

STRUCTURING ESTUARIES

GREEN INFRASTRUCTURE FOR GUANABARA BAY'S PRIMORDIAL DRAINAGE AREAS

Country /City Brazil, Rio de Janeiro

University / School UFRJ - Federal University of Rio de Janeiro - Faculty of Architecture and Urbanism

Academic year 2020

Title of the project STRUCTURING ESTUARIES: Green Infrastructure for Guanabara Bay's primordial drain areas.

Authors Franklin Gaspar, ADVISOR: Prof. DSc. Sérgio Magalhães

TECHNICAL DOSSIER

Title of the project	STRUCTURING ESTUARIES: Green Infrastructure for Guanabara Bay's primordial drain areas.
Authors	Franklin Gaspar, ADVISOR: Prof. DSc. Sérgio Magalhães
Title of the course	MPAP - Landscape Architecture Professional Master Program
Academic year	2020
Teaching Staff	Prof.DSc. Cristóvão Duarte, Prof.DSc. Lúcia Costa, Prof.DSc. Patricia Maya.
Department / Section / Program of belonging	MPAP - Landscape Architecture Professional Master Program
University / School	UFRJ - Federal University of Rio de Janeiro - FAU: Faculty of Architecture and Urbanism



Written statement, short description of the project in English, no more than 250 words

In the Guanabara Bay five river drainage zones correspond to 82.86% of the total freshwater inputs of the bay. Such drainage areas are concentrated in three estuaries at the bottom of the water body. Based on this, Structuring Estuaries proposes design interventions in the three major estuaries, areas of extreme relevance for the renewal of waters of Guanabara Bay.

Through the use of graphic and cartographic analyzes, this research aims to demonstrate by metrics and diagrams on the Landscape Planning scale, the territorial complexity and hydrological peculiarities of the Guanabara Bay that make it a structural component, both environmental and cultural, of the surrounding landscape.

Complementarily, in this document for the Barcelona Biennial, the intervention for one of these three estuaries is briefly presented: the Iguazu Estrela estuary, which corresponds to 32.42% of the amount of freshwater that flows into the bay.

For further information

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SCHOOL PRIZE

STRUCTURING ESTUARIES

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GUANABARA BAY

RELEVANCES OF AN ESTUARY BAY

Estuaries are flooded areas, characterized as transitory environments where freshwater from rivers reach salted seawater.

In short, an estuary can be understood as a transition zone between a river and the sea.

This brackish water environment, develop unique conditions for the development of life: the combination of freshwater and sea water provides an environment with a high load of nutrients and organic matter.



latim: zstuarium.
aeSTUM: heat + ÂRIUM -sufix, place where things are kept (place where the heat is kept).

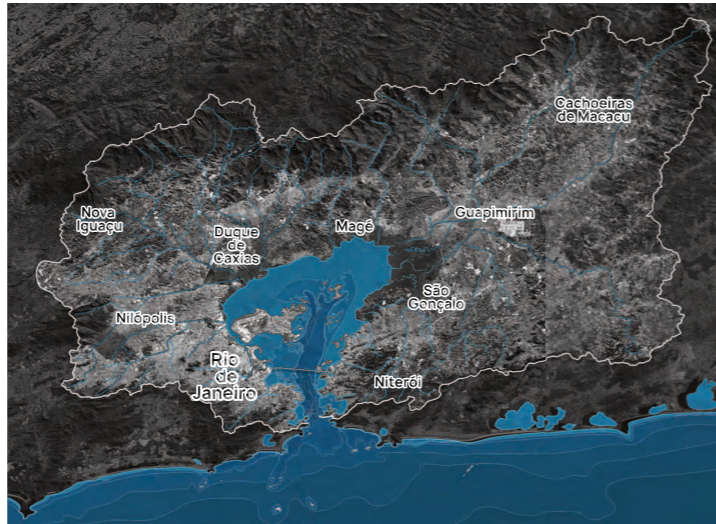
Fig.02: map: Orthophoto and hidrography. Source: Author.

1: Enlargement of a river near its mouth, which feels the effects of the tides;

2: Arm of the sea that forms due to the mouth of a river;

3: V track.

Such environments are closely influenced by tidal variations, subjecting constantly Changes in temperature and salinity. Under those circumstances, as water exchange movements seasonally, the estuary is a medium with a calendar of very regular biological activities throughout the year.



LOCAL ECOSYSTEMS

The Guanabara Bay is located in an ecological hot-spot where three of the main Brazilian ecosystems are connected: the Atlantic Forest, the Restingas and the Mangroves.



the Word Guanabara comes from the Indigenous tupy: Goanāpará
GOA= brest, basin + NA = similar + PARA = sea (brest/basin similar to the sea).

The French missionary Jean Lery (1536-1613), one of the founders of Antarctic France Mission, was the hrst person to register the Word Guanabara, in his book Histoire d'un voyage fait en la terre du Brésil (title as in the original published in 1578). Therefore, the Word of indigenous origin Guanabara means literally a body/breast similar to the sea.

The exuberance of this estuary bay, surrounded by a range of mountains and Che liveliness of Rio de Janeiro's metropolitan area contributed directly to the UNESCO World and Cultural Heritage title, "Rio de Janeiro: Carioca Landscapes between the Mountain and the Sea", a significant recognition given to the City in 2012.



83% OF FRESHWATER CONVERGING INTO 3 ESTUARIES

The analyzis shows that the five main river systems corresponds together to 82.86% of the total freshwater incomes of the Guanabara basin. Moreover, these drainage areas are concentrated in three large estuaries at the bottom of the bay, thus, three strategic points for the renewal and oxygenation of the waters and of

extreme relevance for the maintenance of the bay's ecosystem. Based on the data collected, Structuring Estuaries proposes design interventions in these three major flow zones of Guanabara Bay, elaborating on two questions:

- 1- What is the current significance of Guanabara Bay's main estuaries?
- 2- What can landscape architects do to improve the current scenario?

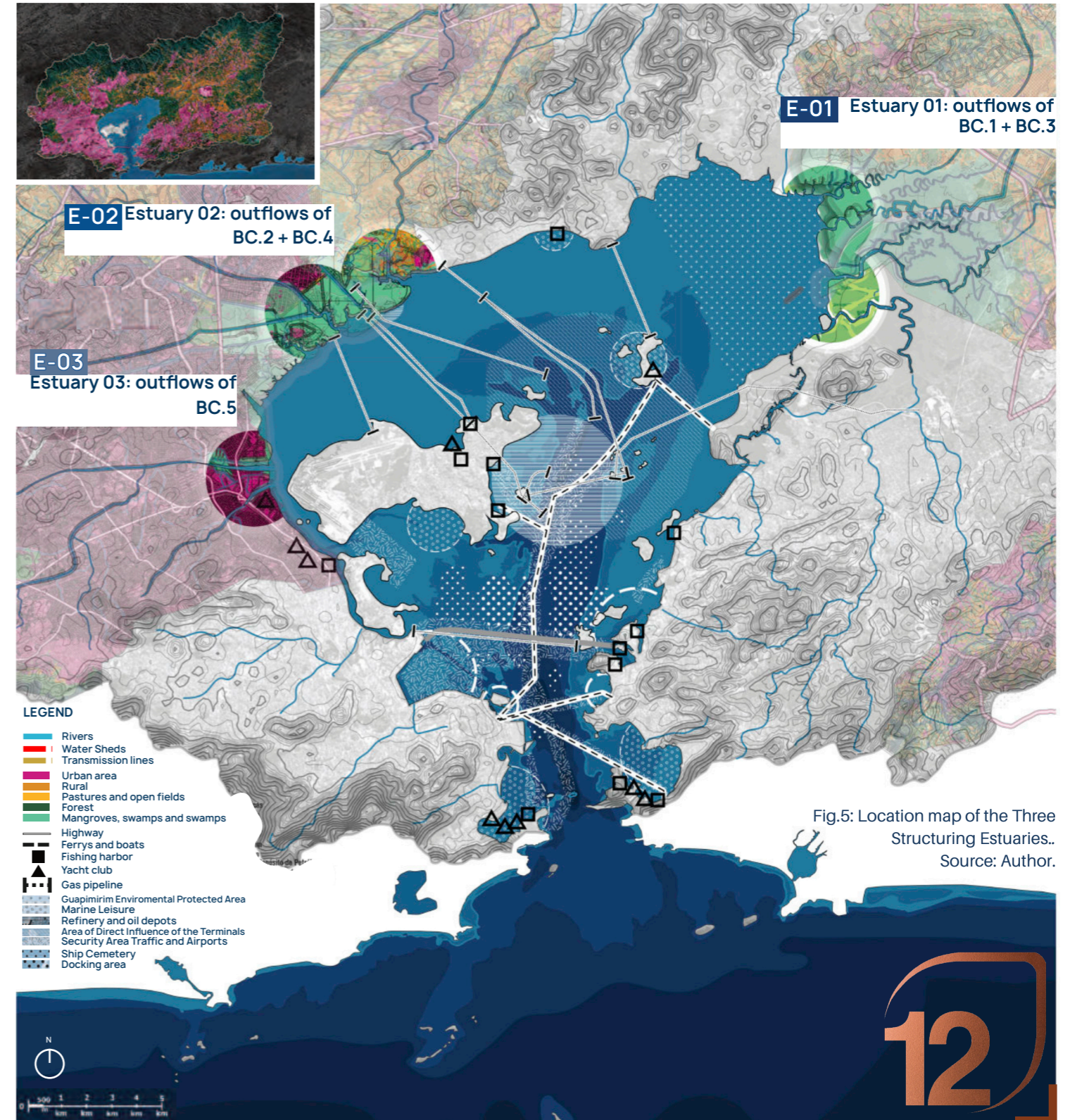
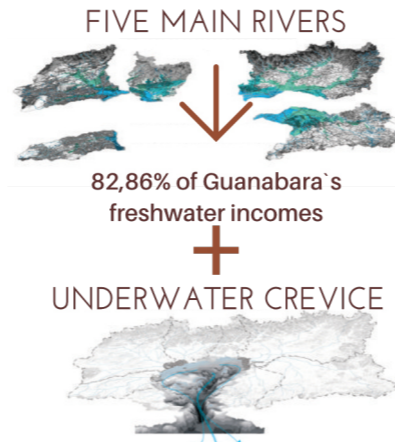


Fig.5: Location map of the Three Structuring Estuaries.. Source: Author.

GUANABARA BAY RUNOFF AND MAIN RIVERS

The rivers that flow into the Guanabara Bay are born in the Atlantic Forest and descend the steep hills of Serra do Mar in the north and the northeast coastal mountains, with strong erosive power and energy.

This energy is quickly lost in the lowlands due to the decrease of runoff speed, which cause the river to spread itself, increasing its groundwaters seepage and forming large swampy areas in the plains. (COELHO, 2007).



Among the draining rivers, the ones that most contribute to the discharge into the bay form ten main fluvial meandering systems and estuarine deltas. In a combinatorial average based on three different official assessments, the five main river systems are responsible for 82.86% of the total amount of fresh water supply of the Guanabara Bay. This percentage is distributed as follows:

ESTUARIES	Contributing Basins	Drainage Area (Km²)	Flow Rate (m³/s) (average)	% of Guanabara's Flow Rate (average)	% of Guanabara's Drainage Area	Flow Rate/Area	Main Location
E-01	Guapimirim+Caceribú	BC01+BC03	1.992,10	64,25	43,86%	51,32%	Guapimirim
E-02	Iguaçu+Estrela	BC02+BC04	1.046,50	52,26	32,43%	26,96%	Caxias
E-03	Meriti+Acari	BC05	163,50	11,46	6,57%	4,21%	Rio de Janeiro

BASINS	Drainage Area (Km²)	Flow Rate (m³/s) (SAMPAIO)	Flow Rate (m³/s) (ANA)	Flow Rate (m³/s) (P.C.Intl. dry)	Flow Rate (m³/s) (P.C.Intl. average)	Flow Rate (m³/s) (P.C.Intl. rainy)	% of total Flow Rate (SAMPAIO)	% of Flow Rate (ANA)	% of Flow Rate (P.C.I. dry)	% of Flow Rate (P.C.I. average)	% of Flow Rate (P.C.I. rainy)	Flow Rate (m³/s) (average)	% of Flow Rate (average)	Km² - Sub basins area (SEMADS, COELHO, AMADOR)	% of Guanabara's Drainage Area	Flow Rate/Area	Main Location	
BC.01	Guapimirim+Macacu+Soberbo	1.233,70	29,34	63,60	31,98	46,10	66,40	35,39%	22,74%	33,59%	35,37%	47,48	32,74%	1.262,03	31,78%	1,03	Guapimirim	
BC.02	Iguaçu+Sarapuí	704,00	16,74	74,80	23,12	28,75	36,88	20,20%	26,74%	24,28%	22,06%	36,06	22,72%	716,73	18,13%	1,25	Caxias	
BC.03	Caceribu/Porto das Caixas	758,40	18,04	35,20	4,72	9,42	16,46	21,76%	12,58%	4,96%	7,23%	16,77	11,12%	811,34	19,54%	0,57	Itaboraí	
BC.04	Estrela+Saracuruna+Inhomirim	342,50	8,15	38,50	7,30	10,95	16,10	9,83%	13,76%	7,67%	8,40%	16,20	9,71%	348,88	8,82%	1,10	Magé	
BC.05	Meriti+Acari	163,50	3,88	31,00	6,26	7,31	8,86	4,68%	11,08%	6,57%	5,61%	11,46	6,57%	154,26	4,21%	1,56	Rio de Janeiro	
BC.06	Canal do Cunha	70,23	1,43	8,90	3,89	4,50	5,34	1,72%	3,18%	4,09%	3,45%	2,94%	4,81	3,08%	70,23	1,81%	1,70	Rio de Janeiro
BC.07	Roncador	115,19	2,55	8,30	2,54	3,94	5,95	3,07%	2,97%	2,67%	3,02%	3,28%	4,66	3,00%	115,19	2,97%	1,01	Magé
BC.08	Guaxindiba+Alcântara+Mutondo	173,07	0,281	0,4	4,02	5,06	6,74	0,34%	0,14%	4,22%	3,88%	3,71%	3,30	2,46%	173,07	4,46%	0,55	Niterói
BC.09	Irajá + Canal da Penha	78,25	0,649	4,1	2,91	3,30	3,88	0,78%	1,47%	3,06%	2,53%	2,14%	2,97	2,00%	50,95	2,02%	0,99	Rio de Janeiro
BC.10	Suruí	84,44	1,265	-	1,37	2,09	3,19	1,53%	-	1,44%	1,60%	1,76%	1,58	1,27%	84,44	2,18%	0,58	Magé
BC.11	Canal do Manguê	37,95	-	5,1	1,92	2,24	2,71	-	1,82%	2,02%	1,72%	1,49%	2,39	1,41%	37,95	0,98%	1,44	Rio de Janeiro
BC.12	Iriú	19,63	0,20	4,40	0,33	0,47	0,68	0,24%	1,57%	0,35%	0,36%	0,37%	1,22	0,58%	19,63	0,51%	1,15	Magé
BC.13	Imboassú	29,43	0,28	3,80	0,90	1,11	1,43	0,33%	1,36%	0,95%	0,85%	0,79%	1,50	0,86%	29,43	0,76%	1,13	São Gonçalo
BC.14	Canal Canto do Rio	6,21	-	1,00	0,40	0,44	0,52	-	0,36%	0,42%	0,34%	0,29%	0,47	0,28%	6,21	0,16%	1,75	Niterói
BC.15	Canal de Magé	17,08	0,11	0,50	0,31	0,45	0,66	0,13%	0,18%	0,33%	0,35%	0,41	0,27%	17,08	0,44%	0,61	Magé	

BASIN	RIVERS	Drainage Area (Km²)	Flow Rate (m³/s) (SAMPAIO)	Flow Rate (m³/s) (ANA)	Flow Rate (m³/s) (P.C.Intl. dry)	Flow Rate (m³/s) (P.C.Intl. average)	Flow Rate (m³/s) (P.C.Intl. rainy)	% of Flow Rate (SAMPAIO)	% of Flow Rate (ANA)	% of Flow Rate (P.C.I. dry)	% of Flow Rate (P.C.I. average)	% of Flow Rate (P.C.I. rainy)	% of Flow Rate (average)	% of Flow Rate (P.C.I. average)	% of Flow Rate (P.C.I. rainy)	% of Guanabara's Drainage Area	Centralidade	
BC.01	Guapimirim+Macacu	1.233,70	29,34	62,10	31,98	46,10	66,40	35,39%	22,20%	33,59%	35,37%	36,60%	31,78%	35,37%	36,60%	31,78%	Guapimirim	
BC.02	Iguaçu	544,20	12,94	43,10	23,12	28,75	36,88	20,33%	15,61%	24,28%	22,06%	20,33%	14,02%	22,06%	20,33%	14,02%	Caxias	
BC.03	Caceribú/Porto Caixas	758,40	18,04	35,20	4,72	9,42	16,46	21,76%	12,58%	4,96%	7,23%	9,07%	19,54%	7,23%	9,07%	19,54%	Itaboraí	
BC.04	Estrela	342,50	8,15	32,80	-	-	-	9,83%	11,73%	-	-	-	8,82%	-	-	8,82%	Magé	
BC.02	Sarapuí	159,80	3,80	31,70	-	-	-	4,58%	11,33%	-	-	-	4,11%	-	-	4,11%	Caxias	
BC.05	Meriti	163,50	3,88	24,00	6,26	7,31	8,86	4,68%	8,58%	6,57%	5,61%	4,88%	4,21%	6,57%	5,61%	4,88%	Rio de Janeiro	
BC.06	Canal do Cunha	70,23	1,43	8,90	3,89	4,50	5,34	1,72%	3,18%	4,09%	3,45%	2,94%	1,81%	4,09%	3,45%	2,94%	Rio de Janeiro	
BC.07	Roncador	115,19	2,55	8,30	2,54	3,94	5,95	3,07%	2,97%	2,67%	3,02%	3,28%	2,97%	3,02%	3,28%	2,97%	Magé	
BC.05	Acari	(meriti)	-	7,00	-	-	-	-	2,50%	-	-	-	-	-	-	-	-	Rio de Janeiro
BC.11	Canal do Manguê	37,95	-	5,10	1,92	2,24	2,71	-	1,82%	2,02%	1,72%	1,49%	0,98%	1,72%	1,49%	0,98%	Rio de Janeiro	
BC.12	Iriú	19,63	0,20	4,40	0,33	0,47	0,68	0,24%	1,57%	0,35%	0,36%	0,37%	0,51%	0,36%	0,37%	0,51%	Magé	
BC.13	Imboassú	29,43	0,28	3,80	0,90	1,11	1,43	0,33%	1,36%	0,95%	0,85%	0,79%	0,76%	0,85%	0,79%	0,76%	São Gonçalo	
BC.04	Saracuruna	(estrela)	-	3,00	7,30	10,95	16,10	-	1,07%	7,67%	8,40%	8,87%	-	8,40%	8,87%	-	Magé	
BC.09	Irajá	27,30	0,65	3,00	2,91	3,30	3,88	0,78%	1,07%	3,06%	2,53%	2,14%	0,70%	3,06%	2,53%	2,14%	Rio de Janeiro	
BC.04	Inhomirim	(estrela)	-	2,70	-	-	-	-	0,97%	-	-	-	-	-	-	-	-	Magé
BC.01	Soberbo	(guapimirim)	-	1,50	-	-	-	-	0,54%	-	-	-	-	-	-	-	-	Guapimirim
BC.09	Canal da Penha	50,95	-	1,10	-	-	-	-	0,39%	-	-	-	-	-	-	-	-	Rio de Janeiro
BC.14	Canal Canto do Rio	6,21	-	1,00	0,40	0,44	0,52	-	0,36%	0,42%	0,34%	0,29%	-	0,34%	0,29%	-	-	Niterói
BC.15	Canal de Magé	17,08	0,11	0,50	0,31	0,45	0,66	0,13%	0,18%	0,33%	0,35%	0,41	0,27%	0,33%	0,35%	0,44%	Magé	
BC.08	Mutondo	(guaxindiba)	-	0,20	-	-	-	-	0,07%	-	-	-	-	-	-	-	-	Niterói
BC.08	Alcântara	(guaxindiba)	-	0,10	4,02	5,06	6,74	-	0,04%	4,22%	3,88%	3,71%	-	3,88%	3,71%	-	-	Niterói
BC.16	Bomba	26,78	-	0,10	1,20	1,40	1,72	-	0,04%	1,26%	1,07%	0,95%	-	1,07%	0,95%	-	-	Niterói
BC.08	Guaxindiba	173,07	0,28	0,10	-	-	-	0,34%	0,04%	-	-	-	-	-	-	-	-	Niterói
BC.10	Suruí	84,44	1,27	-	1,37	2,09	3,19	1,53%	-	1,44%	1,60%	1,76%	-	1,60%	1,76%	-	-	Magé
BC.17	Carioca	21,68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Rio de Janeiro
BC.18	Baía São Cristóvão	-	-	-	0,18	0,24	0,31	-	-	0,19%	0,18%	0,17%	-	0,18%	0,17%	-	-	Rio de Janeiro
BC.19	Baía Cabo de Brito	-	-	-	0,22	0,38	0,60	-	-	0,23%	0,29%	0,33%	-	0,29%	0,33%	-	-	Caxias
BC.20	Baía Botafogo	-	-	-	0,19	0,36	0,60	-	-	0,20%	0,28%	0,33%	-	0,28%	0,33%	-	-	Rio de Janeiro
BC.21	Baía Mauá	-	-	-	0,32	0,44	0,63	-	-	0,34%	0,34%	0,35%	-	0,34%	0,35%	-	-	Magé
BC.22	Baía Charitas	-	-	-	0,24	0,30	0,41	-	-	0,25%	0,23%	0,23%	-	0,23%	0,23%	-	-	Niterói
BC.23	Baía Itaoca	-	-	-	0,12	0,18	0,27	-	-	0,13%	0,14%	0,15%	-	0,14%	0,15%	-	-	São Gonçalo
BC.24	Baía Catedrar	-	-	-	0,42	0,48	0,57	-	-	0,44%	0,37%	0,31%	-	0,37%	0,31%	-	-	Niterói
BC.25	Baía Norte Centro	-	-	-	0,36	0,42	0,52	-	-	0,38%	0,32%	0,29%	-	0,32%	0,29%	-	-	Magé
TOTAL		3882,04	82,899	279,7	95,22	130,33	181,43	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%		

Different water courses converging into large estuaries: After traveling through different routes, the five main river systems converge on three major flood zones of the Guanabara Bay: the Structuring Estuaries.

Table 01: Main contributing rivers, basins and estuaries: Combinatorial average based on the results of three official analyzes (Pacific Consultants International, em 2003; Agencia Nacional de Aguas, em 2007; SAMPAIO, em 2003). Source: Author.

- 1st - The Macacu-Guapimirim River System, with an average flow rate of 47,48 m³ which corresponds to 32,74% of Guanabara's total amount of freshwater supply;
- 2nd - The Iguaçu-Sarapuí River System, with an average flow rate of 36,06 m³ which corresponds to 22,72% of Guanabara's total amount of freshwater supply;
- 3rd - The Caceribú-Porto das Caixas River System, with an average flow rate of 16,77 m³ which corresponds to 11,12% of Guanabara's total amount of freshwater supply;
- 4th - The Estrela-Inhomirim River System, with an average flow rate of 16,20 m³ which corresponds to 9,71% of Guanabara's total amount of freshwater supply;
- 5th - The Meriti-Pavuna River System, with an average flow rate of 11,46 m³ which corresponds to 6,57% of Guanabara's total amount of freshwater supply;

STRUCTURING ESTUARIES

GREEN INFRASTRUCTURE FOR GUANABARA BAY'S PRIMORDIAL DRAINAGE AREAS

INTERVENTION AREAS

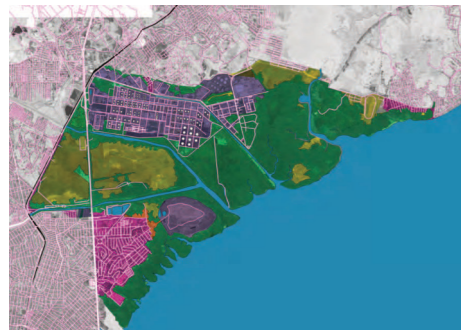
ESTUARY 02: ENVIRONMENTAL PROTECTION AREA OF THE ESTUARY OF ESTRELA, IGUAÇU AND SARAPUÍ RIVERS + CAXIAS ECOLOGICAL STATION



Although the Estuary 02 suffered several landfills and river rectifications in the second half of the 20th century, this area has a mosaic of green areas to buffer and isolate the petrochemical industries and the urban zone, functioning nowadays as a green belt inside the city of Duque

de Caxias. The landscape zoning of this project is based on this assumption, adding constructed wetlands engineering for the phytoremediation of the rivers before flowing into the bay.

1. ESTUARY 02 LEGACY PLAN



YEAR OF 2020: CURRENT SITUATION
INDUSTRIAL + DAMPING AREA + MILITARY AREA

- LEGEND**
- Rivers
 - Highway
 - River beds
 - Access to the river (naturalized)
 - Access to the river (urban)
 - Access to the river (infrastructure)
 - Urban area
 - Rural
 - Pastures and open fields
 - Forest
 - Mangroove, swamps, lowlands



YEAR OF 2025: SHORT TERM
GREEN CORRIDORS TO DEFINE BOUNDARIES + BUFFER ZONES

- LEGEND**
- Rivers
 - Highway
 - River beds
 - Access to the river (naturalized)
 - Access to the river (urban)
 - Access to the river (infrastructure)
 - Urban area
 - Urban area expansion
 - Urban Park
 - FMP - Infrastructural Edge
 - Protection Marginal Strip (100m)
 - Degraded Area Recovery



YEAR OF 2040: LONG TERM
CAXIAS ECOLOGICAL STATION + ENVIRONMENTAL PROTECTION AREA

- LEGEND**
- GREEN INFRASTRUCTURE and NBS's**
- 01 NBS Drainage in Public Areas
 - 02 Water border park
 - 03 Renaturalized water channel
 - 04 Lowland area
 - 05 Constructed Wetlands

- CONSTRUCTED WETLANDS FOR RIVER WATER TREATMENT**
- G Preliminary
 - T1 Primary Wetland
 - T2 Secondary Wetland
 - T3 Tertiary Wetland
 - T4 Quaternary Wetland

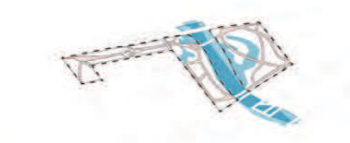
2. PERSPECTIVE PLAN OF THE URBAN RECREATIONAL AREAS



- 01 - JARDIM GRAMACHO URBAN PARK**
- STUDY CENTER, LIBRARY AND SOCIAL EQUIPMENT.
 - SPORTS ACTIVITIES.
 - URBAN POLLUTION MONITORING.
 - SPORTS ACTIVITIES.
 - SPORTS ACTIVITIES.
 - WATER TRANSPORTS



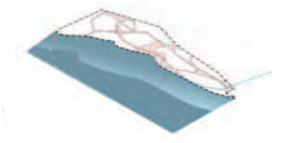
- 02 - SARAPUÍ RIVER LINEAR PARK**
- COMMUNITY GARDEN
 - URBAN POLLUTION MONITORING.
 - SPORTS ACTIVITIES.
 - CRVM: MANGROOVE VEGETATION REPLANTING CENTER



- 03 - IGUAZU RIVER LINEAR PARK**
- STUDY CENTER, LIBRARY AND SOCIAL EQUIPMENT.
 - COMMUNITY GARDEN
 - URBAN POLLUTION MONITORING.
 - SPORTS ACTIVITIES.

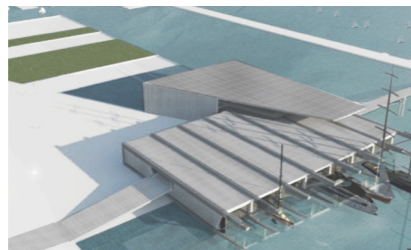


- 04 - PACOBAÍBA URBAN PARK**
- COMMUNITY GARDEN
 - CRVM: MANGROOVE VEGETATION REPLANTING CENTER
 - URBAN POLLUTION MONITORING.
 - SPORTS ACTIVITIES.



- 05 - MAUÁ WATERFRONT**
- DECK FOR MONITORING DOLPHINS AND AQUATIC FAUNA.
 - URBAN POLLUTION MONITORING.
 - SPORTS ACTIVITIES.
 - WATER TRANSPORTS

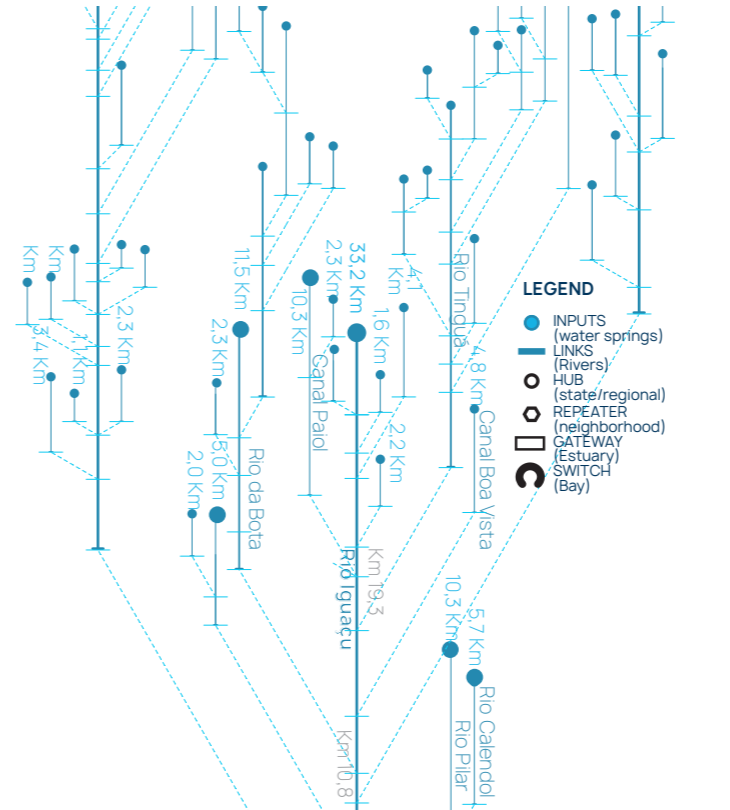
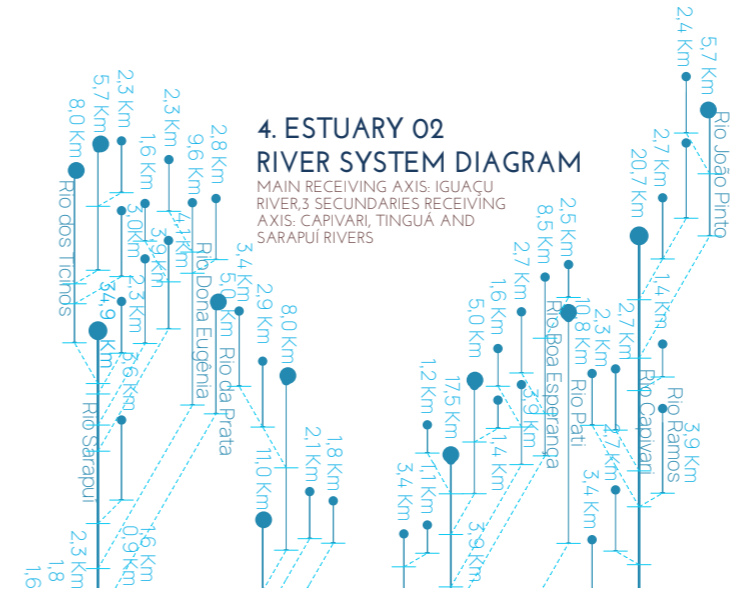
3. WATERSENSITIVE ACTIVITIES AT THE BAY



3.1. WATER ACTIVITIES

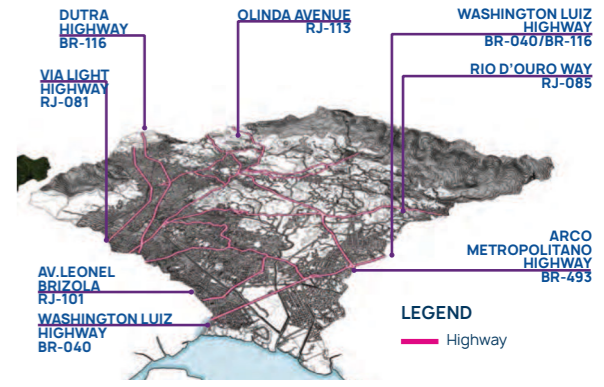
3.2. JARDIM GRAMACHO BOAT STATION

3.3. JARDIM GRAMACHO WATERFRONT

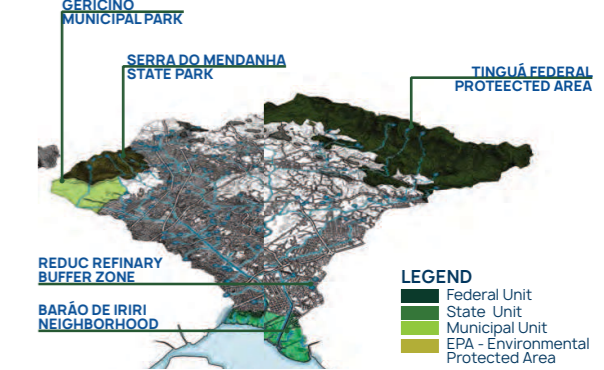


5. ESTUARY 02 RIVER SYSTEM DIAGRAM

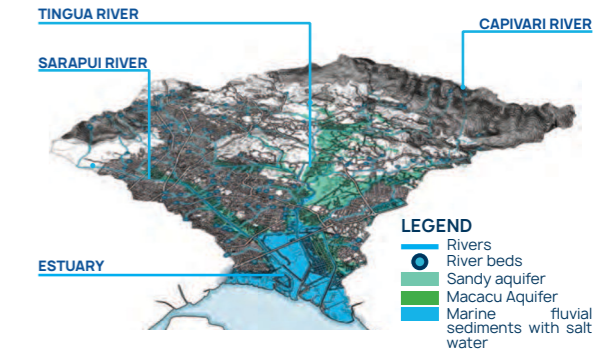
5.1. MAIN TRANSPORTATION



5.2. GREEN AREAS AND CONSERVATION UNITS



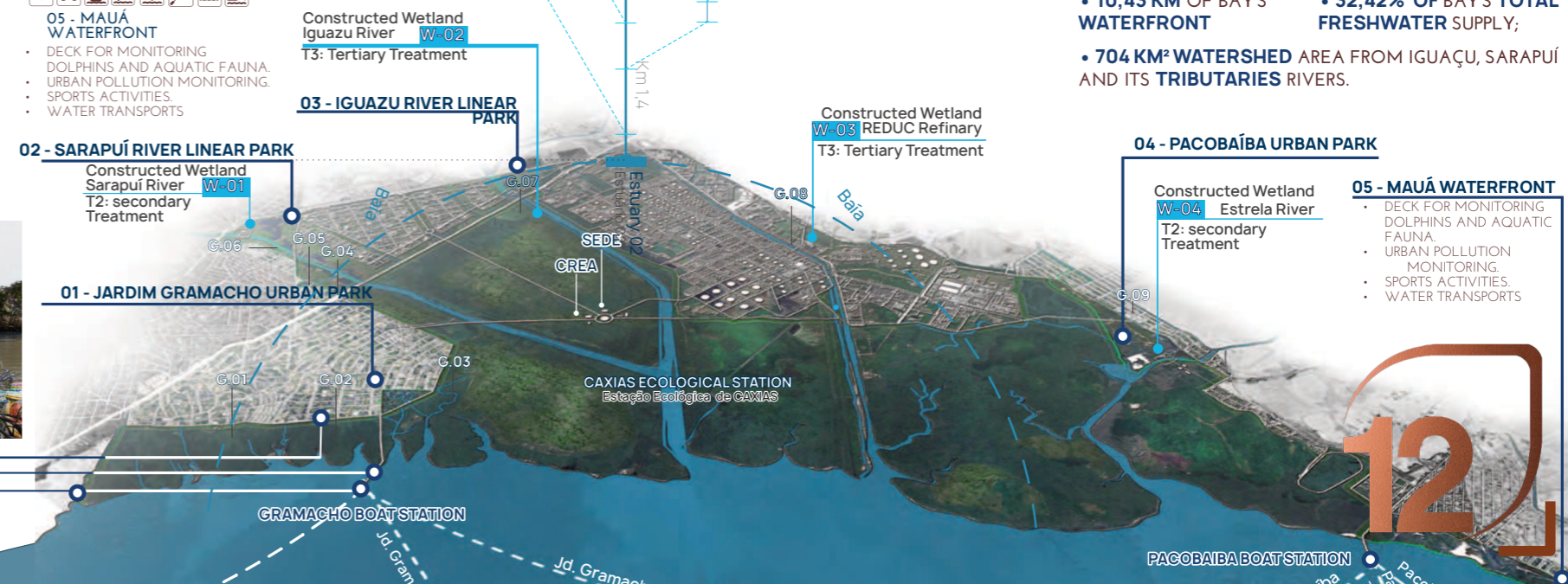
5.3. MAIN RIVERS AND AQUIFERS



6) ESTUARY 02 PERSPECTIVE PLAN

PLANO PERSPECTIVADO DO SISTEMA DE UNIDADES DE CONSERVAÇÃO + ZONAS DE ESPECIAL INTERESSE URBANO DO ESTUÁRIO

- 10,43 KM OF BAY'S WATERFRONT
- 32,42% OF BAY'S TOTAL FRESHWATER SUPPLY;
- 704 KM² WATERSHED AREA FROM IGUAÇU, SARAPUÍ AND ITS TRIBUTARIES RIVERS.



6) ESTUARY 02 PERSPECTIVE PLAN