest fresh water reserve in the metropolitan region of São Paulo. Conceived at the beginning of the last century with the primary purpose of responding to the needs of water and energy supply for the embryonic metropolis of

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[6] The Henry Borden Power Plant is made up of two complexes: External Power Plant – older, has eight external conduits with a total of eight groups of generators, with an installed capacity of 469 MW and the Underground Power Plant – consisting of six generators installed in the interior of Serra do Mar , in a cavern 120 m long, 21 m wide and 39 m high, with an installed capacity of 420 MW. Source: <http://www.emae.com.br/conteudo.asp?id=Usina-Hidroeletrica-Henry-Borden>. Accessed on: 20 Apr. 2016. The Billings dam was built to generate electricity within a project that provided for the channeling of the Pinheiros and Tietê rivers, and the reversal of their waters to the Baixada Santista, through the construction of the Billings reservoir. For decades, Billings received polluted water from the Pinheiros and Tietê rivers. Until 1989, this reversal was constant and made it possible to generate electricity at the Henry Borden Plant, located near the city of Cubatão. Pumping was restricted to some situations by the State Constitution of 1989 (article 46 of the Temporary Constitutional Provisions Act), with the aim of reducing pollution and guaranteeing the use of Billings for public supply. (WHATELY, 2009, p. 73).

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São Paulo, it resulted in the construction of a large reservoir with 127.5 km² of water mirror, for which it collected waters from a basin with 528.8 km², totaling an estimated storage capacity of 1.23 billion m³ of drinking water (WALDMAN, 2005).

After its construction, for more than a decade, the crystalline waters allowed the dam to also be used for recreational purposes, where its banks were considered the "beach of São Paulo people", in view of the existence of farms and sites located in its surroundings. However, the city of São Paulo in 1940 already had as an important component of its economy the establishment of an industrial base linked to the automobile sector, which was decisive in increasing job offers and an inducing factor for its population growth and, consequently, of urban area.

This situation intensified the demand for basic infrastructure services, leading to the operation of reversing the waters of the Pinheiros River, whose purpose was to transport the waters of the Tietê River and its tributaries to the Billings Reservoir, contributing to the increase of electric power generation of the Henry Borden Plant, a measure that was put into practice with the implementation of the Pedreira and Traição Pumping Plants in 1942.

However, with a mismatch between the pace of growth of the cities that made up its metropolitan region and the limitations of the infrastructure network,, an increase in the picture of deterioration of the waters of the Tietê River, causing serious environmental impacts, considering that its contaminated waters were pumped into the Billings Reservoir, sensibly impairing its quality, and in a short time it was realized that the solution had become a serious problem, since the city did not stop growing, continuously releasing domestic sewers raw materials and industrial products on the Tietê River and its tributaries (CAPOBIANCO; WHATELY, 2002, p. 15).

To make matters worse, due to the increase in demographic rates in the ABC region around 1958, water from the Billings Reservoir began to meet the need for public supply in the municipalities of Santo André, São Bernardo and São Caetano do South. Throughout the 1960s, the continuous urban expansion of the capital of São Paulo and the consolidation of the industrial pole of greater expressiveness in the country, installed in the ABCD region, provoke an intense process of degradation of its over the years a serious problem for the production of electricity, damaging the initial purposes that motivated its implementation.

Faced with this situation, in 1970 the Company of Technology and Environmental Sanitation (CETESB) adopted, on an emergency measures, for the removal of the anaerobic spot, formed by cyanofic algae (cyanobacteria) spread due to the volume of sewage existing in the reservoir, which somehow contributed to the triggering of a series of new actions to contain the degradation process, with the edition of the standards of protection to the springs - Laws nº 898/1975 and 1.172/1976, which proved to be incipient (this issue will be dealt with in more detail in a later topic).

To do so, it was necessary, in the early 1980s, the removal of water from the Rio Grande arm, in order to increase the production of water for public supply, which occurred with the construction of the Anchieta Dam – the current Rio Grande dam. Great. This work was necessary, because it would allow the separation of the waters of the Rio Grande arm, which at the time had better quality compared to the waters of the other arms of the Dam.

Despite the existence of laws to protect springs since 1976, the reservoir enters the 1980s facing serious problems generated by the pollution of its waters. The severity of the problem reached in 1983 made it one of the main issues discussed at the first meeting of the State Council for the Environment (CONSEMA). Subsequently, the state government opted for the return to the natural course of part of the waters of the Tietê and Pinheiros Rivers – the upper middle Tietê, in order to allow Cetesb to implement the water quality monitoring system in the Billings reservoir through its natural purification capacity.

However, the government initiatives adopted proved to be incipient in the face of the complexity that had taken the picture of environmental degradation, so that the pressures arising from the environmentalist movement to interrupt the Tietê-Billings pumping became progressively scathing.

In this context, the promulgation of the State Constitution in 1989 was a watershed for the issue of preservation and recovery of water resources, by expressly defining in its article 46 - of the transitory provisions, the purpose of public supply, and the determination of total stoppage within a period of three years. In compliance with legal determinations, the reversal of the waters of the Tietê River and its tributaries to the Billings Reservoir was interrupted in 1992, with permission only for the control of floods at risk of flooding and risk of collapse in the electricity supply system – approved by the Resolutions of the Water Resources and Environment in accordance with the proposals presented by the Consema (SÃO PAULO, SMA/CEA, 2010).

Even considering it as a flood control technique in periods of intense rainfall, the waters of the Tietê River are pumped to the Billings Reservoir – even if it is sporadic, it compromises the entire recovery process, not to mention the high cost of treatment of its waters.

In this context, it is also worth highlighting another aspect considered in the interruption of pumping water from the Tietê River and its tributaries to the Billings Reservoir, which are the impacts on the energy production system, which had its capacity reduced by 75%, conditioning its use only to meet the lack of energy only at peak times, as well as in emergency situations that, by chance, will occur in São Paulo. With this significant reduction in the amount of water, the plant began to operate at minimum load, producing only 35 megawatts, significantly impairing its initial energy production capacity designed to generate approximately 800 megawatts in full operation and 400 megawatts on average – power capacity needed to maintain the lighting system in an urbanized area with up to two million inhabitants (CAPOBIANCO; WHATELY, 2002, p. 16).

In order to reverse this scenario, in order to allow the Henry Borden Hydroelectric Power Plant to operate at full power again, without compromising the quality of the water in the Billings Reservoir, the Empresa Metropolitana de Águas e Energia (EMAE), based on the use of flotation technologies developed a project to decontaminate the waters of the Pinheiros River. The final report presented by the State Secretariat for the Environment (SÃO PAULO, 2010, p. 13), reports that its implementation was in the testing phase under the supervision of an environmental agency, considering that the flotation process, in addition to being a part of the sewage treatment was the first time used in the country.

> The flotation project of the Pinheiros River, in preparation by the State Government, aims to ensure the water quality required for the pumping of 50 m³/s from the Pinheiros and Tietê rivers to the Billings reservoir. There are also other objectives, such as improving the water quality of the Pinheiros River and increasing the water availability of the reservoir. The flotation process is a part of sewage treatment and, in Brazil, it will be the first time that the process will be used for the depollution water intended for public supply. Tests and real-time monitoring of the environmental impact are being carried out, to support the preparation of the Study and the respective Environmental Impact Report (EIA/RIMA), to be submitted to the competent body. (SÃO PAULO, SMA/CPLA, 2010).

Without obtaining the necessary results for its depollution, the Reservoir has not achieved a satisfactory performance of its functions, due to the level of pollution of its waters, compromising its initial function – the generation of energy. In addition to serving it, it could contribute to alleviating the current water supply crisis that affects the metropolis, especially when considering the potential of its waters, if they were not polluted, they could meet the needs of approximately 4.5 million inhabitants.

However, nowadays, the spring has been used for multiple uses – its main function is public supply, even considering that the amount it produces is intended to supply only 1.2 million inhabitants with a catchment of 4.8 m³/s, but it is still used for leisure and recreation, and is used in a predatory manner as a receiver for domestic and industrial sewage.

In August 2000, the first operation was put into practice with the purpose of expanding the production capacity of water for public supply, through the use of other sectors of Billings, which should be interconnected to the Guarapiranga[8] Dam through the Taquacetuba arm.

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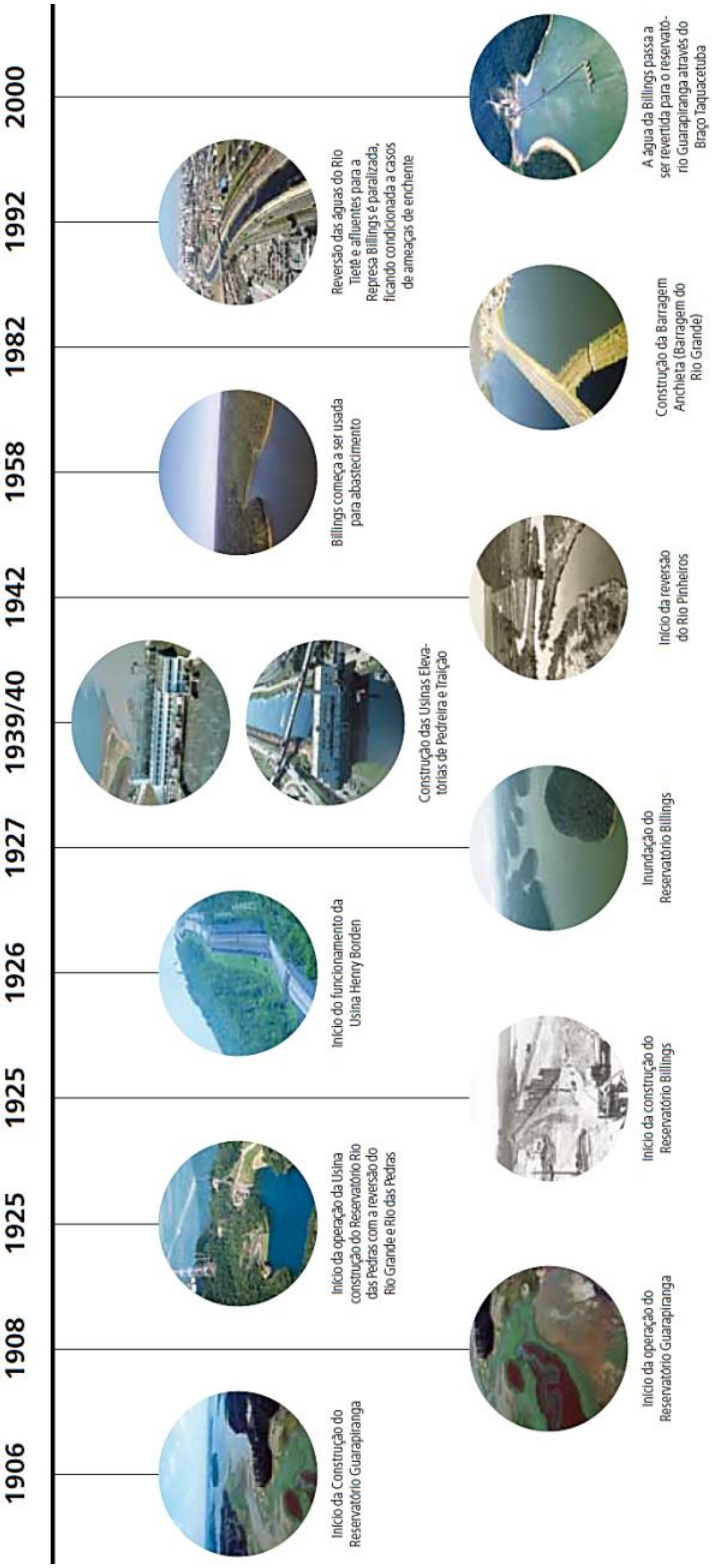
[8] Based on the new legal regulation, from 2000 onwards, Sabesp, with the purpose of expanding its water production capacity for public supply, puts into execution a system - maintained until the present date, through which the collection and transfer of water from the Billings Reservoir to the Guarapiranga Reservoir, using the Taquacetuba Arm in this operation

Figure 5 – Timeline of Billings history




Source: São Paulo (2010, p. 55).

In this process should also be considered another agent that contributes to the intensification of the deterioration picture: the improper deposition of solid waste, aggravated by the proximity of dumps such as Alvarenga, Cama Patente, Pedreira Itatinga and Diadema, and even if some are deactivated do not fail to generate environmental impacts they produce slurry, one of the most harmful contaminants to the groundwater. The loss of its potential resulting from the partial contamination of its waters, in addition to revealing the impotence of all normative and institutional arsenal, is still a chance that fades, especially in relation to the implementation of policies aimed at the environmental recovery of the spring, which among other effects, would expand the possibilities of water supply to the RMPS, minimizing the need to capture water from the Piracicaba basin.

## 3 CHARACTERIZATION OF THE BILLINGS DAM

The Billings reservoir hydrographic sub-basin is inserted in the territory of the Alto Tietê hydrographic basin, where it occupies an area of 582.8 km³, in the southeast portion of the RMSP, where it borders the Guarapiranga reservoir hydrographic basin to the west and, at the south, with Serra do Mar. According to Aguilar (2009, p. 97), “the water surface of the Billings Dam covers 108.14 km², corresponding to 18% of the total area of its hydrographic basin, which makes it the largest water reservoir in the São Paulo Metropolitan Region".

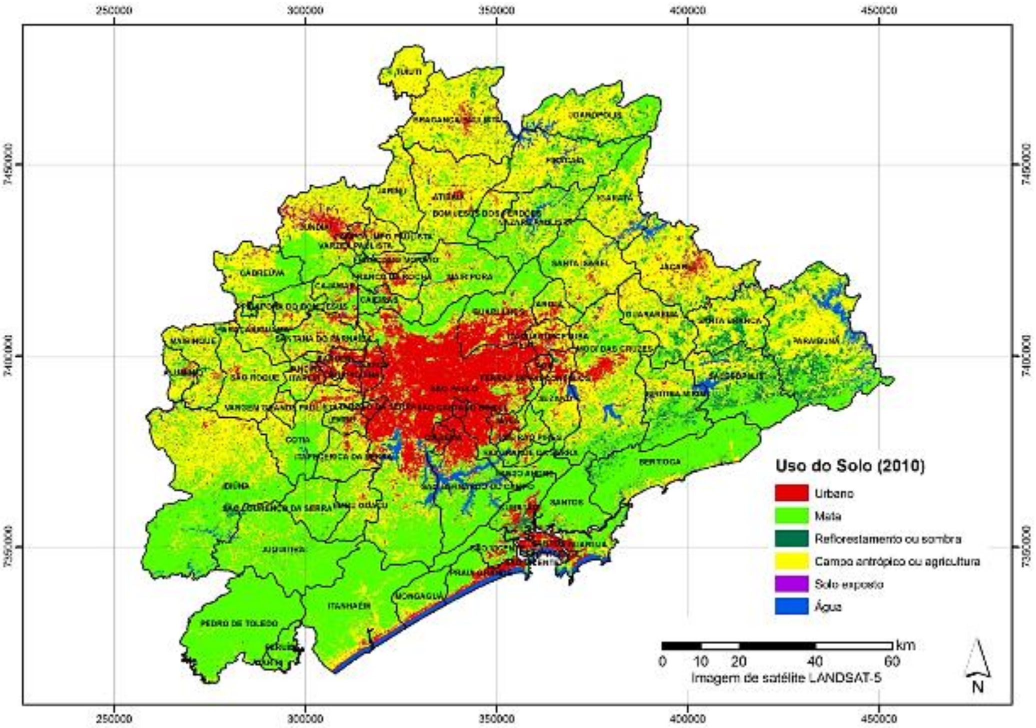
Its territory has a vegetation cover, being part of a remnant of the Atlantic Forest biome, thus contributing to the delimitation of the São Paulo green belt[9] biosphere reserve (Figure 6). This vegetation cover of the territory contributes to the maintenance of the region's climate and is divided between tropical and subtropical, with an average temperature estimated at 19 °C and significant rainfall distributed throughout the year. According to the Alto Tietê basin plan,

> The Atlantic Forest is today, surely, the biome of the country most influenced by the action of man. Forest fragments, conservation units and other protected areas are today important remnants of the natural environments of the Alto Tietê Basin (BAT) and harbor a biodiversity of extreme importance for conservation. (CBHAT, 2009, p. 12).

[9] “In 1993, UNESCO recognized the São Paulo Green Belt Biosphere Reserve as an integral part of the Atlantic Forest RB, but with its own identity given the peculiarities of the surroundings of one of the largest metropolises in the world. In addition to São Paulo, the Cinturão Verde RB involves 71 other municipalities where 10% of the entire Brazilian population is concentrated. RBCVSP's actions focus on 2 main foci: the "Youth Program" which promotes social inclusion and eco-professionalizing courses for young people from peri-urban regions, and the study of environmental services (water, climate, carbon, etc.) generated by the Mata Atlantic around cities. These studies make up one of the pilot projects of the ‘Millennium Assessment’ that involves the analysis of ecosystems at a global level.” (RBCV, 2016).

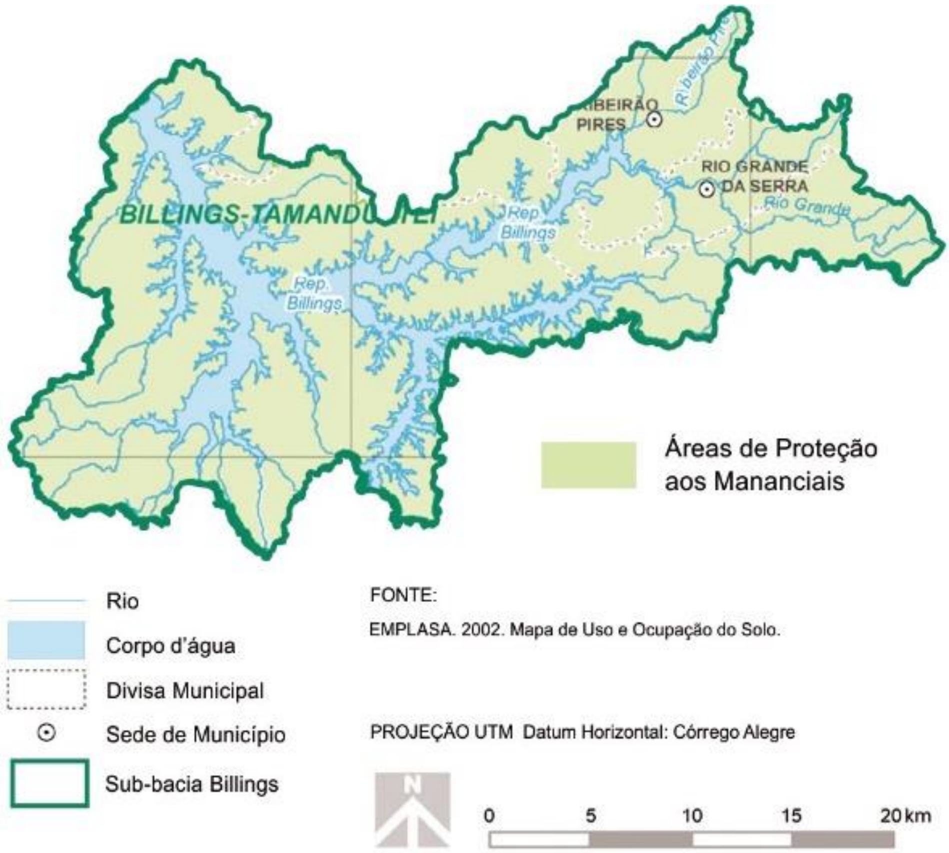
*Periódico Eletrônico*
**Fórum Ambiental da Alta Paulista**
ISSN 1980-0827 – Volume 18, número 2, 2022

Figure 6 – São Paulo Green Belt Biosphere Reserve




Source: Sato (2012, p. 66).

Figure 7 – Watershed areas of the Billings sub-basin

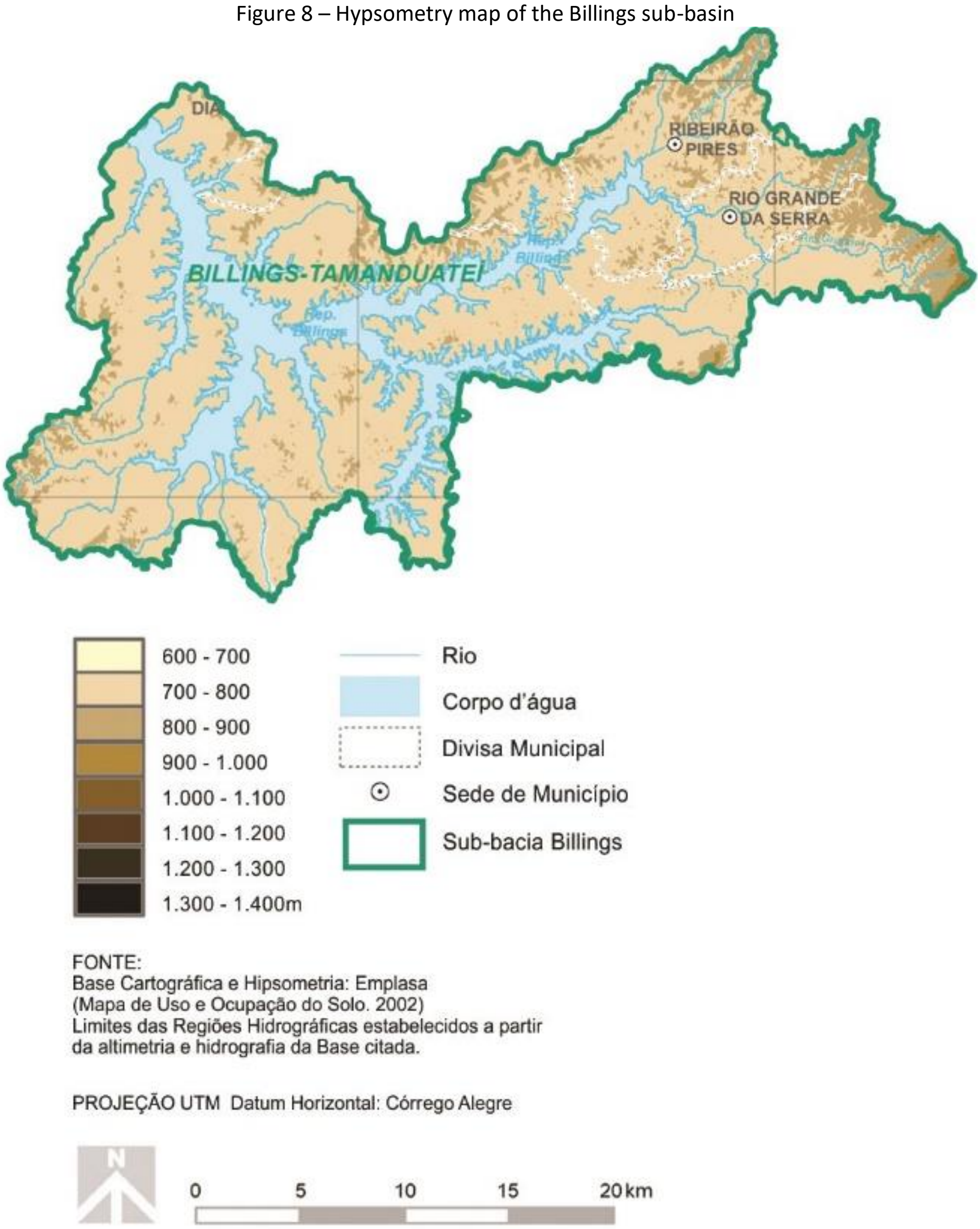



Source: CBHAT (2009, p. 17), adapted by the author.

In this sense, considering the dynamics of nature, it is emphasized that the ecosystems present in the Billings sub-basin are mainly responsible for the production of water. Thus, due to this function, the protection area of the Billings dam springs is considered strategic for the supply of water to the RMSP (Figure 7).

Due to its proximity to the Serra do Mar, the Billings sub-basin has high annual average total precipitation rates, and within the average annual basin is around 1,400 mm (Figue 8).

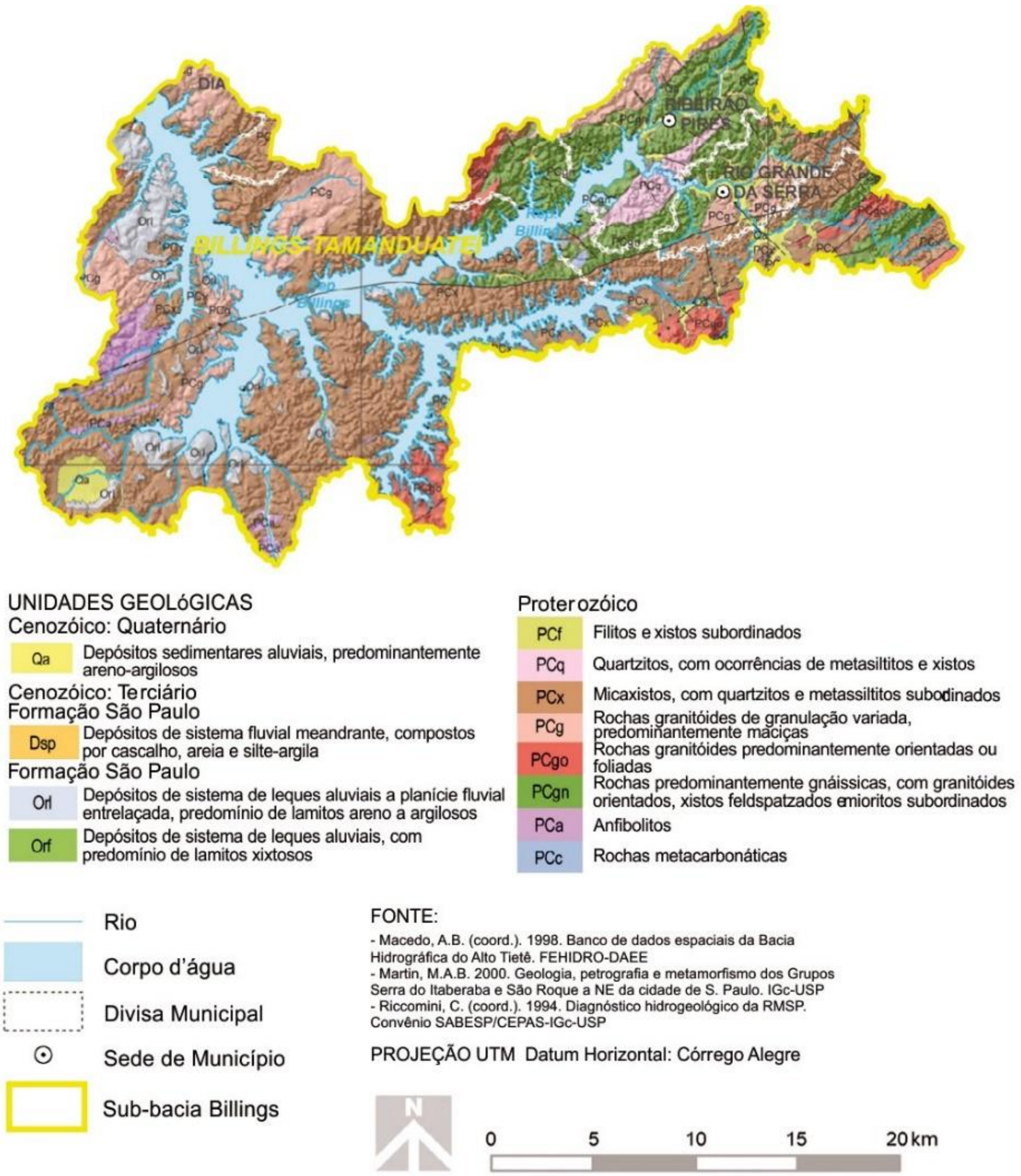
Figure 8 – Hypsometry map of the Billings sub-basin




Source: CBHAT (2009, p. 10), adapted by the author

It should also be noted that the geological process of the Billings sub-basin contributed to the modeling of the relief, a fact that directly influences the hydrological hydraulic behavior (Figure 9 – Geological Map).

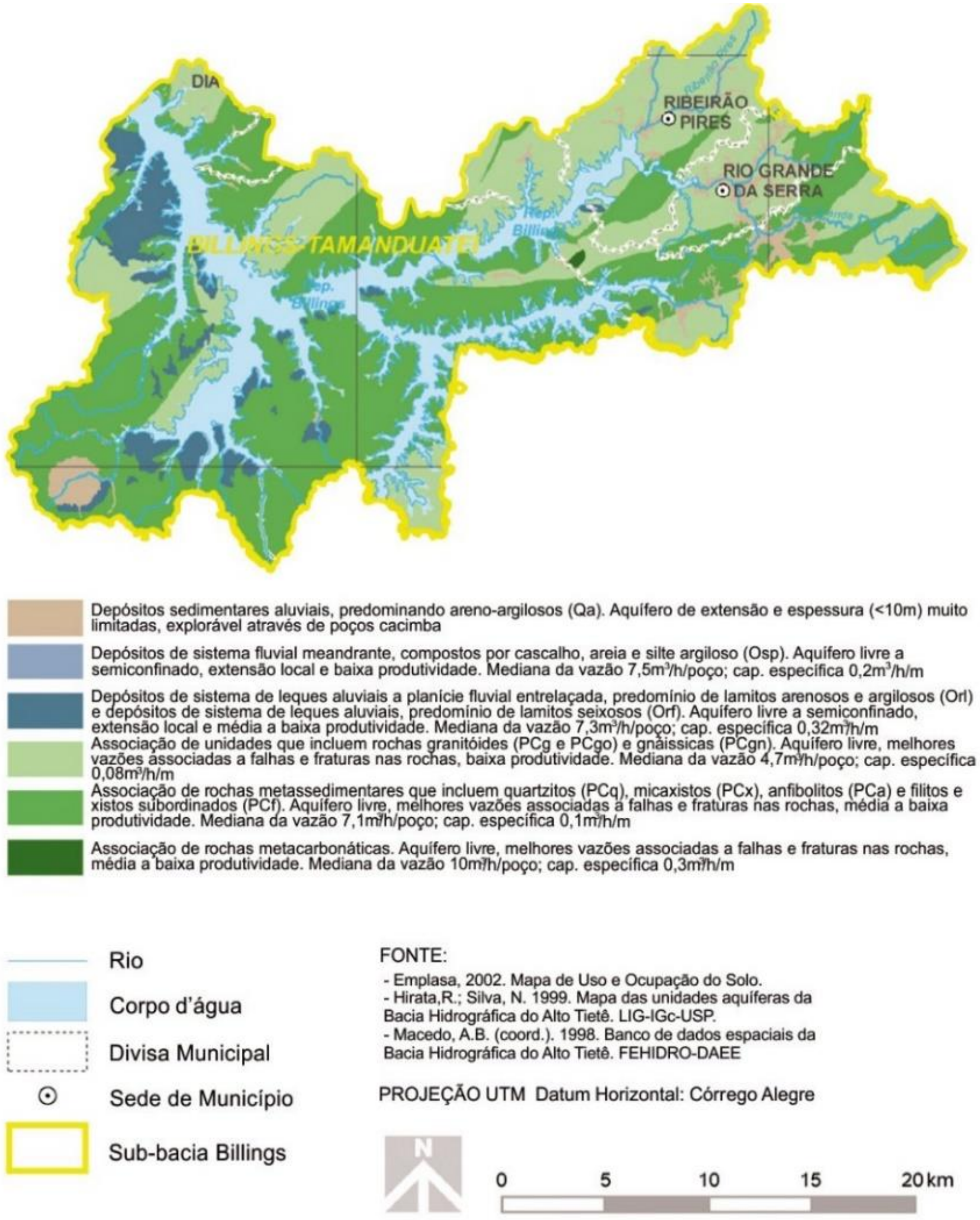
Figure 9 - Map of the geology of the Billings basin




Source: CBHAT (2009, p. 13), adapted by the author.

Next, the hydrogeological map of the Billings sub-basin (Figure 10) in which it is possible to identify the general characteristics and productivity of the aquifers, as well as their hydrogeological importance in the context of Billings Dam's protection area.

Figure 10 – Hydrogeology map of the Billings sub-basin




Source: CBHAT (2009, p. 14), adapted by the author.

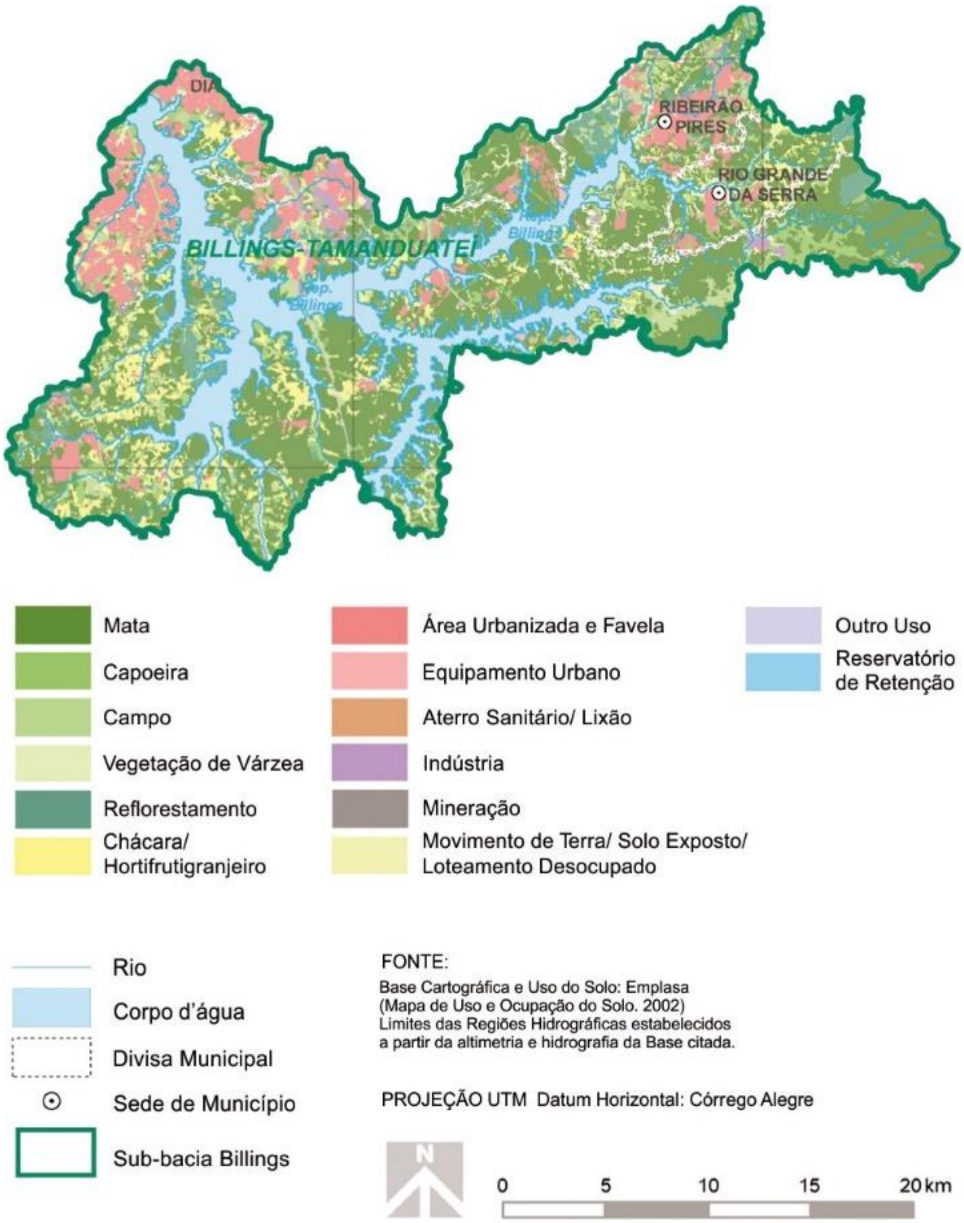
The vulnerability of aquifers in the Billings sub-basin is strictly related to the urbanization process. Within the scope of the Alto Tietê basin, Cetesb identified, up to 2006, 959 contaminated areas, with 37% of these locations being classified as “areas of high vulnerability to aquifer pollution, 41% in areas of medium vulnerability and 22% in areas of medium to low vulnerability” (CBHAT, 2009, p. 12).

Regarding the use and occupation of the soil of the sub-basin Billings, it should be noted that the production of urban space exerts strong pressure on the ecosystems of the springs, mainly by the occupation of informal settlements, removal of vegetation

*Periódico Eletrônico*
**Fórum Ambiental da Alta Paulista**
ISSN 1980-0827 – Volume 18, número 2, 2022

cover, irregular deposit of waste and the discharge of effluents, such as domestic sewage released *in natura* into the water bodies (Figure 11).

Figure 11 – Land use map of the Billings sub-basin



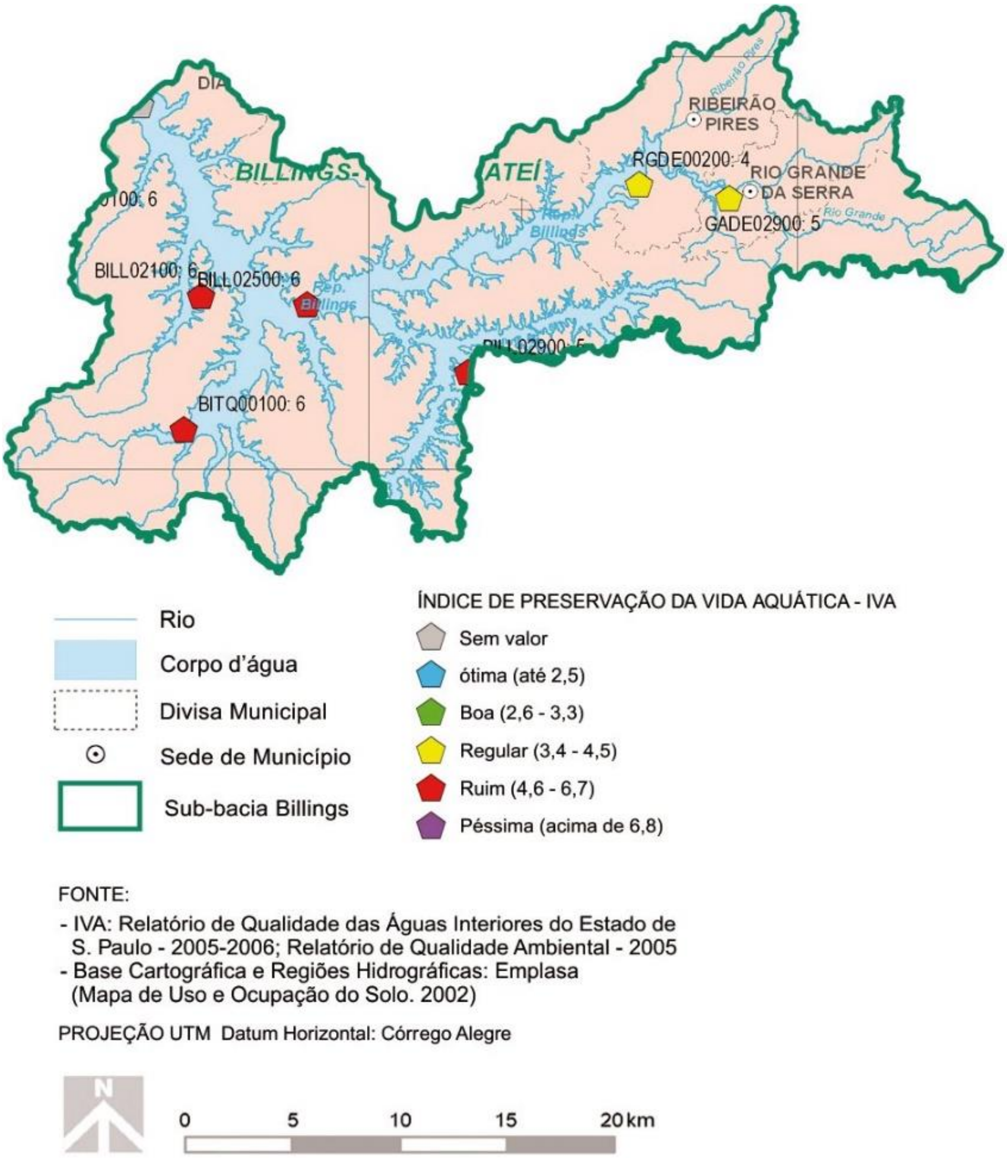

Source: CBHAT (2009, p. 19), adapted by the author.

Considering the demand for grants in the Alto do Tietê watershed, the survey found that 59.23 m³/s of them were issued for capture and 39.67 m³/s for release. Of these values, 59% were used from water collection for public supply and 39% for industrial purposes, with 59% of effluent discharges coming from industrial sources and 41% resulting from domestic sewage (CBHAT, 2009).

The grants issued for capturing water were intended to meet the demands of public supply, industrial and hydro-agricultural use, while the purpose of releasing effluents was for sanitary (domestic sewage) and industrial use. According to data from the Alto Tietê basin plan (CBHAT, 2009), the production of urban space is primarily responsible for the current situation of water quality in surface water courses.

The negative impacts resulting from the urbanization process can be verified by analyzing the rates of preservation of aquatic life (Figure 12).

Figure 12 – Spatialization of the aquatic life preservation index of the Billings sub-basin




Source: CBHAT (2009, p. 40), adapted by the author.

The current scenario is due to the absence of investment in the collection, transportation and treatment of sanitary sewage systems. For this reason, the "rivers and streams came to be seen by the population as a dirty place, place of disposal of waste and garbage, and its banks began to be occupied by the low-income population, with the floodplains suffering intense process of favelization" ( CBHAT, 2009, p. 37).

## 4 FINAL REMARKS

With the intention of seeking to understand the history of construction of the Billings dam, the Billings watershed was characterized in the socio-environmental context, seeking to perform a systemic reading of the region in which it is inserted, through its most important natural and physical elements.

When considering the environmental dimension, all this conjuncture involved in the treatment given to protected areas, specifically the areas of water sources, shows a critical context, coming from a series of aspects that permeate since the irregular housing occupation, indiscriminate subdivision of land and predatory in distant peripheries, in which the lack of infrastructure and precariousness of public services of primary need have been for decades a reality experienced by millions of people, ineffectiveness of plans and programs or resulting from the failure of the management system.

Based on this contextualization, it appears that this critical situation is the result of a mistaken and incipient planning process that, among other aspects, allowed for the intense informal occupation of its protection areas, in particular the indiscriminate removal of vegetation cover that occurred over the years, leading to an intense process of degradation of water bodies, in addition to intensifying socio-environmental vulnerabilities.

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