

8.7 Flood control system in the Água Espraiada Creek in São Paulo by Aluísio Pardo Canholi

8.7.1 System characteristics

In the beginning of the twenty century a hydropower system was planned by Light & Power Co (Canadian Company) in Tietê and Pinheiros rivers (near São Paulo City). It was developed until the 50's. In this system, Tietê River has part of its flow diverted to Pinheiros River which has its flows pumped (two pumping stations called Traição and Pedreiras) to a Lake (called Billings). This lake is the storage system of the hydropower system which uses the an energy of 720 m (800 MW) of the coastal mountains (see item 8.5 for more information).

These basins were urbanized and the main issues are related to floods and water quality. Since Pinheiros flows has high hydraulic head, the urbanized tributaries usually flooded the confluences. A parallel channel was built, called Brooklin drain, in order to reduce this type of flood (figure 8.36).

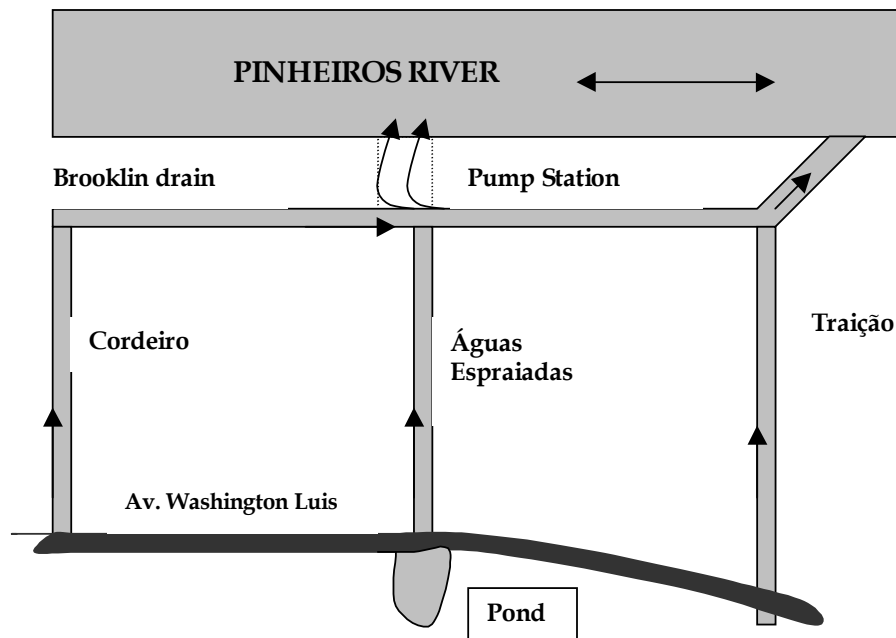


Figure 8.36 System characteristics

Água Espraiada is the Pinheiros River tributary which has not been channeled, and most part of its deck is occupied with slums. In the middle of the 1980's was started the construction of the Água Espraiada channel, preventing side roads implementation. The channel works stopped right after the construction of a small part of it. In 1995 the project was retaken under the responsibility of EMURB –(Urban Municipal Company). Água Espraiada channel would require a two fold increase in its flow conveyance of Brooklin drain. Since the cost and the implementations of the works were not feasible, a new design was required. The flood control design studied the system as whole taking Água Espraiada and Brooklin Drain as one system.

Água Espraiada stream still has natural course condition and some free space which allow the construction of an urban pond to damp the peak flow. Thus, the alternatives were focused on both, the reduction of the channel requirements and low cost.

8.7.2 Studied alternatives

Nine layouts were studied for the flood control works. The measures studied were based on flow damping by urban detention pond and by-pass with pumping systems.

The former design was based on the increase of the open channel conveyance of Água Espraiada stream and Brooklin Drain, downstream of Água Espraiada's entrance. The selected alternatives of the reviewed study were based mainly on technical and economic feasibility using the following concepts:

- Reservoir detention to reduce downstream flood peak;
- The exceeding flow bend from the Brooklin Drain to the Upper Pinheiros channel, resulted on each alternative configuration.
- Direct derivation through special gates and derivation through a pumping system.

Three alternative groups were selected in terms of project flow. For each group non-conventional alternatives were selected and described in the table 8.10. The design of the component structures of each alternative was quantified using the cost relation to the first high cost solution (table 8.11).

Table 8.10 Summary of the studied alternatives

GROUP	Alternative	Águas Espraiadas		Brooklin Drain	
		Solution	Q m ³ /s	Solution	Q m ³ /s
A	1	Former Designed	100	Galleries Reinforcement	100
	2	Channel (no basin detention)	100	(designed)	100
	3		100	Pumping System Direct Spilling	100
B	4	Pond next to Washington Luís Avenue	25 - 50	Galleries Reinforcement	44
	5			(designed)	44
	6			Pumping System Direct Spilling	44
C	7	Two ponds: Washington Luís Reservoir and Água Espraiada Mouth (Berrini)	25 - 50	Galleries Reinforcement	26
	8			(designed)	26
	9			Pumping System Direct Spilling	26

Table 8.11 Resumed total costs

Group	Alternative	costs compared with alternative 1 %
A	1 (original)	100
	2	74
	3	46
B	4	78
	5	51
C	6	40
	7	84
	8	57
	9	52

The alternatives of group C (two detention ponds) have higher costs than the group B of alternatives (one detention). The selected solution was B-5 because of the following: (i) safest system; (ii) it is independent of Pinheiros River water levels, downstream of the system. The selected alternative has design peak flow of 44 m³/s. The cost of hydraulic works for this solution was estimated as 51% of the former high costs alternative. The total cost estimate of the selected alternative was US \$ 20 millions.

The selected alternative has the following works:

- detention pond with 400.000 m³ damping part of the peak flood (Washington Luis);
- Água Espraiada's concrete rectangle channel downstream of the pond;
- Pumping System's with flow capacity of 44 m³/s and a derivation structure in the Brooklin drain, upstream of Água Espraiada entrance.

8.7.3 Design of the selected alternative

Hydrologic and hydraulic studies

The hydrologic studies were developed based on the design hydrographs of the several sections from Água Espraiada and Brooklin Drain. The design flow was calculated by the Soil Conservation Service (SCS) model. This model uses the a design storm based in the intensity-duration-curve of the place and a rainfall-runoff relationship based in parameters which represents the basin occupation conditions according to the design scenarios (see chapter 3).

The design rainfall storm duration was 120 minutes which is the upper limit of convective rainfall and greater than the basin time of concentration. The Água Espraiada peak inflow and the pond outflow are presented in table 8.12.

Table 8.12 - Água Espraiada Creek design peaks

LOCAL	Basin area (km ²)	Q (m ³ /s.)	
		Return Period (years)	
		T = 25	T = 50
Washington Luís Avenue	8.6	94	110
Eng. Luís Carlos Berrini	11.6	98	116
Intermediate Basin (between W. Luís Ave. And Luís Carlos Berrini)	3.0	33	39

The Washington Luís Pond

The detention pond will be used during the storm duration, becoming dry on the winter periods. This system has a channel which follow the entire reservoir along side and has the the basin low flow capacity. The stored volume is used during the storm duration, when the flow is greater than the channel downstream capacity limited by a structure.

The reservoir physical characteristics were designed to minimize the private areas and the interference on the existing facilities and road system.

The pond upper level was planned at 737 m, which uses an area of 13.000 m². Part of the pond area was planned for leisure. This height was defined in such a way that the water levels from 2-year of return period do not reach the recreational area. Therefore, the most frequent storm flows will be contained in the reservoir's inferior area, which will receive pervious paving and have access entrances to make the cleaning process easier. This inferior area will

have its access controlled and will have sporting and leisure equipment, besides landscape treatment.

According to the pond maximum water level of 742.50 m, which corresponds the minimum of the surrounding road system, the reservoirs capacity is 400.000 m³.

The pond outflow structure has a concrete tower. This tower has a bottom opening of 2.20 m of width and 1.00 m at 733 m. At the intermediate level of 740.5 m was designed a sharp crested free weir with 2.2 m width. For safety reasons culverts were designed, formed by four roof gutter made of concrete with 1.50 m width. The top of the roof gutters is at the level 742 m. The total length of the spilling weir at this height is 65 m. The spillway at maximum designed level has 80 m³/s capacity.

Channel downstream of the pond

Downstream of the pond, the flow is transported by a rectangular open channel with width varying from 6 to 8m and depth varying from 2.9 to 3.6 m. The channel construction will be built using previously modeled reinforced concrete components and a bottom slab with a drainage system.

The average slope is 0.004 m/m on the final reach. The Brooklin Drain entrance was adapted to the existing gallery structure, so it could compete with the new channel bottom levels.

The Pumping System

The Brooklin Drain has a flow capacity of 44 m³/s. The flow above this limit is diverted by a pumping station located upstream of Água Espraiada's entrance in the Brooklin Drain. This derivation will be studied by a physical model in the laboratories of FCTH (Foundation of Hydraulic Technological Center – São Paulo University).

The Pumping Station has stop-logs, trash-racks and clean-up device, control panels and check valves located downstream to each unit. The connection between the Pumping Station and the Upper Pinheiros Channel was designed with four steel penstocks of 1.5 m diameter, which will be implemented through soil tunnels works to avoid traffic bends on Marginal Avenue.

The power source will use the Traição Sub-Station system, in double circuit, in order to establish a better guarantee, mainly during thunderstorms.

8.7.4 Conclusions

The Canalization Project of Água Espraiada stream, besides gathering an important road system at the South Part of São Paulo and promote the valley's drainage, transforming a damped area of trash solid waste on a sound drainage system. The solution used the following basic principles:

- The search for an optimized solution from the study of alternatives;
- A complete view of the drainage problem including the Água Espraiada stream and the Brooklin Drain, from which is the affluent, proposing a gathered solution and emphasizing the technical and economical benefits from this association;
- Use of a dry detention open pond in areas which have been maintained dry except during the summer flow events. Such characteristic will allow the usage of part of the Washington Luís pond for recreational and entertainment, and yet for new green areas;
- The implementation of trash collector carried by the stream, at the reservoirs entrance, protecting all the space downstream from these materials;

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