Scientific article doi: 10.1590/2175-3369.013.e20200208

ISSN 2175-3369

Possibility of using compensatory urban drainage techniques as leisure units to expand public areas into subdivisions

Possibilidade de uso de técnicas compensatórias de drenagem urbana como unidades de lazer para ampliação de áreas públicas em loteamentos

Geovana Geloni Parra [a], Bernardo Arantes do Nascimento Teixeira[b], Érico Masiero [b], Thais Borges Martins Rodrigues [a]

[a] Universidade Federal de São Carlos (UFSCar), Postgraduate Program in Urban Engineering, São Carlos, SP, Brazil
[b] Universidade Federal de São Carlos (UFSCar), Department of Civil Engineering, Graduate Program in Urban Engineering, São Carlos, SP, Brazil

How to cite: Parra, G. G., Teixeira, B. A. N., Masiero, E., & Rodrigues, T. B. M.(2021). Possibility of using compensatory urban drainage techniques as leisure units to explain public areas into subdivisions. *urbe. Revista Brasileira de Gestão Urbana*, v.13, e20200208. https://doi.org/10.1590/2175-3369.013.e20200208

Abstract

Many housing estates of social interest have not contributed to implementing leisure areas and reducing their environmental and urban quality. This paper aims to propose a leisure unit using a compensatory urban drainage technique in a housing complex of social interest in the city of São José do Rio Preto, São Paulo, Brazil. The characterization of the area, land use and occupation surveys, area sectorization, and catchment division were carried out. Afterwards, proposals for interventions based on surface runoff were presented using calculations of existing runoff and future scenarios. Results related to environmental and social gains for the area are discussed, as well as the possibility of implementing decentralized compensatory techniques. Moreover, 156 rain gardens and 3 ditches were proposed throughout the subdivisions, which enabled a gain of 989m^2 of contribution area to infiltrate the whole area, and the use of the retention basin as a leisure area. The total storage volume achieved with the sum of all the techniques implemented was approximately 3,000 cubic meters more than that projected for the existing retention basin.

Keywords: Social Interest Housing, Compensatory Urban Drainage Techniques, Urban Planning.

Resumo

Muitos conjuntos habitacionais de interesse social não tem contribuído com a implantação de áreas de lazer, e reduzindo sua qualidade ambiental e urbana, portanto, este trabalho tem como objetivo propor uma unidade de lazer em uma técnica compensatória de drenagem urbana em um conjunto habitacional de interesse social na cidade de São

GGP is architect and urbanist, Ph.D Student in Urban Engineering, e-mail: geovanaparra.arquiteta@gmail.com
BANT is civil engineer, Ph.D in Hydraulic and Sanitation Civil Engineering, e-mail: bernardo@ufscar.br
EM is architect and urbanist, Ph.D in Urban Engineering, e-mail: erico@ufscar.br
TBMR is architect and urbanist, Master in Urban Engineer, e-mail: arq.thaisborges@hotmail.com

José do Rio Preto, São Paulo, Brasil. Foi realizada a caracterização da área, levantamentos do uso e ocupação do solo, setorização de áreas, e divisão por microbacias, e então apresentadas propostas de intervenções baseadas no escoamento superficial, por meio de cálculos do escoamento existente e de cenários futuros. Foi possível discutir os resultados relacionados aos ganhos ambientais e sociais para a área, além da possibilidade de implantar técnicas compensatórias descentralizadas. Foram propostos 156 jardins de chuva e 3 trincheiras em todo o loteamento, o que possibilitou o ganho de 989m^2 de área de contribuição para a infiltração na área toda, e a utilização da bacia de detenção como área de lazer. O volume total de armazenamento alcançado com a somatória de todas as técnicas implantadas foi cerca de três mil metros cúbicos a mais do que o projetado para a bacia de detenção existente.

Palavras-chave: *Habitação de interesse social, Técnicas Compensatórias de Drenagem Urbana, Planejamento Urbano.*

Introduction

Urban areas in Brazilian cities have grown uncontrollably since 2009 after creating the "Minha Casa Minha Vida" (MCMV or My Home My Life) program, one of the State's responses to habitation and economic problems at the time (Rolnik, 2015). This program has made it possible for cities to spread widely as its implementation most often occurs in the outskirts of cities, horizontally, forming mega housing estates.

These estates located far from central areas often accommodate over 1,000 families, who end up having few leisure options and other public facilities near their residence. According to Rolnik (2015), they are large real estate developments that are devoid of leisure activities and services, and in practice, function as dormitory towns, as they have the same characteristics, where people leave in the morning and only return at the end of the day.

These subdivision areas are highly waterproofed and largely contribute to flooding and inundation problems in already consolidated areas. In order to avoid or reduce these events, cities propose legislations that obligate new subdivisions to execute retention/seepage basins in their areas.

The new subdivisions provide large areas for those retention/seepage basins, which are often underused, working only on rainy days, while other public areas are reduced or rendered unusable to meet this need. Some cities such as São José do Rio Preto, São Carlos and Ribeirão Preto in the state of São Paulo already uphold these laws.

In addition to the retention/seepage basins, there are other compensatory techniques that can also be used in subdivisions, such as ditches and rain gardens. Melo et al. (2014) evaluated the functions of retention, storage and infiltration of rainwater from a roof in an experiment in the city of Recife, in which they obtained satisfactory results related to the infiltration capacity of rainwater, mainly for rains of a return time of 5 years.

With the growing interest in the function of open spaces, carefully planned to reach the flood regulation and other ecosystem services, there are many measurements and concepts of planning that aim to accommodate surface water instead of excluding it, as proposed by the Water Sensitive Urban Design (WSUD) and the Low Impact Development (LID) (Schucha et al. 2017).

As a way of trying to alleviate these problems related to the lack of public areas, this article aims to identify the urban problems of the housing complex of social interest called "*Vida Nova Dignidade*", in São José do Rio Preto, and to propose using rainwater compensatory techniques that the basins already installed in the complex may be used as a leisure area for residents. The proposal aims to bring solutions that ensure improvements in public areas, enabling greater social integration, and consequently improving the quality of life. The choice of the place is due to it being located in the outskirts of the city, as well as its lack of public facilities to assist the population, worsened by urban mobility difficulty.

The "Estatuto da Cidade" (City Statute), 10.250 Federal Law from 2001, establishes norms of public order and social interest that regulate the usage of urban property in favor of the common good, security and well-being of citizens, as well as environmental balance (Brasil, 2001). Among its general guidelines, there is a guarantee of the right to sustainable cities, understood as the right to urban land, housing, environmental sanitation, urban infrastructure, transportation and public services, work and leisure, and the ordering of land use to prevent its misuse or non-use.

Considering this legislation, more adequate spaces for housing, based on implementing the instruments present in it, such as applying the "Operação Urbana Consorciada" (Consortium Urban Operation), which allows the modification of indexes and characteristics of the division, use and occupation of soil and subsoil can be ensured, as well alterations in building norms, taking into account the environmental impact; and the regularization of constructions, remodeling or expansions carried out in disagreement with current legislation.

Part of the consolidation policy of the "Estado de Direitos" (Rule of Law) that was established in Brazil after 2003, the right to adequate housing is now considered an important vector of social inclusion and transformation. The "Política Nacional de Habitação" (PNH or National Housing Policy), created in 2004, aims to provide more access to housing, regardless of a family's income, with allowances and tax incentives, which would allow low income families to purchase their own home, as well as the social market housing, that would ensure access to the population via bank financing (Rolnik, 2015).

In 2009, the MCMV program proposed, in its first phase, to build 1 million housing units. For the development of housing projects contracted by "Fundo de Arrendamento Residencial" (FAR or Residential Leasing Fund), we highlight the inclusion of housing projects in the urban network or in urban expansion zones defined by the "Plano Diretor" (Master Plan); when in an urban expansion zone, the housing must be contiguous to the urban network and have areas intended for commercial activities; the housing projects must be provided with urban infrastructure, such as road paving, drainage, sidewalks, guides and gutters, electricity and street lighting, drinking water supply network, sewage solutions and garbage collection service, until the delivery date of the project.

Beside this, the ordinance states that housing with more than 1,000 units should allocate institutional areas for the implementation of public facilities. These definitions were established to ensure that MCMV housing projects were executed in consolidated urban areas.

Nevertheless, the choice of areas disconnected from the urbanized areas is still present within the program's performance, proving to be difficult to address the theme "building cities" from the perspective of "housing construction". These complexes are built solely to meet basic approval guidelines without considering how the areas may be of better use for the resident population.

Many public areas are lacking in implementation. Priority is given to areas for housing and areas for leisure are left out, thus the necessary facilities are not implemented. Moreover, the necessary facilities are not provided. Large areas that could also be used for leisure, such as urban drainage ones, are isolated and unused by the population.

Rainwater management, integrated with urban planning, can serve as an ally for quality use proposals for public areas. Retention/seepage basins, when integrated into the landscape, are better accepted by the population and less likely to deteriorate.

Peroni (2016) analyzed retention basins in the cities of Araraquara and São Carlos concerning their state of conservation, ease or difficulty of access to structures, visibility, concentration and multipurpose. Their results showed that Study Basin 1 was completely fenced and had controlled access, but its maintenance status was adequate, and it was at the beginning of reforestation. In Study Basin 2, during the survey, solid residues of plastic materials and exposed soil were found.

There are several examples of cities around the world and in Brazil that have already adopted compensatory techniques integrated into the landscape and leisure. Oliveira et al. (2016) present the integration of infiltration ditches in a soccer field (Figure 1) and retention basins integrated into reflection pools and the landscape under a viaduct (Figure 2) in the city of Guarulhos, São Paulo (SP), where the population, after the project execution, began to use the region in a contemplative manner.

Figure 1 – Infiltration ditches integrated into a soccer field in Guarulhos, SP Source: Adapted from Oliveira et al. (2016).

Figure 2 – Retention basins integrated into reflection pools under a viaduct in Guarulhos, SP. Source: Oliveira et al. (2016).

Another example is the city of Pienkenhoef, in the Netherlands. As it is located in a region of great water importance and, in order to reduce the possibility of flooding, it has implemented some alternatives using compensatory techniques for urban drainage integrated into the landscape. Figure 3 shows the proposal of ditches integrated into the residential landscape, where a wooden deck that serves as a passage for residents in both dry and rainy seasons was installed (Dolman et al., 2013). In Figure 3, it can be observed that, on both occasions, the space is integrated into the urbanization and is well maintained.

Figure 3 - Large ditch intended for the seepage of water runoff from the residences located around Source: Adapted from Dolman et al., 2013.

Some other cities around the world also implement WSUD guidelines to improve water quality and reduce flooding. According to the "Centro de Pesquisa das Cidades Sensíveis a Água" (2017) (Cooperative Research Centre for Water Sensitive Cities), these countries have already realized the importance and improvement in the quality of life of their inhabitants, especially when drainage techniques are integrated into public spaces, as shown in Figure 4, which shows some cities, such as Tel Aviv, Singapore, Kunshan and Melbourne.

Figure 4 – Cities that implemented WSUD in the world. Source: Adapted from "Centro Cooperativo de Pesquisa para Cidades Sensíveis à Água" (2019) (Cooperative Research Centre for Water Sensitive Cities).

To calculate the size of these techniques and their area of contribution, superficial water runoff indexes are required, which are given by Baptista et al. (2005). The superficial runoff coefficients are the relation between the impermeable surfaces that contribute to the rainwater runoff of over the total surface of the basin. These values range from 0.10 to 0.95 depending on the material, considering 0.70 to 0.95 for areas with dense residential occupation, 0.70 to 0.95 for concrete or paved roads, and green areas or parks from 0 0.1 to 0.25.

Research conducted by Bruno, Amorim and Silveira (2013) also experimentally evaluated the following structures with rain simulation: grass covered soil, exposed soil, conventional concrete and solid and hollow concrete blocks (Table 1). The area is located on the campus of the Universidade Federal do Mato Grosso

(UFMT) and the soil type is clayey. Each experimental portion was 0.70m² in size and was isolated by a metal frame. It evaluated rainwater runoff under two precipitation intensity situations: 79 mm/h and 121 mm/h, conducting three trials on each of the five surfaces.

Table 1 - Medium water runoff (mm/h) found by Bruno, Amorim and Silveira (2013)

Types of surface	Grass covered soil	Exposed soil	Solid concrete blocks	Hollow concrete blocks	Conventional concrete
Precipitation intensity 79mm/h	Total runoff	29.15	48.2	78.07	3.11
Precipitation intensity 121mm/h	96.3	42.85	48.71	84	6.01

Source: Adapted from Bruno, Amorim and Silveira (2013).

The grass surface was the one with the best result, obtaining water runoff only in the rain simulation of 121mm/h, and the runoff coefficient was 0.15. Considering this result, we realize the importance of the impacts caused by the removal of soil vegetation, in relation to the superficial runoff generated during the rain events.

In Brazil, these compensatory urban drainage techniques are generally underutilized, accumulating unwanted vegetation and waste due to lack of public power maintenance and the population´s knowledge. If new uses were given to these areas using “Estatuto da Cidade” instruments, it would be possible to achieve greater environmental and well-being quality for the population and space, thus fulfilling the social function of urban land. Therefore, there was a need to propose a leisure unit in a compensatory urban drainage technique, located in an underutilized area of a housing complex produced through “Minha Casa Minha Vida”.

Material and methods

To accomplish the proposed retention basin use, we adopted a documental analysis of the housing to identify the existing public areas in the project, and afterwards we visited the site, verifying its situation and conditions of use. To make it possible to use the retention/seepage basin as a leisure area, we made comparative calculations between the existing public areas in the housing complex and the ones required by the corresponding legislations, such as the Federal Law nº 6766, from 1979, which requires urban land division and provides other measures, and the Municipal Master Plan. We produced maps and projects to identify urban problems and locate areas where we could find possibilities for urban intervention. We made the maps and projects using AUTOCAD, COREL DRAW and GOOGLE EARTH. The superficial runoff calculations and their representation charts were made in EXCEL. After we noticed the sub utilization of existing public areas, we made drainage calculations in the neighborhood and in the existing basin to identify the contribution areas and decentralize the rainwater catchment techniques, enabling the catchment to be used for leisure facilities.

Characterization of the study area

The object of study of our research is located in the city of São José do Rio Preto, in the state of São Paulo. It is a housing complex of social interest produced by “Minha Casa Minha Vida” and is called “*Vida Nova Dignidade”*. We chose this complex because it is an example of the housing developments that have been built all over Brazil. It has a high number of housing units and is located on the outskirts of the city, as well as having a lack of public facilities for public service, aggravated by the urban mobility difficulty.

Before the subdivisions were implemented, the area was intended for agriculture and livestock, predominantly for grazing. The area is located in the northern region of the city, between two areas of permanent preservation, and in one of them there are about 12 springs that comprise the formation of the São Pedro tributary stream of the Rio Preto.

The complex under study (Figure 5) was carried out in an area of 654,615.51m² plot. It has 1,680 subdivisions, of which 1,536 are for housing, intended for an estimated population of 6,720,000 inhabitants. Regarding the remaining areas, 172,990.60m² (26.43%) are for traffic lanes, 123,761.10m² (18.90%) for green areas, 9,905.95m² (1.51%) for leisure areas and 1,900.49m² (0.29%) for institutional areas.

Figure 5 – Soil use in "Vida Nova Dignidade" housing set. Source: Adapted from the Urban Design Project obtained in the project approval process from the São José do Rio Preto City Hall (2018).

The institutional areas were occupied by four drinking water wells, responsible for supplying the neighborhood. As a result, there is no institutional area in the neighborhood designed to implement schools or a health care center. Furthermore, the leisure area is concentrated on the central axis of the access to the neighborhood, surrounded by green areas, currently unused by the population. The green areas of the neighborhood were handed over to the population enclosed by metal fences and locked gates, as well as signs indicating that it was prohibited to use the site. Having no public use, the areas have no grass cover, vegetation or any element that suggests an intended use. The neighborhood has a permanent preservation area (PPA), with 12 registered springs. The area is located in a green area of 98,394.92m², where the retention basin is located (Figure 6). This highlights the need to hold the volume and speed of superficial runoff from rainwater from the contribution area.

Figure 6 – Location of retention basin. Source: Google Earth (2018) adapted by the authors (2018).

Calculations of existing areas

The lack of designated areas to install facilities, such as schools and health units, as well as the underutilization of green and leisure areas in the neighborhood, motivated the development of alternative uses for existing areas. This enabled the residents' needs to be met without generating large displacements to access these services. Thus, our proposal aimed to establish alternatives for the use of green, institutional and leisure areas for schools, kindergartens, leisure and public facilities.

The method to define the areas to be used took into consideration the guidelines of Law no. 6,766/1979, which concern land use and occupation. Article 4 of the document stipulates that the subdivisions must contain "areas intended for circulation systems, the implementation of urban and community facilities, as well as free spaces for public use", which must be "proportional to the occupancy density stipulated by the master plan or approved by the municipal law for the area where they are located". Therefore, the municipal legislation must define the "permitted uses and the urban indexes of land division and occupation, which must include the minimum and maximum areas of subdivisions and the maximum utilization coefficients". For this legislation, public facilities for education, culture, health, leisure and the like are considered communal, and urban public facilities for water supply, sewage services, electricity, rainwater collection, telephone network and piped gas.

Thereafter, the municipal legislation of São José do Rio Preto, Law No. 12,965/2018, requires that 20% of the subdivisions is destined for traffic lanes and circulations and 15% for institutional and green areas. The Municipal law No. 5138/1992 determines which institutional area is allocated for constructing public facilities for education, health, culture, sports and public services. Thus, the areas of "*Residencial Vida Nova Dignidade*" are distributed according to Bar Chart 1.

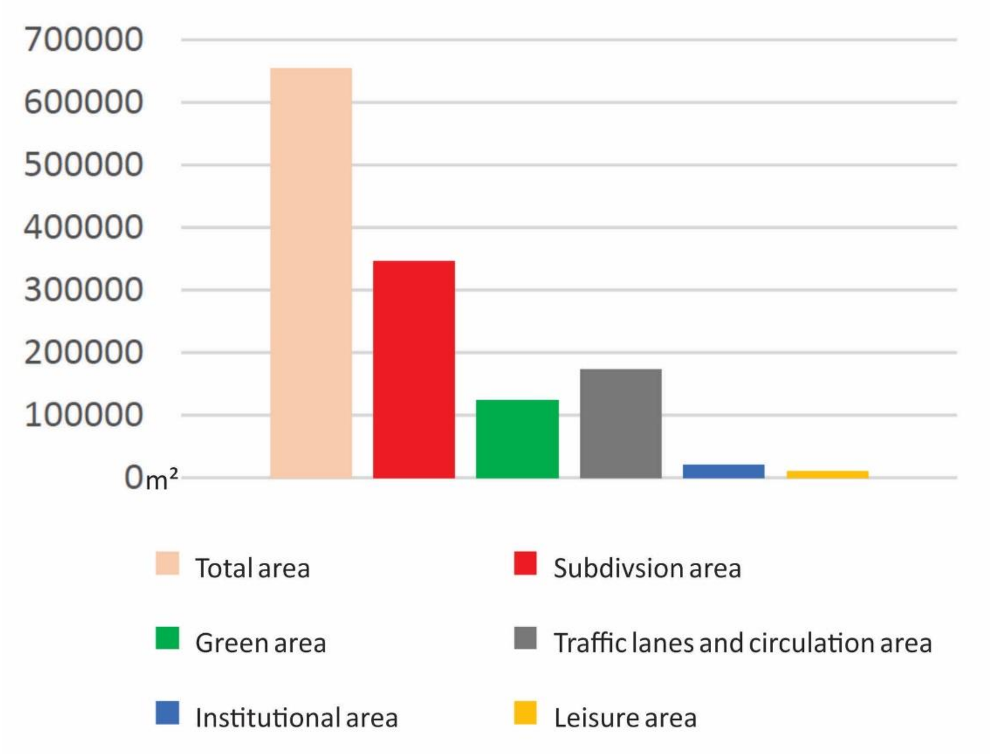


Chart 1 – Projected areas. Source: Pacaembu (2018), adapted from authors (2018)

Calculations of urban drainage micro catchments

In order to use the retention basin as part of the neighborhood's green and leisure areas, the area of contribution to the local rainwater runoff was verified. Only after making these calculations were we able to plan the implementation of other compensatory urban drainage techniques.

The used method for this calculation was the same as the one proposed by Parra (2016), considering the runoff coefficients existing in the basic bibliography of the area and the waterproofed, grass covered, and exposed soil areas.

The formula for making the calculation (1) comprises the Runoff Coefficient multiplied by the area, resulting in the contribution area to the superficial runoff:

$$Aa = C \times A \tag{1}$$

Where:

Aa = Effective contribution area

C = Runoff coefficient

A= Real total area

The runoff coefficient values, according to Baptista, Nascimento and Barraud (2005), can be assimilated to the waterproofing coefficient, that is, the relation between the waterproofed surfaces that contribute to the total basin runoff.

The drainage project scales the retention basin, therefore it is possible to calculate the storage area that will no longer infiltrate due to the proposed leisure use for this space.

The width of the basin at its highest part is about 52m, the lower width is about 37m, the average depth of the basin is 4m, its top length is 245m, and the bottom is 232m. Using the formula of the trapezoid prism volume calculation (2), the basin storage volume was calculated.

Where:

$V=[1/2(52+37)4]245 = 43610m^3$ (2)

and the contribution area for effective seepage is $37m x 232m = 8548m^2$

After analyzing the urbanism and drainage project designed and executed on site, the subdivisions were divided into 4 contribution micro catchments (Figure 7), according to the direction of the rainwater runoff observed in the drainage project provided by the construction company.

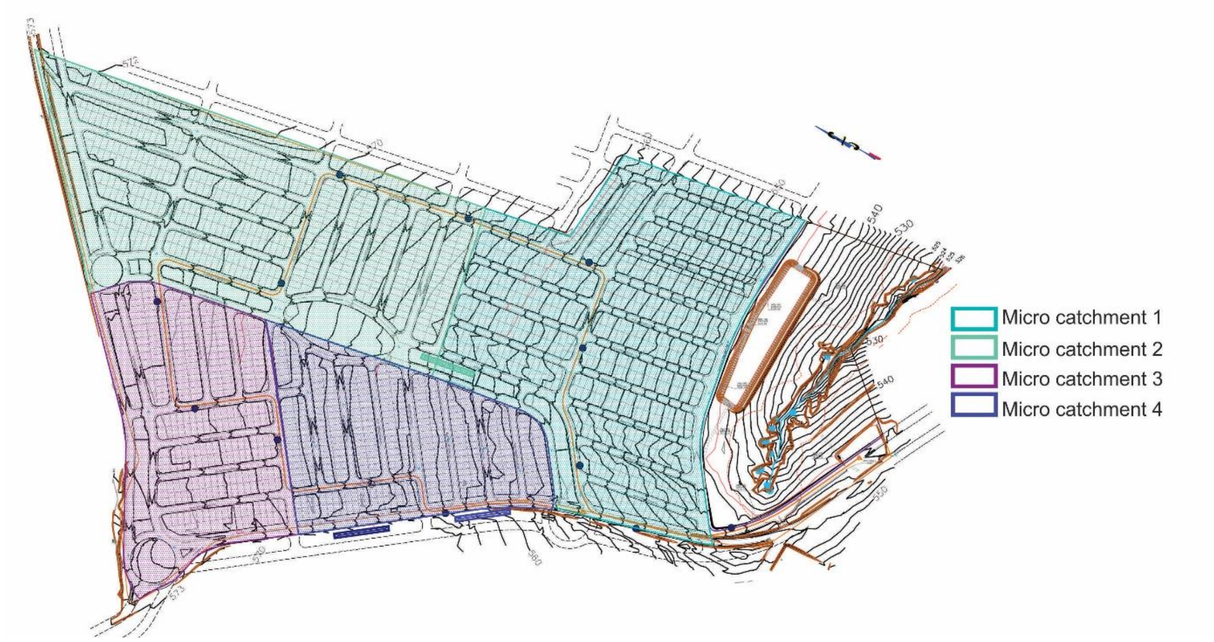


Figure 7– Housing complex division in micro catchments. Source: Adapted from the urban project obtained from the process of approval by the São José do Rio Preto local council (2018).

The total contribution to the subdivision superficial runoff can be seen in Table 2, which shows that the highest contribution percentage to this runoff comes from the subdivided areas and traffic lanes. The green, leisure and institutional areas had the lowest contributions.

Table 2 – Summary of the contribution to the existing superficial runoff in the housing complex

Calculation of the contribution area of existing rainwater runoff					
Areas	**Type of cover**	**Runoff coefficent**	**Areas (m²)**	**Contribution area (m²)**	**Superficial runoff contribution percentage**
Institutional and leisure areas	Area with exposed soil	0.6	11,810,44	7086,264	1%
Green areas	Grass	0.21	123716,1	25980,381	5%
Subdivision area	Buildings	0.9	346098,47	311488,623	61%
Traffic lanes	Asphalt	0.95	172990,6	164341,07	32%
	Total area		654,615,61	508896,338	100%

Source: Authors (2018)

The existing retention basin comprises about 1% of the total runoff contribution area, therefore by reducing this area, one should place the area and equivalent volume in other subdivision areas according to the micro catchments.

Results and discussions

Project of areas alteration

The proposed use of underused areas considered the relocation of commercial, green and leisure areas to meet the needs for kindergarten, nursery, health unit (UBS), support point (or echo point), vegetable garden and community association, leisure areas, religious activities, bike racks, public parking and green areas for concomitant seepage purpose. With the relocation, the new areas are represented in Table 3.

Table 3 – Projected areas X Existing areas

Glebe		Lots		Road system		Institutional		Green areas		Leisure	
Area (m²)	%	Area (m²)	%	Area (m²)	%	Area (m²)	%	Area (m²)	%	Area (m²)	%
Existing areas											
654,615.61	100	346,098.47	52.87	172,990.6	26.43	1,900.49	0.29	123,716.1	18.9	9,909.95	1.51
Projected areas											
654,615.61	100	314,128.93	47.99	172,990.6	26.43	29,270.62	4.47	123,716.1	18.9	14,509.33	2.22

Source: Authors (2018).

Figure 8 shows the new implementation, with new uses of the areas.

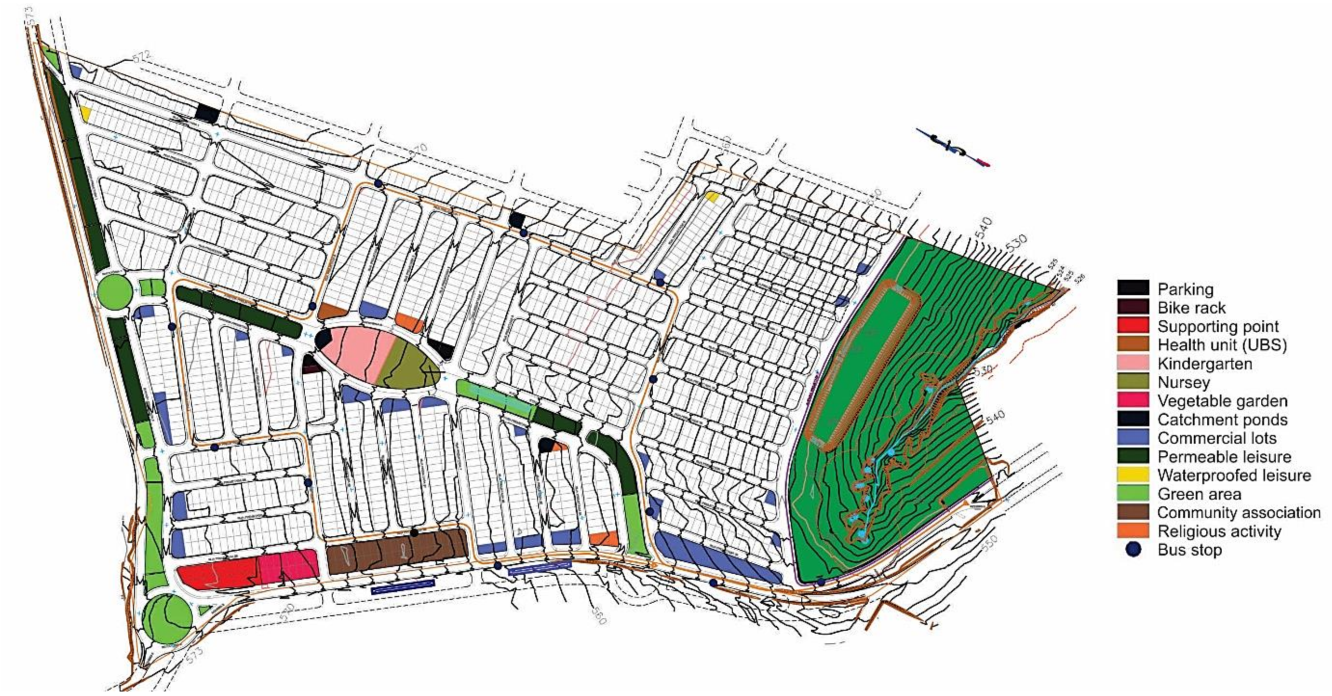


Figure 8 - Implementation proposal as new use of areas. Source: Adapted from the Urban Design Project obtained from the project approval process from the São José do Rio Preto local council (2018)

Micro catchment division project

By dividing the area into micro catchments, calculating the contribution areas and changing the use of existing public areas in the subdivisions, other decentralized compensatory techniques were adopted in order to reduce the storage volume of the general retention basin, item 1 in Figure 9, which presents the location of the new techniques in the subdivisions.

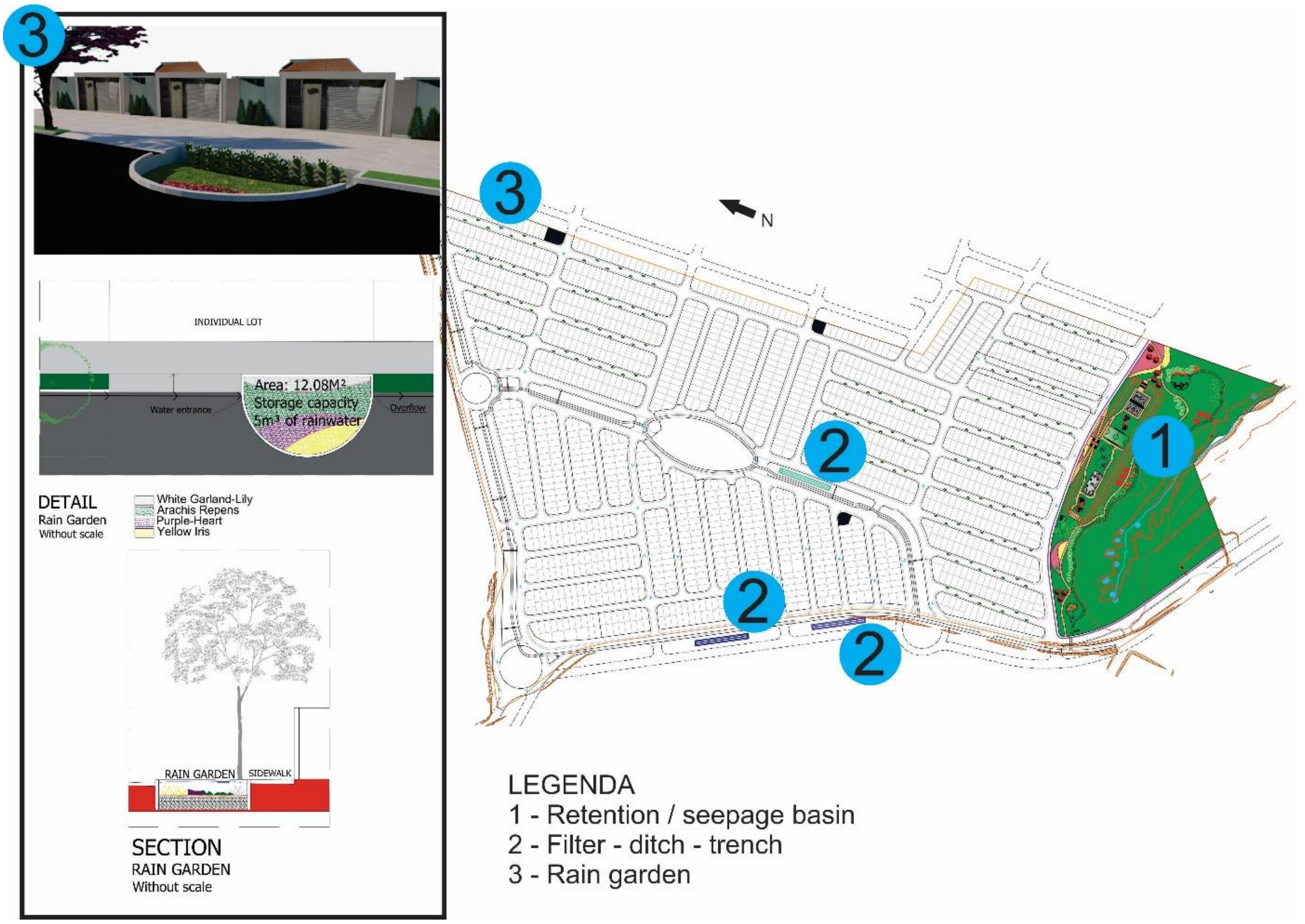


Figure 9 – Decentralized techniques location. Source: Adapted from the Urban Design Project obtained from the project approval process from the São José do Rio Preto local council (2018).

Rain gardens (item 3 - Figure 9) were installed in the streets that cut the contour lines perpendicularly, which the literature does not recommend as it increases the speed of rainwater runoff and the speed of vehicles in circulation. This can be minimized using rain gardens.

In addition to the rain gardens, we proposed three ditches (item 2 in Figure 9) for micro catchments 2, 3 and 4, which, according to Baptista et al. (2005) are linear compensatory techniques implemented close to the surface or at a shallow depth and are widely used in central flowerbeds and sidewalks, along the road system, or in green areas in general.

These ditches were disposed in road system expansion areas and in one that changed into a green area. The ditches are 89m long, 5m wide at their bottom base and 9m at their top base, with 1 meter of depth. Using the same trapezoidal prism volume calculation, with the $V = [1/2\ (5 + 9)\ 1]\ 89$ formula, a value of $623m^3$ of storage, or a seepage contribution area of $445m^2$ per ditch was reached. Multiplied by the 3 units, the storage result is $1869m^3$.

Each rain garden was designed to meet a storage volume of $5m^3$, and $12m^2$ of seepage contribution area and each block of micro catchments 1 and 2 received an average of 8 interleaved rain gardens in opposite positions, totalizing 156 units, $672m^2$ of seepage area or $780m^3$ of storage area.

According to Pereira (2016), if the compensatory technique used presents a periodically flooded area, the species chosen for vegetation cover need to have the capacity to resist periodic water flooding after storms, as well as droughts that occur during the hot months. The vegetative species most suitable for this case is Sphagnum Palustre. In our project, we used the White Garland-Lily and the Yellow Iris, as well as linings that help to reduce erosions due to the rainwater runoff, in the case of Arachis Repens and Purple-Heart.

The front of each subdivision has an average length of 10m, the paving of the sidewalk in most houses is made out of conventional concrete and the paving of the vehicle circulation road is made out of bitumen.

In Figure 9, which also demonstrates the cut-off detail of the rain garden, it can be observed that it comprises a soil aggregate layer, coarse sand and, later, the species planting compound and the rainwater storage space.

After establishing rain gardens and ditches, the value of rainwater storage in these techniques reached 2649 in cubic meters and 2,007m^2 of contribution area for seepage.

Project for the basin's leisure use

After the alterations of use in the public areas to implement compensatory techniques and in institutional areas, it was possible to use the retention basin in the subdivision as a leisure area.

We proposed to include a multi-sports court (Figure 10), a grass covered soccer field (Figure 11), a skate park and a floor fountain for public baths (Figure 12).

The existing retention basin will no longer contribute to the seepage of approximately 2218m^2, with the proposal of implanting waterproofed multi-sports courts with a total area of 970m^2, a floor fountain of 578m^2 for the population to cool off and a 670m^2 skate park, however its storage volume will remain the same 43,610m^3.

The pedestrian paths are drainage concrete molded in loco, which contribute with values close to 100% for the seepage.

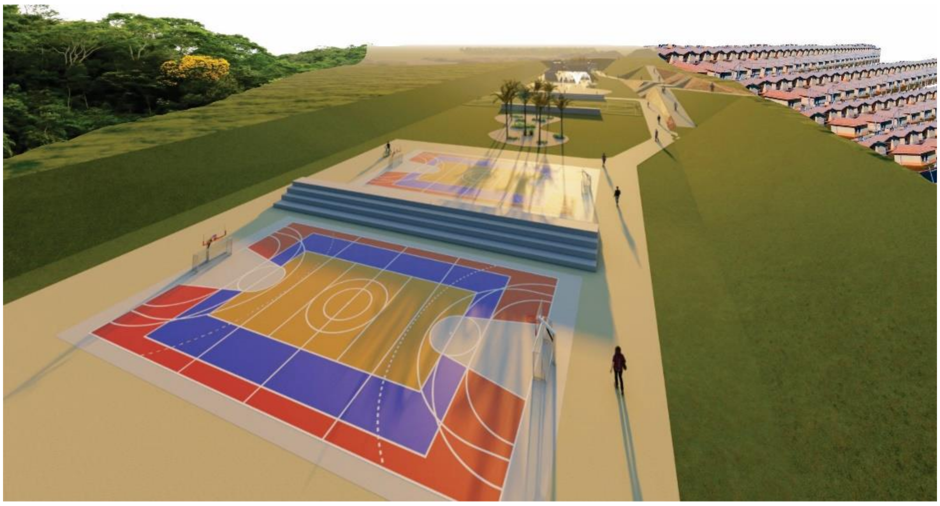


Figure 10 – Illustrative image of a multi-sports court implemented in the retention basin. Source: Authors (2018)

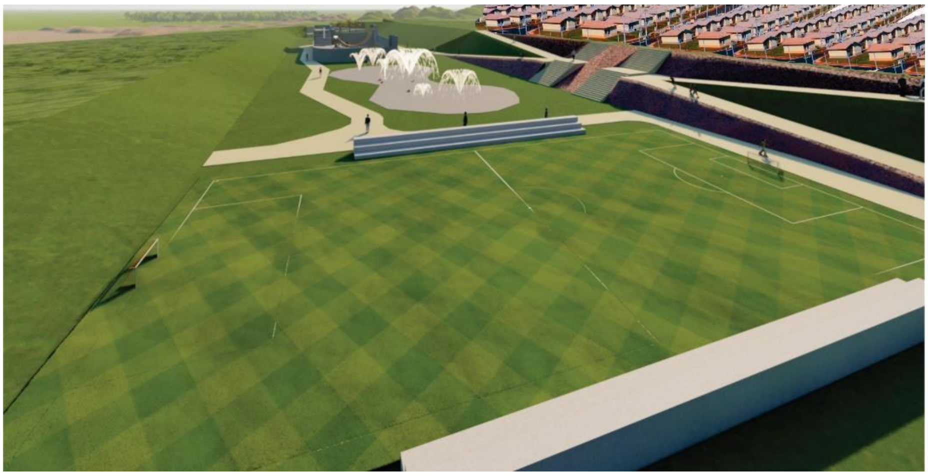


Figure 11– Illustrative image of a soccer field implemented in the retention basin. Source: Authors (2018).

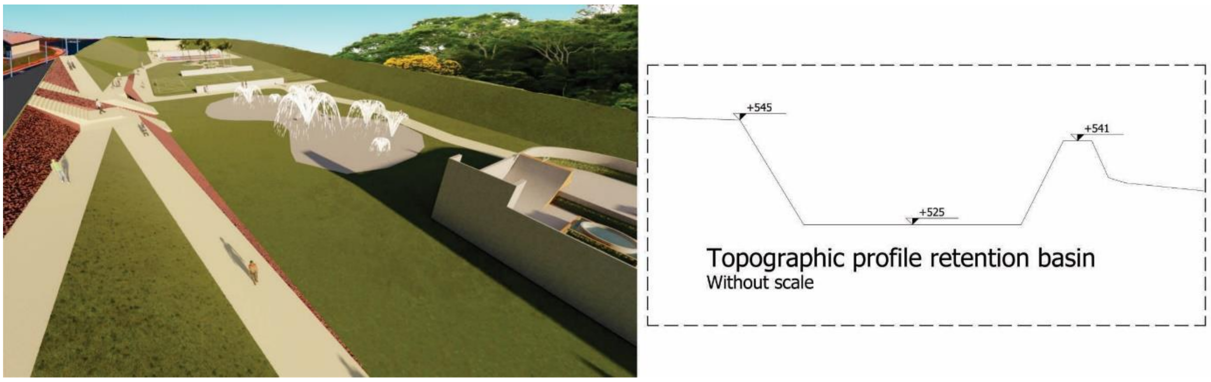


Figure 12 – Illustrative image of the floor fountain for public bathing implemented in the retention basin. Source: Authors (2018).

The area where the basin is located belongs to a green area from the subdivision (Figure 13), however, considering its current situation, this area does not provide any use for the population, therefore besides the use of the retention basin as a leisure area, its surroundings were also explored by implementing a leisure bike path, a walking trail, a playground, toilets, a base for the city guard and a bicycle rack.

Figure 13 - Green area Project with a designated leisure usage. Source: Authors (2018).

Although there was enough area for sports and leisure use in the rest of this green area, its topography is very rugged, and has about 13 meters of slope. This would cause major cuts and embankments to construct soccer fields and sports courts, as well as the need for using the basin area for mixed use due to the possibility of degradation problems already mentioned in the work.

Proposal evaluation

Considering the change in the use of public areas and the implementation of new compensatory techniques, it was possible to expand the green and leisure areas of the housing complex and enlarge the area of contribution to the seepage of rainwater and storage, as shown in Table 4.

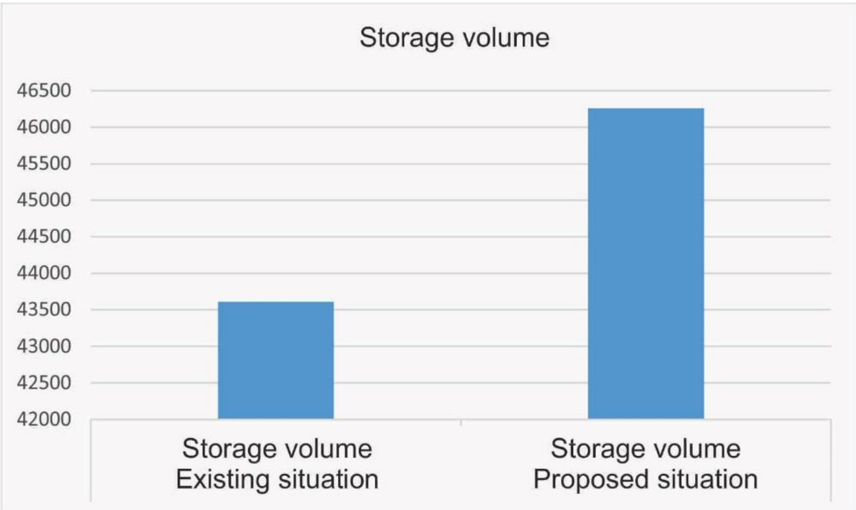
Table 4 - Calculations of contribution areas

Existing situation		
Area of contribution for existing superficial runoff (m²)	508896,33	
Retention basin	Area of contribution for seepage	Storage volume (m³)
	8548	43610
Proposed situation		
Ditches	Area of contribution for seepage	Storage volume (m³)
3 units	445	623
Rain Gardens	Area of contribution for seepage	Storage volume (m³)
156 units	12	5
Total of additional techniques	3207	2649
Usage of the Retention basin for leisure	6330	43610
General amount	9537	46259

Source: Authors (2018).

The initial contribution area for seepage was about 8548m^2 of retention/seepage basin for the subdivision. Considering the necessary interventions, it was possible to give new uses to these areas with greater environmental quality for the space and for the population, increasing the area by 989m^2 contribution to the infiltration of rainwater in the complex.

Regarding the storage volume in compensatory techniques, Bar Chart 2 shows that it was still possible to expand 3,000 cubic meters of water in the proposed situation.



Bar Chart 2 – Storage volume in the actual and proposed project situation. Source: Authors (2018).

Conclusions

Decentralized compensatory techniques were adopted after making calculations and dividing the area into micro catchments, enabling the implementation of 8 rain gardens in the blocks that cut the contour lines perpendicularly and 3 ditches throughout all the subdivisions, which increased the seepage area in

989m^2. The storage volume of rainwater increased by 3,000 cubic meters compared to the existing amount in the retention basin.

Thus, the detention basin can be used as a leisure area. Bringing more quality to the urban space and environment in the neighborhood used by the population, it will not suffer from deterioration due to the lack of care or solid waste disposal site, assimilating with the experiences of other cities where compensatory techniques are used.

Today, approximately 1.51% of the housing complex area is allocated to the leisure system, however there are no facilities in place and the area is surrounded, which prevents the population from appropriating the area.

The green areas of the complex have exposed soil. However, considering the implementation of compensatory techniques in these places, the likelihood of these spaces becoming eroded is reduced, in addition to preventing the soil from reaching the permanent preservation area during the rains, which would cause silting up of the springs.

Inspection by the public authorities could be greater in relation to determining public areas in housing developments, in order to ensure basic rights provided for in the Federal Constitution, thus providing neighborhoods with infrastructures more appropriate to the number of subdivisions implanted.

Having made the calculations and urban projects, the effectiveness in implementing decentralized compensatory techniques can be proven in order to increase infiltration and storage for the use of compensatory techniques as leisure units.

The new proposal for public areas at "*Residencial Vida Nova Dignidade*" aimed to change the urban scene of the place, providing greater quality of life for the population, in addition to greater guarantees of environmental preservation in the basin and green areas. Using basin areas for leisure purposes is an alternative to adapt these needs of the population to the lack of land at affordable prices in housing policies of social interest, and are therefore suggested here as guidelines to be incorporated into Brazilian housing policies, the order to ensure not only the right to housing, but also the right to the city.

References

Baptista, M., Nascimento, N., & Barraud, S. (2015) *Técnicas Compensatórias em Drenagem Urbana*. Porto Alegre: ABRH.

Brasil. Lei Federal nº 6766 de 19 de dezembro de 1979. Dispõe sobre o Parcelamento do Solo Urbano e dá outras Providências. *Diário Oficial da República Federativa do Brasil,* Brasília. 1979.

Brasil. Política Nacional de Habitação. Cadernos MCidades: Habitação, Ministério das Cidades - Secretaria Nacional de Habitação, Habitação, (01 de Novembro de 2004). Brasília. Acesso em 02 de maio de 2018, disponível em http://www.capacidades.gov.br/biblioteca/detalhar/id/127/titulo/cadernos+mcidades+4+++politica+nacional+de+habitacao

Brasil. Lei Federal nº 10.257 de 10 de julho de 2001. Regulamenta os arts. 182 e 183 da Constituição Federal, estabelece diretrizes gerais da política urbana e dá outras providências. *Diário Oficial da República Federativa do Brasil,* Brasília. 2001.

Bruno, L. O., Amorim, R. S. S., & Silveira A. (2013). Estudo da redução do escoamento superficial direto em superfícies permeáveis. *RBRH – Revista Brasileira de Recursos Hídricos*, 18(2), 237-247. http://dx.doi.org/10.21168/rbrh.v18n2.p237-247.

Cunha, G. R. (2014). *O Programa Minha Casa Minha Vida em São Jose do Rio Preto/SP*: Estado, Mercado, Planejamento Urbano e Habitação (Tese de Doutorado). São Carlos, Universidade de São Paulo.

Dolman, N., Savage, A., & Ogunyoye, F. (2013). Water-sensitive urban design: learning from experience. *Ice – Municipal engineer*, 166(ME2), 86-97.

Melo, T. A. T., Coutinho, A. P., Cabral, J. J. S. P., Antonino, A. C. D., & CIRILO, J. (2014). A. Jardim de chuva: sistema de biorretenção para o manejo das águas pluviais urbanas. *Ambiente Construído*, Porto Alegre, 14(4), 147-165. http://dx.doi.org/10.1590/S1678-86212014000400011.

Ministério das cidades. (2016). *Programa Minha Casa, Minha Vida.* Acesso em 02 de março de 2018. Recuperado em 02 de março de 2018, de http://www.minhacasaminhavida.gov.br/habitacao-cidades/programa-minha-casa-minha-vida-pmcmv

Oliveira, A. P., Barbassa, A. P., & Gonçalves, L. M. (2016). Aplicação de técnicas compensatórias de drenagem na requalificação de áreas verdes na cidade de Guarulhos. *Cidades Verdes*, 4(9), 87-101. doi http://dx.doi.org/10.17271/231786044920161385

Parra, G. G. (2016). *Efeitos dos espaços de circulação e permanência de pedestres (ECPP) sobre o manejo das águas de chuva: estudos de caso.* 120 f. Dissertação (Mestrado em Engenharia Urbana). Centro de Ciências Exatas e de Tecnologia, Universidade Federal de São Carlos, São Carlos.

Pereira, T. R. D. (2016). Integração de técnicas compensatórias de manejo de águas pluviais à paisagem urbana: aplicação à microbacia experimental do campus da UFSCar. 131 f. Dissertação (Mestrado em Engenharia Urbana). Centro de Ciências Exatas e de Tecnologia, Universidade Federal de São Carlos, São Carlos.

Peroni, C. S. L., Teixera, B. A. N. (2016). Avaliação da inserção urbana de bacias detenção de águas pluviais em dois condomínios residenciais nos municípios de Araraquara e São Carlos, São Paulo-Brasil. *Cidades Verdes*, 4(10), 50-65. http://dx.doi.org/10.17271/23178604.

Rolnik, R. (2015). *Guerra dos lugares*: A colonização da terra e da moradia na era das finanças. São Paulo: Boitempo.

São José Do Rio Preto. *Lei Municipal nº12.965 de 07 de junho de 2018*. Dispõe sobre a alteração da Lei nº 5.138, de 28 de dezembro de 1992, e dá outras providências. São José do Rio Preto: Diário Oficial de São José do Rio Preto.

Schucha, G.; Serrao-Neumanna, S., Morgana, E., & Choya, L. D. (2017). Water in the city: Green open spaces, land use planning and floodmanagement – An Australian case study. *Land Use Policy*, 63, 539-550. https://doi.org/10.1016/j.landusepol.2017.01.042

Water Sensitive Cities. Healthy communities through clean water. Recuperado em 25 de janeiro de 2019, de https://watersensitivecities.org.au/content/healthy-communities-clean-water.

Editor: Rodrigo Firmino

Received: June 3rd, 2020

Approved: Jan. 11th, 2021