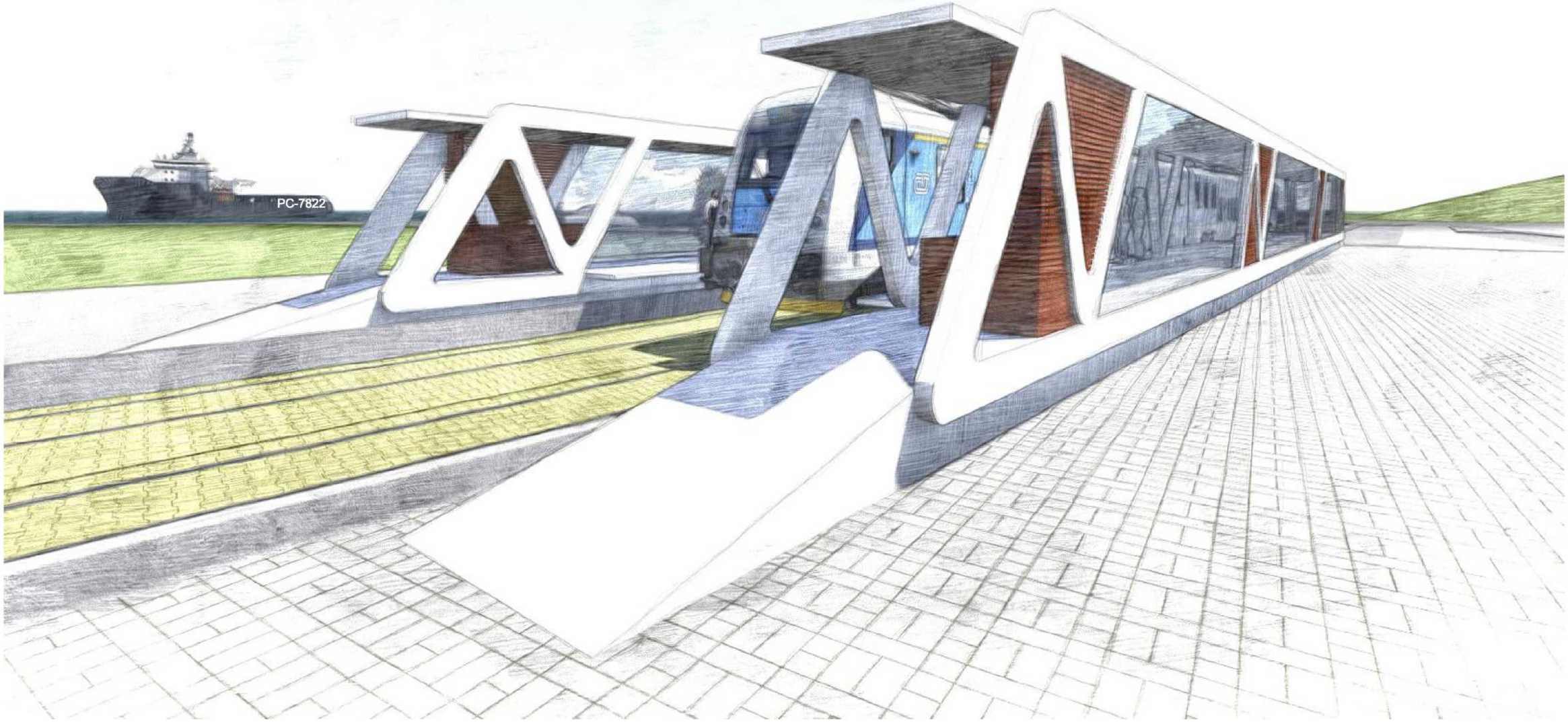
LRV OF SALVADOR

LIGHT-RAIL VEHICLE



CTB
COMPANHIA DE TRANSPORTES DO ESTADO DA BAHIA

VOLUME II – APRIL 2017

BAHIA
GOVERNO DO ESTADO

Presentation

Preliminary Design – Volume II

Presentation

In order to prepare the preliminary design for ***Implementation of railway superstructure*** as a result of "Intensions Protocol" signed between the State Government and the Municipal Government of Salvador, for the implementation of a transport corridor on rails, aiming the movement of Light-Rail Vehicles - LRV, to transport passengers between Comércio and City of São Luís in Paripe.

Initially was presented a Conceptual Design as a reference to support the formation of decisions by the State Government, containing a list of information sufficient for full orientation of the competitors in the pre-qualification opportunity, during the Bidding Process. As a result of this process, it was developed the Preliminary Design, for the subsequent compliance, addressing the program content required by the Program of Needs, defined by the State Government to the Enterprise.

The configuration of the Preliminary Design for better understanding, was divided in two large structured blocks, submitted in two separate volumes, entitled:

- Preliminary Design Volume I
- Preliminary Design Volume II

The first block, as a result of crossing conditions of central urban areas and railroad suburb of Salvador, addresses the environmental, physical and socioeconomic characteristics of the zone of influence, and establishes the aesthetic and functional framework detailing structured components for landscaping, accessibility, with emphasis on level passages, road integration with other modes of transport, addressing the connections to the stops, and the functional and operational facilities, including additional components such as signaling; communication; electrification; lighting and safety.

The second block, due to the geometric constraints imposed by the urban environment and land subdivision along the movement vector, details, conditioned by the restrictions arising from the scope of the preliminary design, under the limited scope of the operational right of way, the procedures to be followed for railroad deployment, involving ***evaluation of support conditions of the lower bed, treatment of required infrastructure and dimensional and structural establishment of the railway superstructure,*** to ensure proper and safe movement conditions for the vehicles of the design.

The subsequent breakdown of the railway superstructure under the responsibility of the subscribed authors is intended for evaluation of the agents involved in the analysis, approval and control of the enterprise, evidently with no intention to exhaust the matter, a situation that should be the subject matter of ***Basic and Executive Designs***, to be prepared after that, in the appropriate opportunity, in the course of contractual obligations. Further clarification will be attached if requested by any of the agents related before, with the relevant technical reasons.

The entire program content has undergone a process for promoting alternatives, selected by weighting the concepts, values and quality in the course of the Reference Conceptual Design, now systematized and consolidated in the core of the Preliminary Design. If this content causes discussion and achieves the subject matter desired in the Program of Needs, we will be gratified by that.

Salvador - Ba, 08/01/2015
Engs. Robério Bezerra & Cynthia Brito & André Cury

Design and Conditions

Design

Even limited by the restrictions of the urban environment and land subdivision, the Route Design cannot be away from the physical purpose imposed by the ambience and social and economic aspect within the considered area of influence over the remarkable points of the desire line.

We considered, in the Reference Conceptual Design presented before, a list of route alternatives, evaluated, commented and subjected to selection, resulting in a reference axis, located in the railway track center, submitted to the approval of the Municipal Government of Salvador, the competent authority for management of land use in the city of Salvador.

Those responsible for the definition of the Urban Party discussed with the official representation of the Municipality of Salvador, establishing in this occasion the limitations and constraints of the final route as a result of alternations and marginal provisions of the tracks intended for road traffic, parking lots and crossings on the permanent track in this situation, all leveled. As a result, the people responsible for the breakdown of the railroad deployment were able to establish the analytical conditions for geometrization of the rail course and the consequent dimensional and structural details of the required superstructure.

Technical Conditions per Route

Due to the different conditions of current use and current characteristics, the route of the railway with a total length of 18,540 km, was divided as follows:

Comércio - Calçada Section → implementation of a new railway with permanent track in double line, spaced with international clearance, with a length of 3,520 km, with concrete ballast, with encapsulated neck rails arranged in bed, 8.00 m wide, continuous and uniform, resting on the floor or existing construction sites (treated as new pavement), limited laterally by concrete guides (curb), 20 cm high.

Enterprise Features - Implementation		
Permanent Track for movement of Light-rail Vehicles - LRV		
Superstructure with encapsulated neck rails in reinforced concrete slab		
Electrified traction with lampposts and centralized catenary in the track.		
Clearance - International	1,435	m
Design Speed	50	Km/h
Extension of the track on dual track	3.520	m
Width of the platform of the Permanent Track	8	m
Minimum horizontal bending radius	140	m
Minimum concave vertical bending radius	3.942	m
Minimum convex vertical bending radius	2.398	m
Maximum grade	1,44	%
Number of stops	4	unit
Number of level passages	11	unit

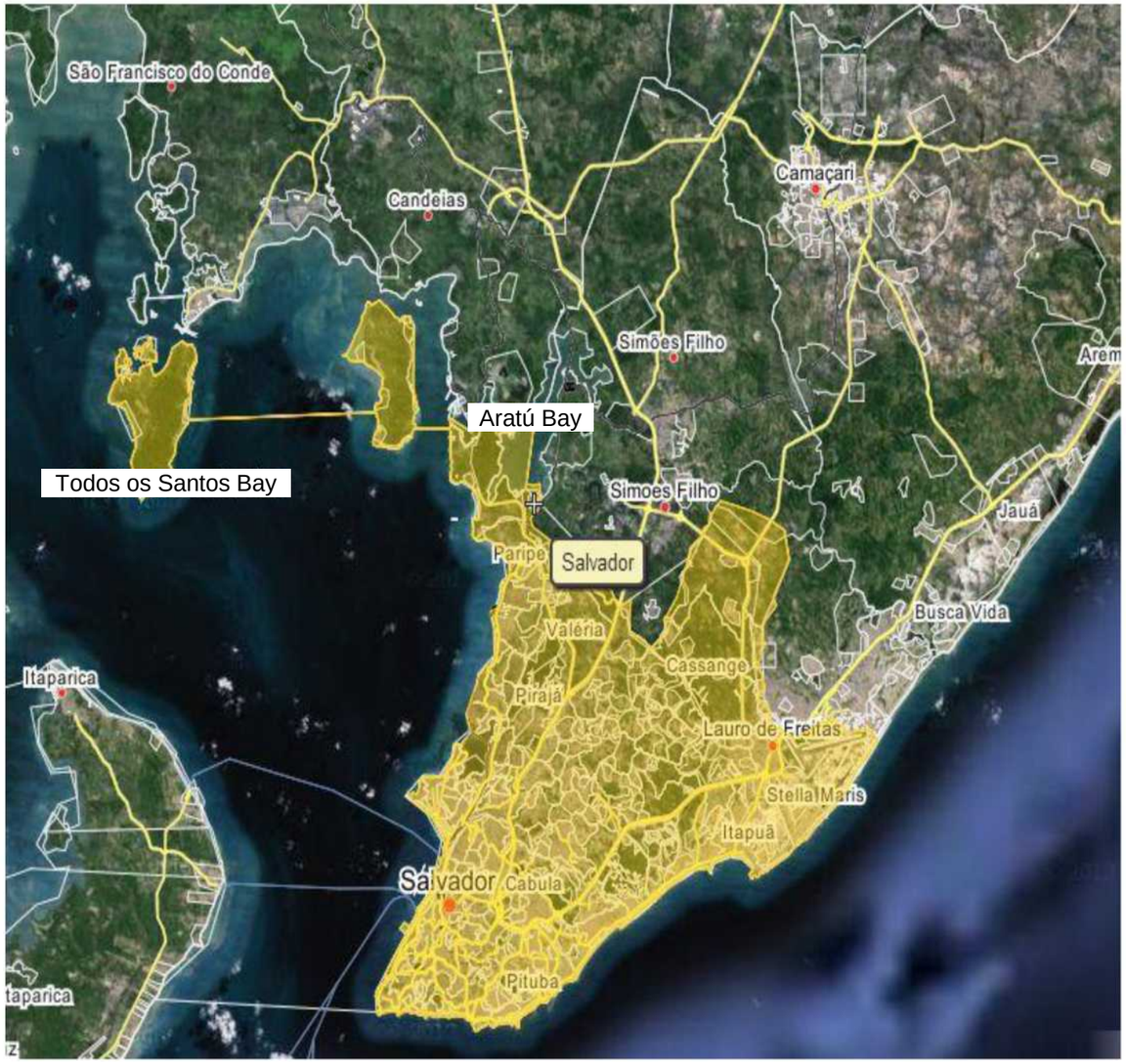
Calçada - Paripe Section → requalification of the railway along the existing section and under operation, in dual line, by changing the current meter clearance, for international clearance, with a length of 13.360 km, with new crushed stone ballast, with conventional rails, TR_45 type, arranged in bed, 8.00 m wide, continuous and uniform, supported on the old ballast to be now configured structurally as sub-ballast, limited laterally by concrete guide, 20 cm high.

Enterprise Features - Requalification		
Permanent Track for movement of Light-rail Vehicles - LRV		
TR_45 Rails - on prestressed monoblock concrete sleepers - crushed stone ballast		
Electrified traction with lampposts and centralized catenary in the track.		
Clearance - International	1,435	m
Design Speed	70	Km/h
Extension of the track on dual track	13,360	m
Width of the platform of the Permanent Track	8	m
Minimum horizontal bending radius	230	m
Minimum concave vertical bending radius	23.946	m
Minimum convex vertical bending radius	23.566	m
Maximum grade	0,78	%
Number of stops	16	unit
Number of level passages	4	unit

Paripe - São Luís Section → Implementation of a new railway within the existing right of way, in dual line, with international clearance, with a length of 1,660 km, with new crushed stone ballast, with conventional rails, TR_45 type, arranged in bed, 8.00 m wide, continuous and uniform, supported on the old ballast to be now configured structurally as sub-ballast, limited laterally by concrete guides, 20 cm high.

Enterprise Features - Implementation		
Permanent Track for movement of Light-rail Vehicles - LRV		
TR_45 Rails - on prestressed monoblock concrete sleepers - crushed stone ballast		
Electric traction with lampposts and centralized catenary in the track		
Clearance - International	1,435	m
Design Speed	60	Km/h
Extension of the track on dual track	1.660	m
Width of the platform of the Permanent Track	8	m
Minimum horizontal bending radius	140	m
Minimum concave vertical bending radius	3.998	m
Minimum convex vertical bending radius	15.742	m
Maximum grade	1,33	%
Number of stops	1	unit
Number of level passages	1	unit

Municipality of Salvador - Catchment Area



Support Conditions

Comércio - Calçada Section → In this section, the railway superstructure will be arranged on the existing asphalt pavement at Avenida da França and Avenida Oscar Pontes, taking advantage of the structure of the existing pavement, as a sub-ballast layer, which normally requires support conditions of CBR = 30%. Note that the existing asphalt coating has structural coefficient k = 2, a thickness of about 10 cm, based on graded crushed stone with CBR = 80 **%** and structural coefficient k = 1 with a thickness of 15 cm and sub-base in stabilized soil with a thickness ranging from 15 to 20 cm, with structural coefficient k = 0.8 and CBR >= 20% (minimum standard requirements for this use).

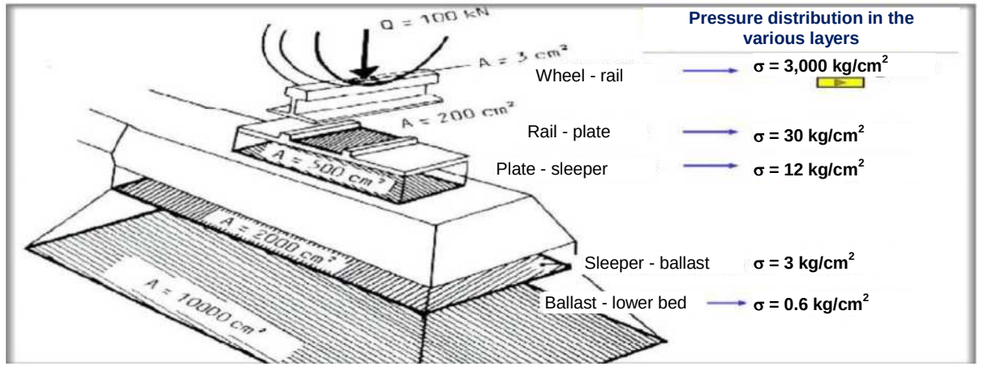
In sections where the railway superstructure is not supported on the existing pavement with asphalt concrete coating, particularly in locations where there is under the future rail bed afforestation sites, the affected areas will be treated with removal of the existing soil in a defined geometric configuration and 45 cm thick to bear a paving complementary structure with 20 cm of stabilized granular soil sub-base, 15 cm of compressed crushed stone and 10 cm of rolled concrete.

On the occasion of the preparation of the Basic Design, this assessment should be confirmed to support the final sizing, by spaced samples along the track, maximum 200.00 m, alternating the left and right axles of the railroad, with readings of recoverable deflections using the "***Benkelman Beam"*** or tests ***FWD*** presenting similar results, but with faster execution process and with less inconvenience to users of these avenues in paved sections with hot-rolled bituminous concrete and stone blocks. The sections in the soil will be subjected to sampling for the determination of the California Bearing Ratio - CBR, also with minimum clearance of 200 m, and can also be used with accuracy advantages, readings of ***"Benkelman Beam"*** or ***FWD tests.*** Inside Calçada station there is a paving section using stone blocks, in which it can be used similar procedure.

Calçada - Paripe Section → This section has conventional superstructure, supported in some section on expansive soil, black clay type or similar, with sub-ballast of inert granular material, ballast in graded crushed stone, prestressed monoblock concrete sleepers and TR_45 type rails; it should be noted that the system has been deployed more than 150 years ago and is maintained with continuous and uninterrupted operation, including, switching between freight trains and passenger trains. For the implementation of the enterprise, the existing grid in meter clearance will be removed and the crushed stone ballast spread to structurally set up a sub-ballast. At the time of assembling the new grid, it will be configured geometrically with international clearance. In this sense, it will be necessary on the occasion of the Basic Design, to support the sizing of the superstructure, evaluate the lower bed conditions through FWD readings tests throughout the sections with samples every 200 m, alternating between the left and right sides of the axis of each track.

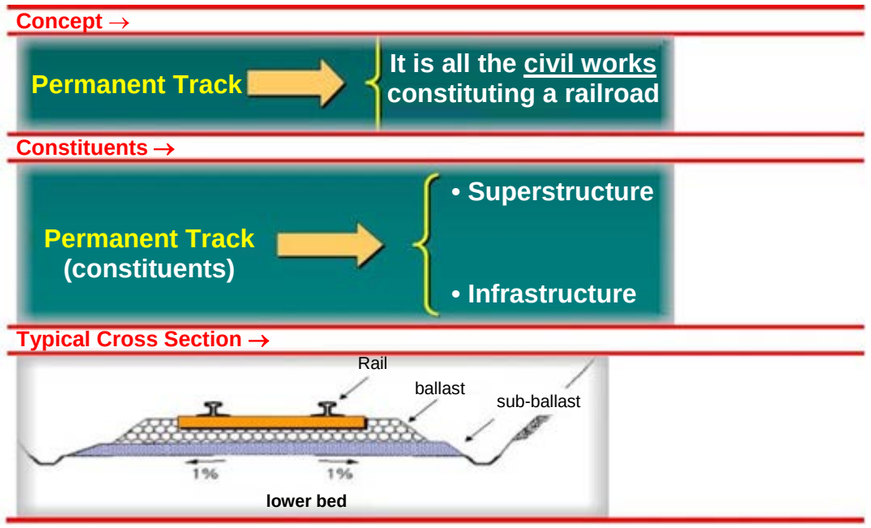
Paripe - São Luís Section → In this section, for about 14 years, there was a conventional superstructure, supported in some places on expansive soil, black clay type or similar, with sub-ballast of granular natural material, ballast in graded crushed stone. Since the sleepers and rails will be removed for implementation of the enterprise, the grade should be elevated, of about 1.00 m, with the incorporation of crushed stone ballast (inert stone material), to ensure the structural conditions required for foundation to the level of the crushed stone ballast. In this sense, it will be necessary on the occasion of the Basic Design, to support the sizing of the superstructure, at the time of preparation of the Executive design, to evaluate the lower bed conditions through FWD readings tests throughout the sections with samples every 200 m, alternating between the left and right sides of the axis of each track.

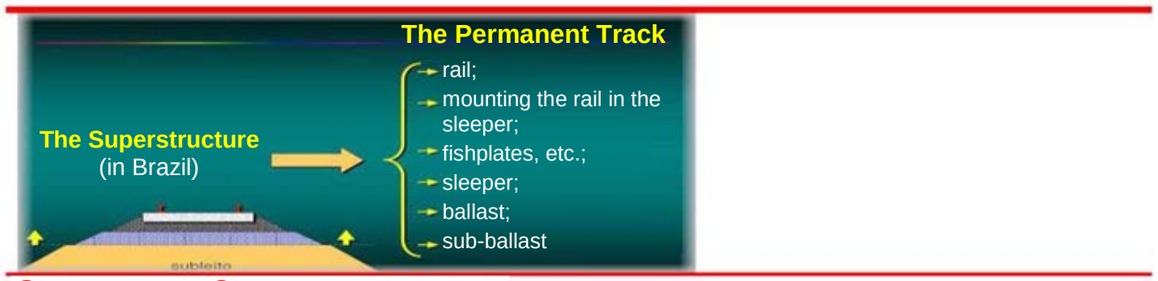
Required Pressures in the Lower Bed → The pressures required to the lower bed level considering the type of vehicles currently traveling on the rail would be of about 0.6 kg/cm^2, since the wheel load would be Q = 100 kN, according to the following illustration. In the case of the LRV, the load is reduced to 50 kN, which would lead to distribution of pressures at the level of the lower bed to values of about 0.3 kg/cm^2 only.



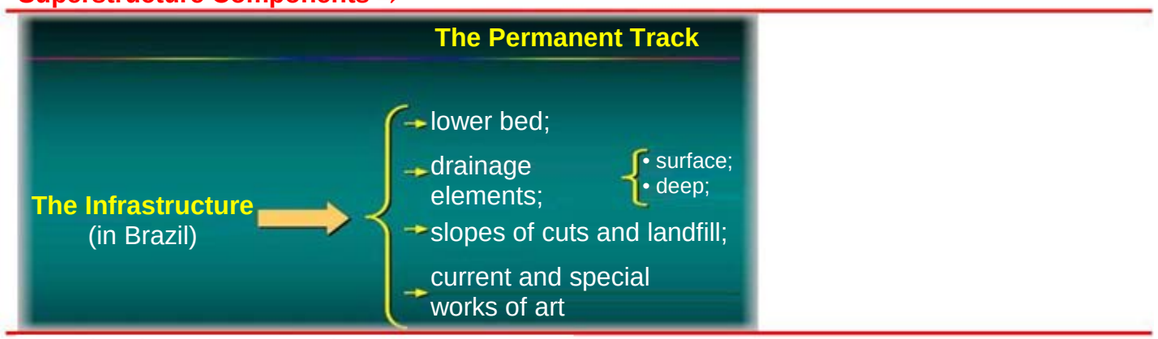
Usually the Permanent Track of conventional railways in the countryside is conceptualized, established and divided as follows:

Superstructure of the Permanent Track





Superstructure Components →



Infrastructure Components →

In the urban areas and when there is need for significant increase in speeds and heavy traffic, the railway superstructure has evolved to suit these situations.

In the case of Calçada - Paripe - São Luís sections, because it is a suburban area, it was possible to add the conventional superstructure with crushed stone ballast and prestressed monoblock concrete sleepers.

In Comércio - Calçada section with more intense and central urbanization, we tried to adopt, among the many technologies available, the most modern, using encapsulated rails embedded in reinforced concrete ballast and neck rails.

The alternative was selected among many others and the following figures illustrate the large number of alternatives available for deployment:

For surface coat, it was chosen concrete from some possible alternatives, although it can admit other standards for compliance with singularities required by the Urban Party.

Draining System

The slope that divides the region into Cidade Alta (Upper Town) and Cidade Baixa (Lower Town), modeled by the Geological Fault of Salvador, limits and confines by the side the rail segment along its entire length.

We thus have a high region with an average altitude of about 30 to 40 m on the right edge of the route, framing a watershed between the ridge lines of the said fault and the edges of the beach, in a concave shape facing the sea.

The slope line between the ridge and the swag region shows a strong inclination followed by a swag region with small declivity that naturally define the behavior of the surface and subsurface runoff.

The section crossed by the railroad, in a total length of 18,540 m, the subject matter of this preliminary design, has distinct settings regarding how it handles this flow, because of their morphology and the way the soil of each locality was occupied.

Comércio - Calçada Section → the oldest occupation, this section, an extension of 3.52 kilometers, starts exactly on the site where it was founded the city of Salvador, near Lacerda Elevator and ends at Calçada station yard, deployed for more than 150 years. The upper part of the slope, known as Cidade Alta (Upper Town), was situated very close to the sea, which led in the evolutionary course of history, the systematic and growing demand for spaces for occupation, the need for landfills over the sea, made without the proper control, creating in consequence a very flat area based on incompetent foundations as a rule and surface little or poorly drained.

The progressive, disordered, poorly structured and growing urbanization paved a flat road for incorporating buildings and structures, waterproofing even more this segment, incorporating primitive and with limited capacity drainage systems.

Thus, we had the entire higher route accumulating enough water during the rainy season, rushing down the slope in a short time, with great speed and finding the lower part area infiltrating or draining superficially with very low speed due to the flat area of the swag region. These cumulative conditions, complemented by the significant hydraulic gradient, formed as a result of the subsurface movement between Cidade Alta (Upper Town) and Cidade Baixa (Lower Town), resulting in a form of runoff, with little predictable behavior because of the existing drainage structures, deployed over these for more than 100 years and the wide variation without sizing consistency of drainage structures, mostly natural and unsuitable dimensional elements.

The local road system was developed longitudinally in the lower part, with several parallel streets with short transverse links between them, which somehow collect part of the flow, with releases little structured towards the sea, transmit surplus that could not capture through the traversal streets, in the form of runoff on the channel of the tracks, thus transferring in each street what has not been possible to capture in the street with lower height, finally concentrating lower points, which ordinarily occur localized flooding.

The accumulation of surface conditions with constant and continuous feeding due to the surface runoff generated by the hydraulic gradient referred to above, further conditioned by variations of tidal heights, which ordinarily reach the heights of 1.80 m and even more, related to the succession of heights of the road system ranging from 3.00 m in height in Comércio region and reaches 2.60 in height in Largo da Calçada region.

This scenario is considered one of the most critical drainage areas of Salvador, known as "Comércio Basin", in which they occur and have occurred with frequency increasing floods that cause inconvenience to the community and especially to the movement conditions of the vehicle traffic.

In this boundary conditioning situation, and in this adverse scenario is where we are implementing a railway, in the center of Av. da França where there is already a highway median strip, which will simply be extended to make room for the passage of the permanent track, and also following the Av. Oscar Pontes, which will create a new site to allow the implementation of the railroad. There are along the avenues aforementioned (França and Oscar Pontes), four (4) low points, considered of fundamental importance for flood prevention.

Calçada - Paripe Section → the latest occupation, this section, in a distance of 13.36 km, begins on Calçada Station and ends in the yard of Paripe Station. The upper part region of the slope is a little bit far from the sea, and near the sea in some places, but still retains the morphological original configuration although completely occupied by households of low-income families.

The evolutionary, disorganized, poorly structured and growing human action, initially occupied the lower part along the railroad, waterproofed the flat surface for incorporation of road and building structures. The area of the hill was occupied in recent decades, with almost complete removal of vegetation and cuts in natural slopes in the search of space for housing.

Thus, we have the entire higher section accumulating enough water during the rainy season, rushing down the slope in a short time, with great speed and finding the lower part area infiltrating or draining superficially with very low speed due to the flat area of the swag region. These cumulative conditions, complemented by the significant hydraulic gradient, formed as a result of the subsurface movement between the upper part and the lower part, also resulting in a form of runoff, with little predictable behavior because of the existing drainage structures, deployed over these for more than 100 years along the suburban railroad and the wide variation without sizing consistency of drainage structures, mostly natural and unsuitable dimensional elements.

The local road system was developed longitudinally in the lower part, presenting transverse connections, which in a way collect part of the flow, with little structured releases towards the sea, transmit the surplus of what could not be captured through the transversal streets, in form of runoff on the slope and the channel of the tracks in the swag region, thus transferring what could not be captured from the slope to streets parallel to the railroad, concentrating finally on the natural thalwegs and in low points where usually occur localized floods.

The accumulation of surface conditions with constant and continues feeding due to the surface runoff generated by the hydraulic gradient referred to above, further conditioned by variations of tidal heights, which ordinarily reach 1.80 m in height and more, related to the succession of heights of the road system, including the railroad that oscillate in a nearly constant average of about 3.00 m, constitute another scenario considered less critical, but extremely sensitive to heavy rains, known as "Suburb Railway Basins".

In this less adverse scenario there has been for over 150 years a railroad, which is still in operation, and has a drainage system consisting of thalwegs crossings with hydraulic structures assembled almost entirely by capped gully holes with crossings in gravity anchoring support built with mortared stone masonry, open at the top, as it was the railway tradition at this time. These structures are still reasonably functioning despite the growing waterproofing of the local soil, due to the intense urban occupation. Evidently most of them are clogged due to debris originating from erosion along thalwegs and transport, and expressive deposit of urban waste. These structures have a certain structural degradation due to climate action and saltpeter effects arising from the sea.

The vast majority of discharge ditches, some of great extension are fully or partially clogged, affecting the release conditions at sea and causing flooding in most critical swag areas, especially in the lower heights receiving influence of the tidal variation.

The partial operation of these crossings is due to the fact that the drainage system upstream is completely defective, providing great retention, infiltration and even reservations that although causing localized flooding in the lower parts, minimize rain peaks, in such crossings, due to the considerable increase in the concentration time during rain peaks.

Some crossing works, performed clandestinely, over the years, due to its hydraulic failure, and misconception (tubular with small diameter), are completely clogged, resulting in some spots, flooding by the railroad bed.

Most of the side ditches, built along the railway are blocked or damaged by weathering or human depredation, requiring reconstruction, clearing and repairs.

Given this scenario, aware that the situation of the drainage in the suburb railway is more easily controlled than the Comércio Basin, due to local conditions, it is necessary to mention the critical condition of Baixa do Fiscal crossing being studied by the Municipal Government. In this basin the retentions upstream are significant, which actually minimizes the downstream floods in the crossing points.

The most serious fact is that the discharge flow ditches between the railroad crossings and sea are completely blocked and affected by backwater effect of tidal variations, which was not yet settled by the entity responsible for Draining System of the City, which has caused constant and significant flooding in the course of heavy rains and aggravated during the critical rainfall.

Concerned about this situation, which involves for its final solution, the action of the Municipal Government, the authors of the Conceptual Design entitled to this situation of Preliminary Design, presented in the core of the reports, a preliminary study of the hydraulic behavior of the Suburban Railway basins, which flow into and crossing under the thalwegs of the rail bed, in order point out the preliminary division of contribution areas, its amplitude and the theoretical behavior of these basins with respect to resulting time period in which the rain reaches the extreme limits of the basin and the sectioning point in the thalweg crossings - concentration time.

In the preliminary evaluation submitted is proposed to demonstrate the estimated size of natural singular structures required to be compared with the drainage capacity of existing culverts, to decide and choose to implement new works or expansion of the existing capacity always with structural rearrangement thereof, in the latter case.

It was identified along the railway in this section, approximately 55 points of release on thalweg lines, which grouped into favorable and appropriate circumstances could consolidate and systematize in 37 structured and powered crossings from the point of view of hydraulic behavior.

It is recommended that the opportunity of preparation of the Basic Design, as subsidy of final sizing of the Executive Design, the most appropriate location of crossings and the delimitation of its basin are reviewed, especially the verification of possible transpositions resulting from deployments of the urban road draining systems, for better consist the dimensional and functional elements of each crossing.

It is also suggested to be kept the railway tradition of open capped gully holes, due to the ease and simplicity for expansion offered by this type of structure. It is recommended that the minimum cross section of these structures is 1.00 m x 1.00 m to ensure maintenance facilities. The observations and findings made lead to the height of the water depth in these structures are in the order of up to 1.20 to avoid backwater and tidal influence in the release points to the crossing of the railroad.

It is intuitive the need to incorporate in the Basic Design the actions and subsidies that result in unblocking of the release channels from the crossing to the sea.

It was incorporated in the conceptual preliminary study of the preliminary design, indications of regularization of the area between the bed of the permanent track and the edge of the right of way of the railroad, with varying widths, in places not occupied by buildings or urban tracks, and with adequate geometry so that it can function as a side ditch for surface runoff further promoting the system integration and small continuous thalweg in order to dewater the various crossing points arranged, some existing and maintained, and expanded to other new ones.

The close and constant presence of the slope, with morphology and proper and suitable geological formation for water infiltration, its temporary storage and disposal in the form of expressive sub-surface gradient, also considering the presence in all its extension of rocks consisting of clay minerals of montmorillonite type, which expand in the presence of water, turning them into expansive soils locally called black clay, led to the indication of deep drains in all sections in which this gradient is set as expressive and when these slopes are sufficiently close to the rail bed so as to be affected by the ascending flow of water in its bed. In the past, there were some landslides of rail bed sections as a result of this phenomenon, one of them recently.

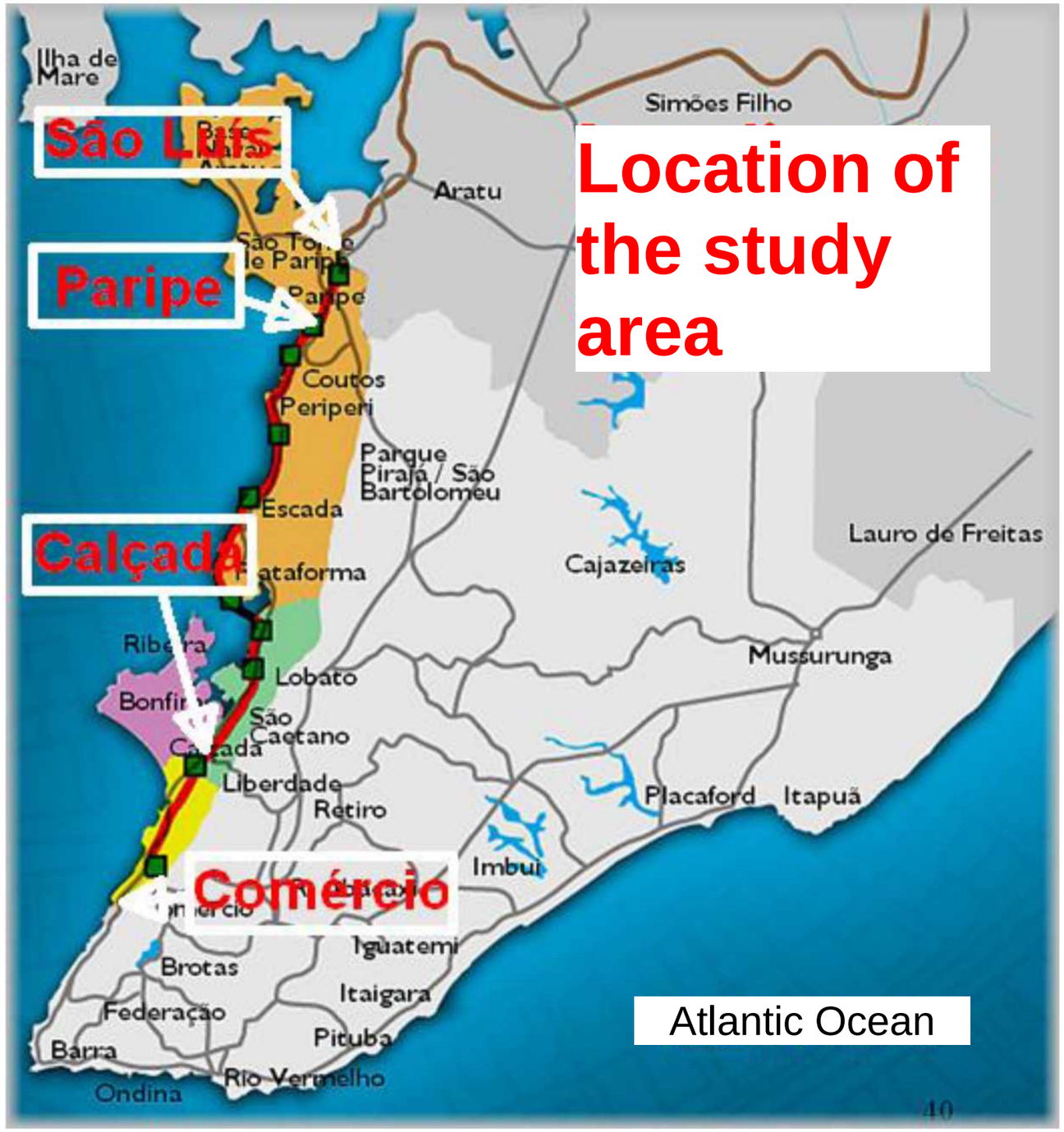
Paripe - São Luís Section → It offers the same features as the Calçada - Paripe section, it is subject to the same indication and suggestion typology, differing only in conditions due to the presence of the slope in this case being much more away, being fully formed in swag areas with slower surface runoff and higher retentions.

However, it must be kept, in this case, the indications of deep drains, due to the presence of expansive soils located of black clay type, which require special treatment of foundation and the surface and sub-surface drainage. In this section the grade was increased with the addition of inert material, crushed stone type, in order to avoid strongly earthworks or excavations in these soils.

Also in this section, superficial adjustments of the area between the bed of the permanent track and the edge of the railroad right of way were indicated, with suitable geometry so that, to function as a side ditch for surface runoff further promoting integration with the existing drainage systems in Paripe. In this section, the most of the area is occupied with urban debris and trash.

The superstructure (ballast and sub-ballast) of the railroad still exists in some places, but most of the rails and sleepers were removed.

Location of the Enterprise



Enterprise Objectives

The following main objectives were listed:

- Requalify the electrified permanent track and in double track of the existing section and under operation, Calçada - Paripe with construction of a new grid (rails and sleepers), geometrically modifying the clearance changing from meter clearance to International;

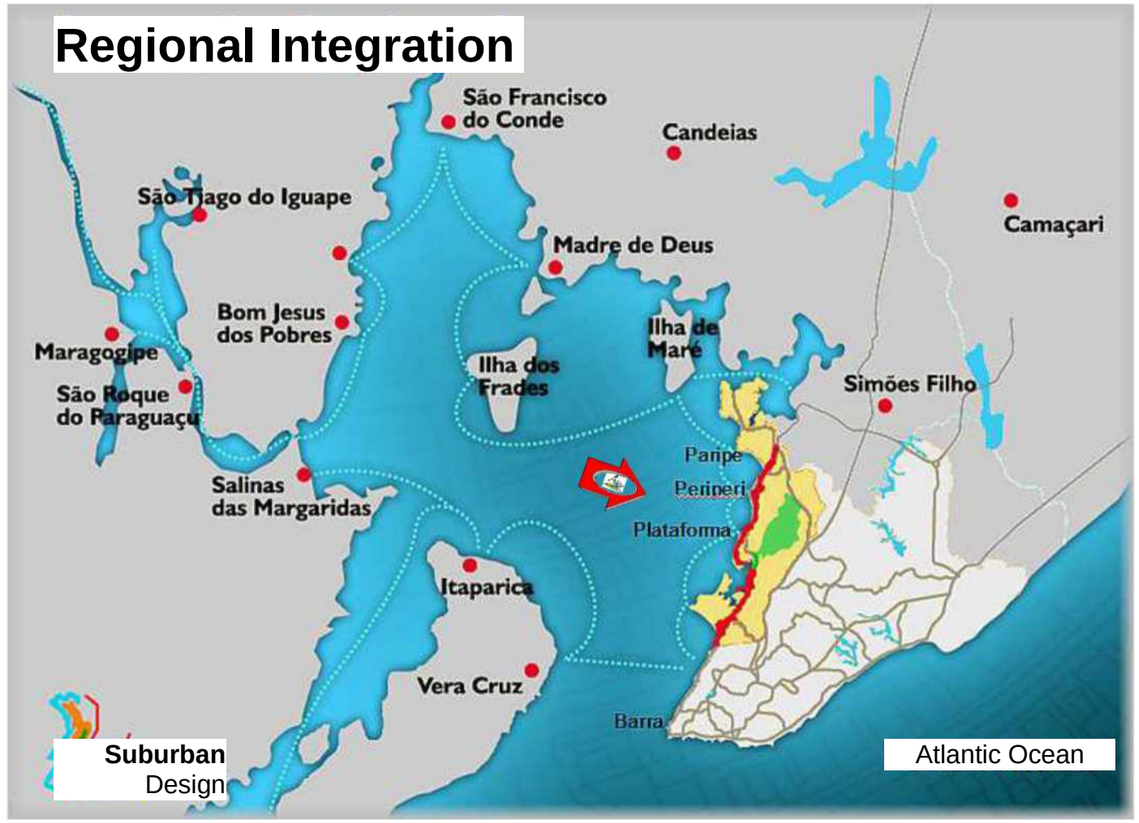
- Extend the section - Calçada - Paripe through the implementation of a new Permanent Track, connecting the Comércio Center, near the Lacerda Elevator and Plano Inclinado up the Calçada Station, using Light-Rail Vehicle - LRV;

- Restore the permanent track and provide and promote the rail connection of the Sections - Paripe - São Luís, currently not in use and without superstructure (ballast and grid - rails, sleeper and mounting devices);

The following were the main guidelines established:

"Design of a new track, in space planned by the Municipal Government of Salvador - Road Corridor Comércio - Calçada for implantation of a railway superstructure intended for mass transport, using Light-Rail Vehicles - LRV".

"Re-qualify the existing Permanent Track between Calçada Station and Paripe Station, by modifying the railway superstructure, currently structured in metric clearance, to international clearance intended for mass transport, using the Light-Rail Vehicles - LRV".



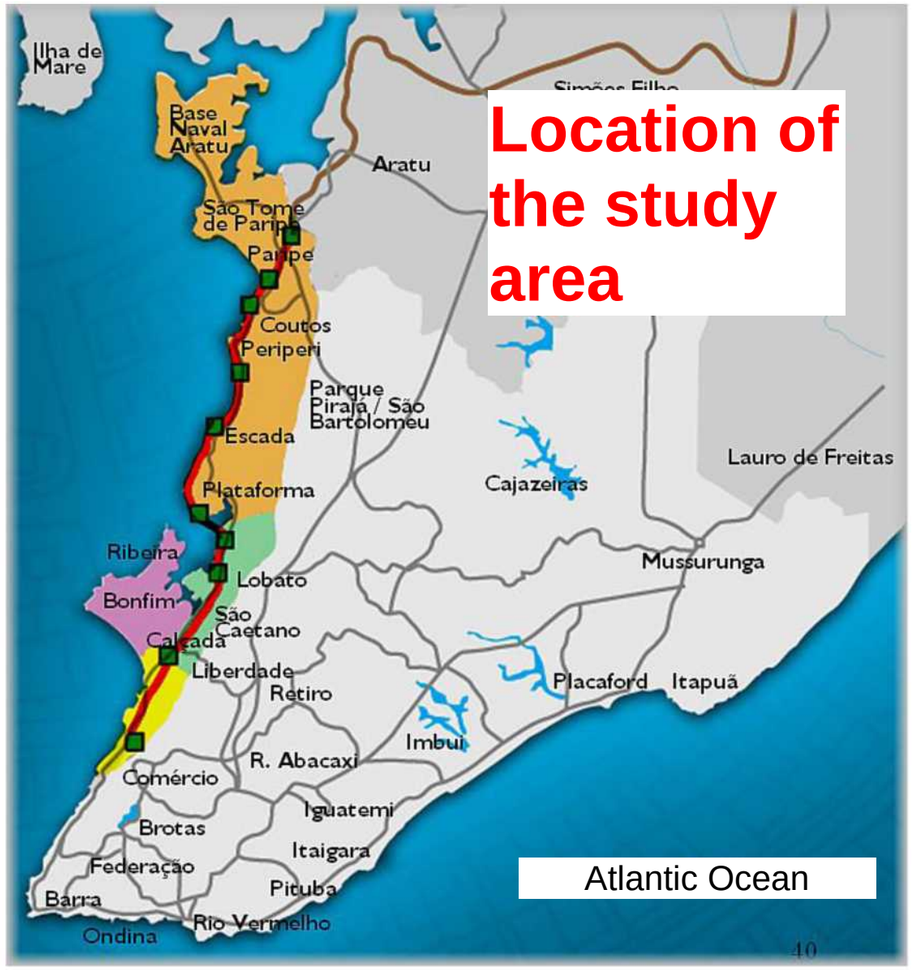
"Design of a new track, with complete recovery of the superstructure on the section between Paripe Stations and the City of São Luís, located on the outskirts of the municipalities of Salvador and Simões Filho, for the mass transport using Light-Rail Vehicles - LRV".

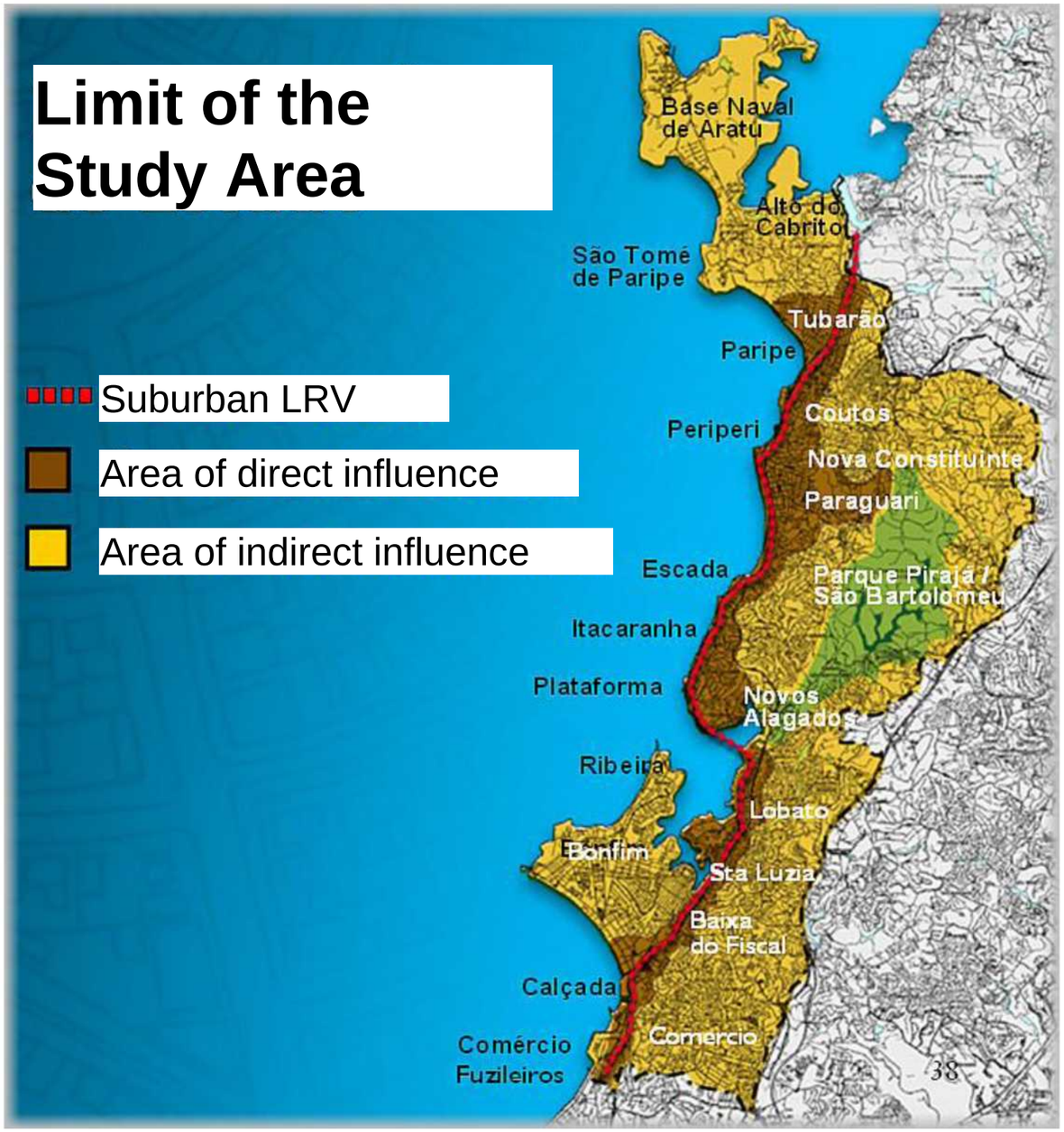
Thematic Information

Considering the assumptions determined by the Government of the State of Bahia, in their Program of Needs for implementation of a rail transport system using LRV vehicles, which in addition to performing the connection function of internal displacement in Comércio, Port and Suburban area, should also allow the integration of neighborhoods in the central region.

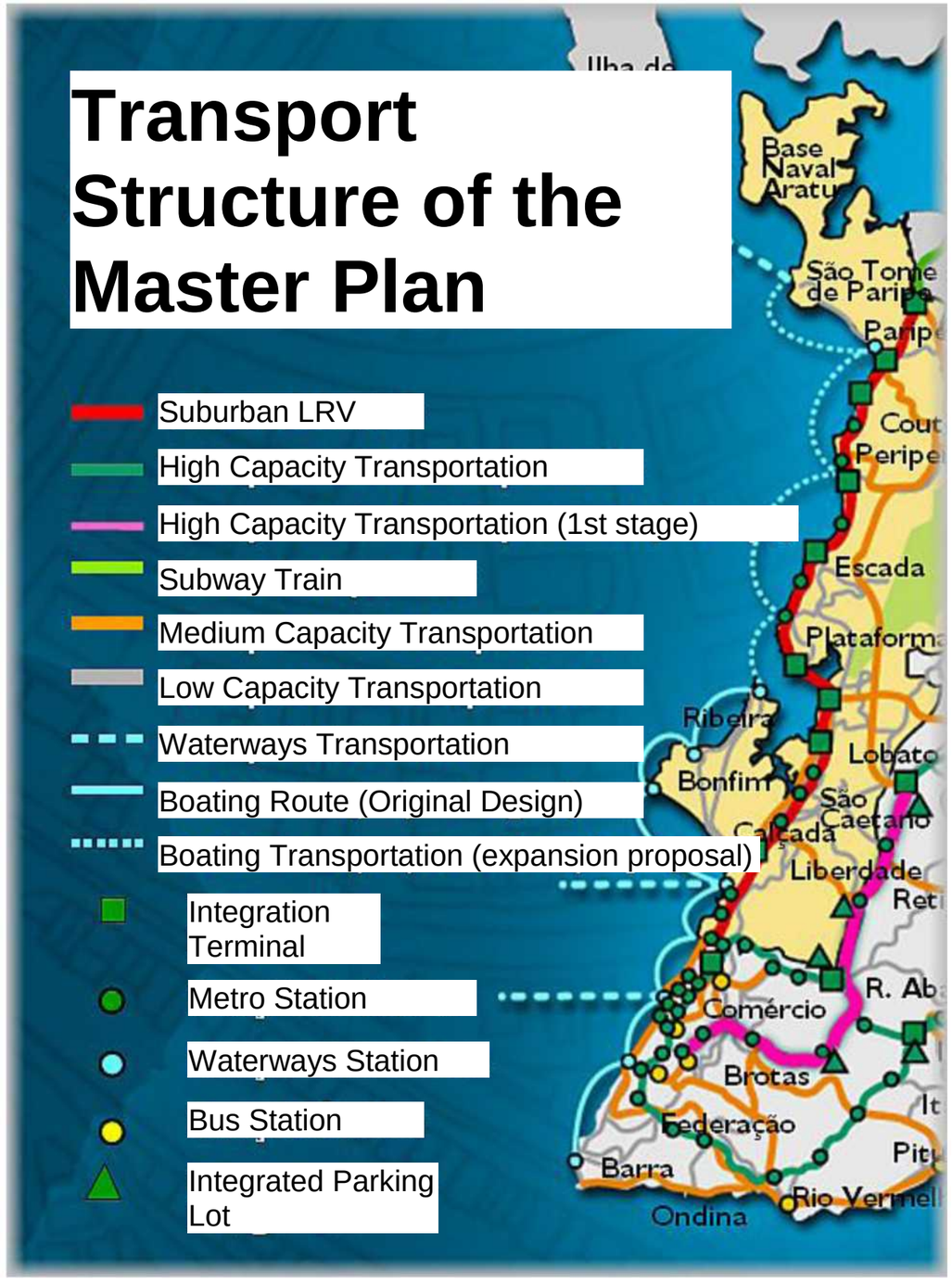
The following are the objectives of this connection: fulfilling the connection function for displacement between the Central Trade Area of Comércio, the Port of Salvador and the Suburban Region, integrating with the subway stations and the New Bus Station in Águas Claras.

Study Area → The source of these thematic basis is a study made by the Municipal Government of Salvador in partnership with the Government of the State of Bahia.

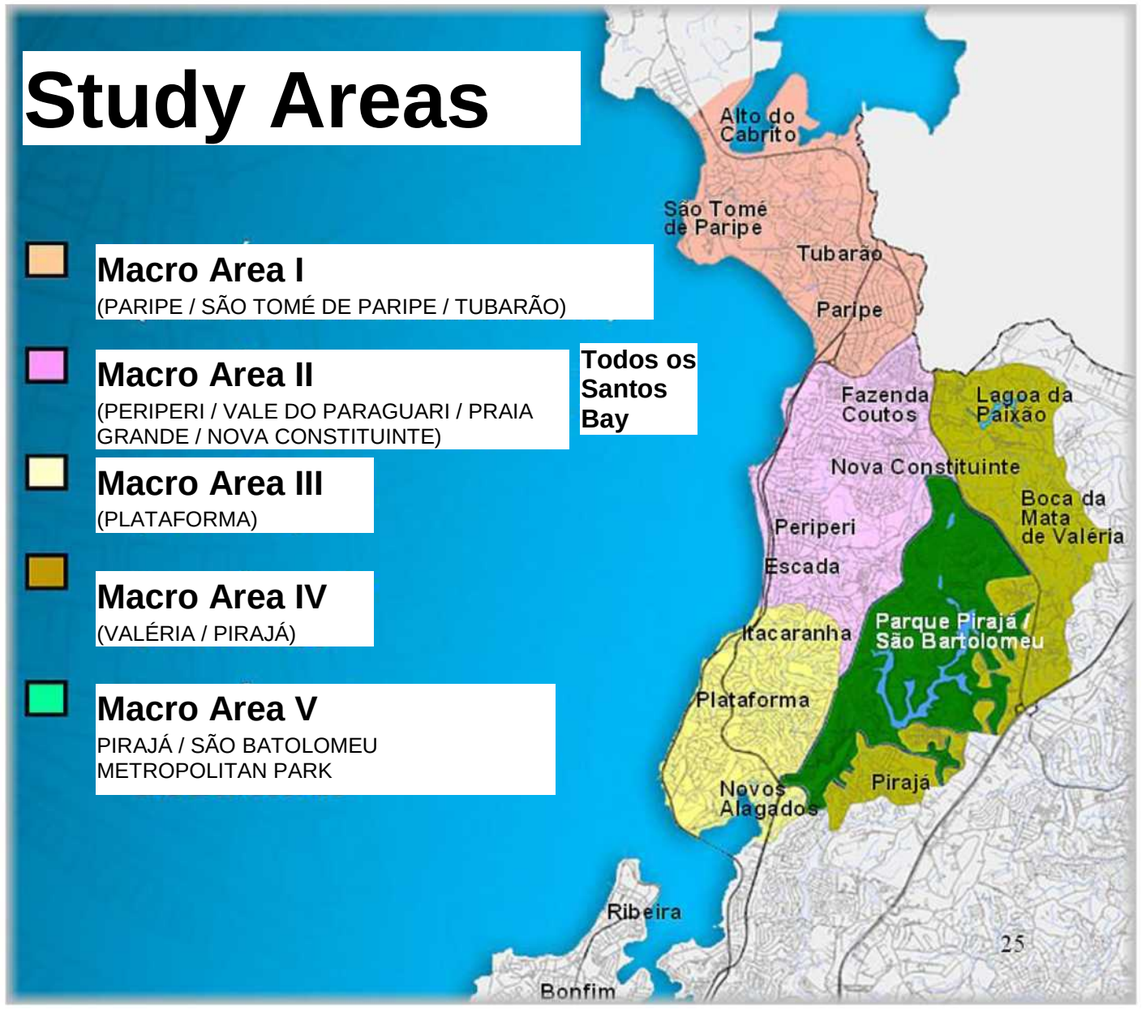




Characterization of Transport Movement → for a better understanding of the internal movement in the study area will be presented, first, the Transport Structure established in the Master Plan of the Municipal Government of Salvador:



The access routes to the Study Area have significant volumes of traffic, according to the information obtained from the studies being conducted by the PMS. The current circulation will be outlined in five distinct blocks: This procedure is based on the fact that the implementation of the works in the region will result in a radical change in traffic conditions due to the creation of a new road system and as a result from future occupations.



The passenger transport system in Salvador is composed of the following ways:

- ✓ Road;
- ✓ Rail;
- ✓ Subway;
- ✓ Waterways;
- ✓ Luiz Eduardo Magalhães Airport;
- ✓ Intermunicipal Transport;

I

- ✓ Metropolitan Transportation;
- ✓ Municipal Transport.

Road System → the Metropolitan bus system is managed by the State of Bahia and the Municipal bus system by the Municipal Government of Salvador.

The Interstate and Metropolitan Bus Terminal currently operates in facilities Nearby the Iguatemi, causing inconvenience to the traffic, reason why is being transferred to the town of Águas Claras, allowing significant reduction of traffic on Av. Paralela and Iguatemi Central Region.

Urban buses have decentralized terminals, emphasizing Lapa Terminal, located in the central trade area of Cidade Alta (Upper Town), which is integrated in its beginning with the Subway System - Lapa Subway Station, and Pirajá also connected to the Subway System - Pirajá Station.

Rail system → The rail system of passengers has 13.36 kilometers of electrified permanent track, operated by the Government of the State of Bahia, through the CTB, it will be extended to 3.52 km (Comércio - Calçada section) and 1.66 km (Paripe - São Luís section) to be deployed.

In the study area, the railway system has a central station - Calçada Station to be re-qualified for integration with Road modal, an extension stop to the trade center - Comércio Stop to be implemented, allowing the connection to public advisers (Lacerda Elevator, Plano Inclinado Gonçalves, Taboão, etc.) and urban public transport in general.

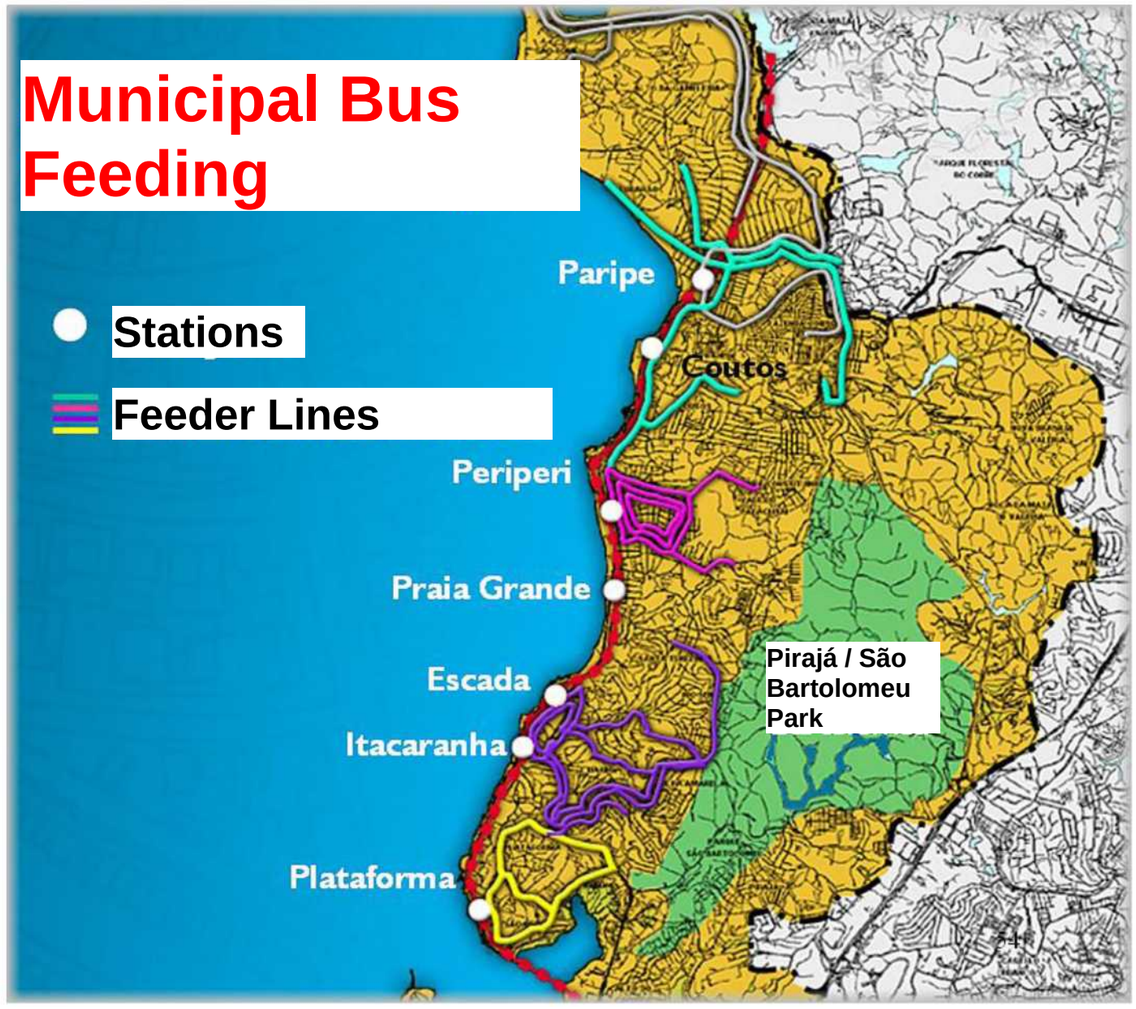
The Paripe station will be re-qualified to enable integration with Road modal in this site the railway line will also be extended to São Luís Stop, near the Viaduct of the Naval Base Road in the future will enable the continuity of the Metropolitan Railway System, possibly by connections Paripe, Mapele, Simões Filho, Camaçari, Dias DÁvila and Candeias.

The Subway Transport System of Salvador, currently operated by the State Government through the CTB, connects Lapa Station in the Commercial Center of Cidade Alta (Upper Town), to Acesso Norte (North Access) where it bifurcates into two distinct lines one toward the Airport, passing through Iguatemi, following by Avenida Luis Viana Filho and reaching the Municipality of Lauro de Freitas.

The other bifurcation branch of Acesso Norte (North Access) to the City of Pirajá, where are located their maintenance workshops, is being extended to the Interstate Station and Intermodal of Águas Claras.

The integration of the Rail System with Subway System will be made for the implementation of the BRT connecting the final train stop of São Luís to Águas Claras, where are provided the Subway final station and the new interstate and intercity Bus Station, enabling in this site the integration of three transport modes - Bus, Subway and Rail.

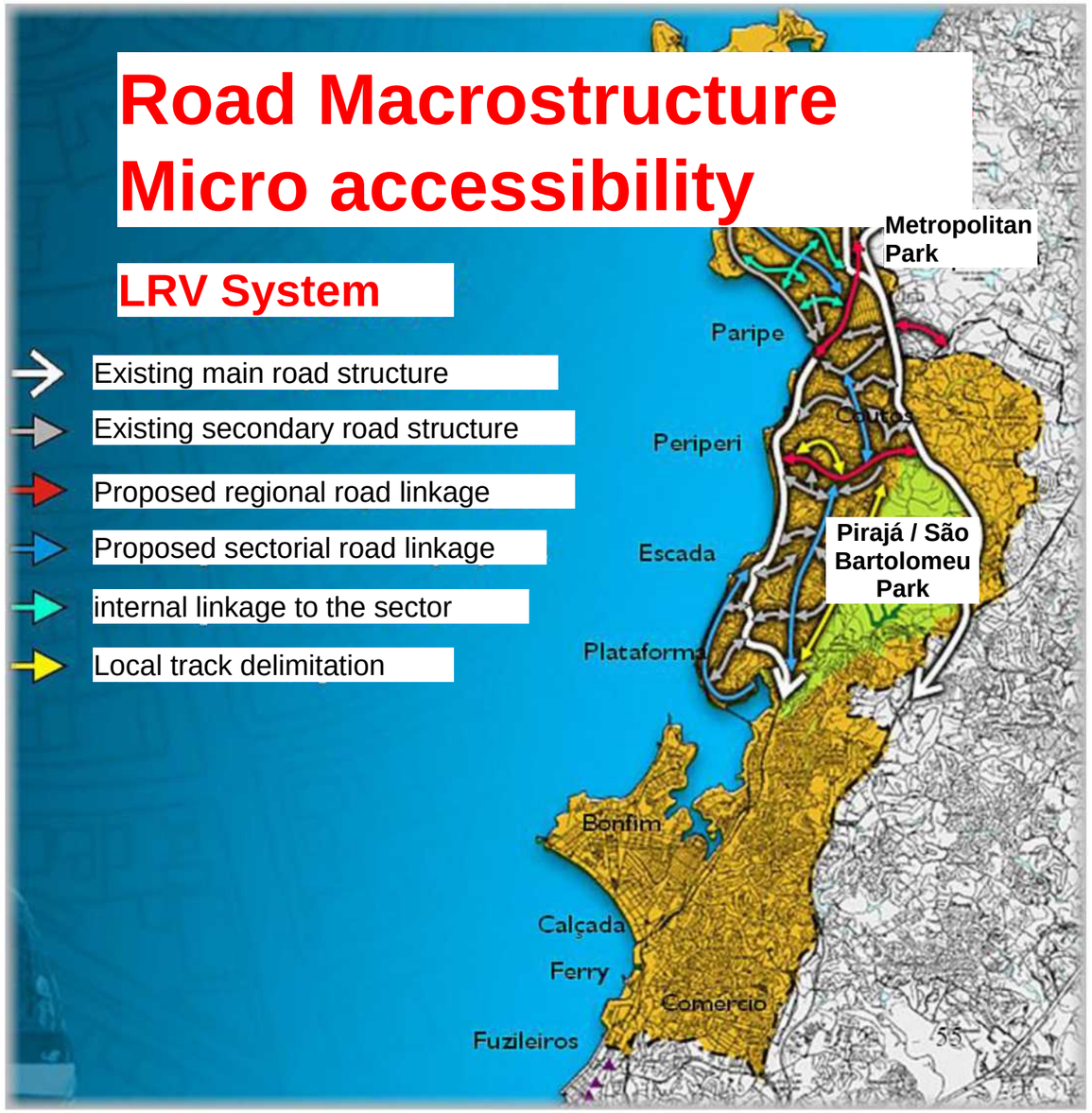
The accessibility to the railway system will be as follows:



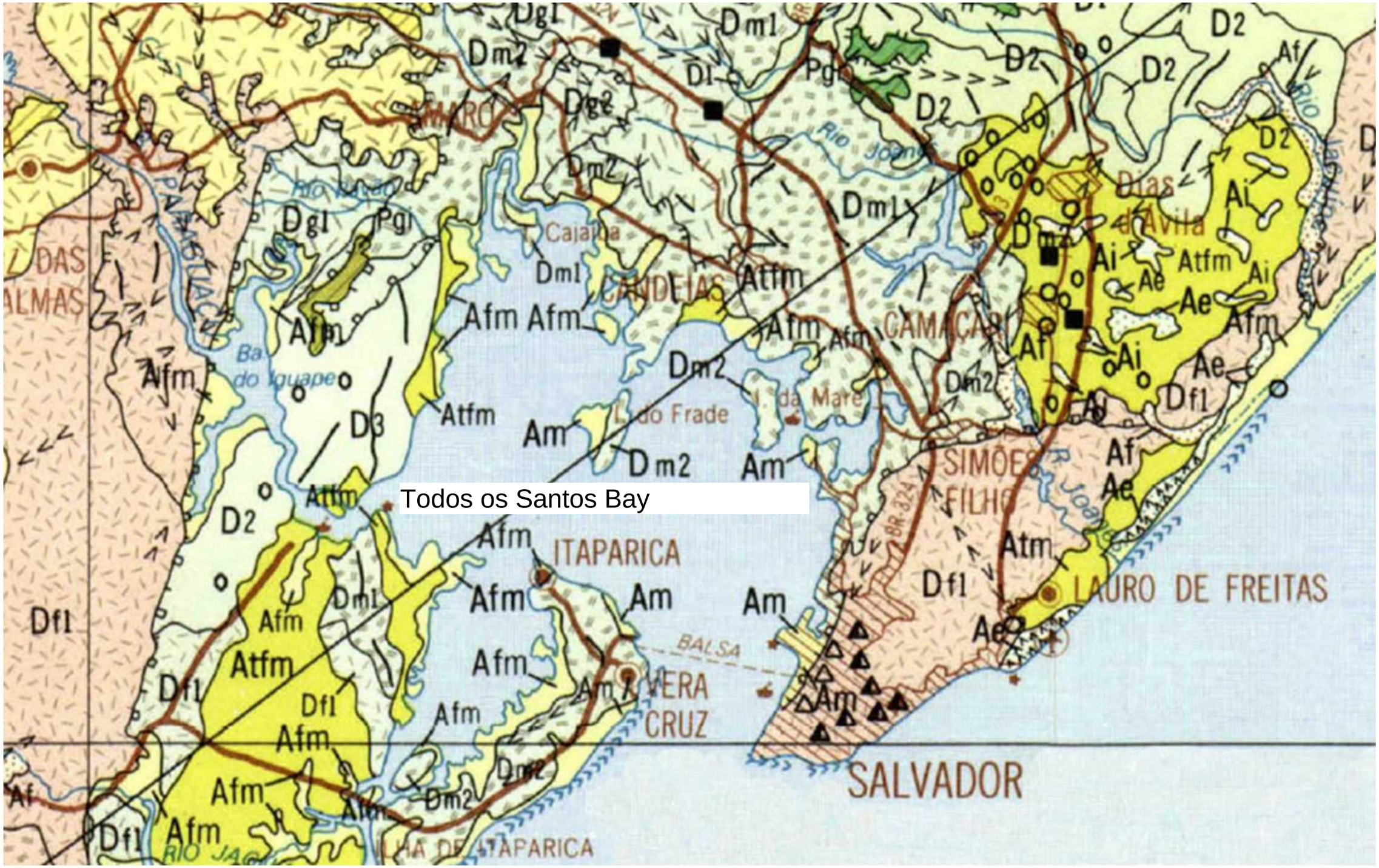
Road Macrostructure
Micro accessibility

LRV System

- Existing main road structure
- Existing secondary road structure
- Proposed regional road linkage
- Proposed sectorial road linkage
- internal linkage to the sector
- Local track delimitation



Regional Geomorphology



DOMAINS, REGIONS AND GEOMORPHOLOGICAL UNITS

SEDIMENTARY DEPOSITS

COASTAL PLAINS

Marine and Fluviometric Plains

FLOODED PLATEAUS

CIMEIROS PLATEAUS

Plateau of Geraizinhos

LOW PLATEAUS

Provincial Tablelands

Coastal Tablelands

SEDIMENTARY BASINS AND COVERS

RECÔNCAVO

Recôncavo Tablelands

Coastal Lowlands

PARDO RIVER

Pardo River Tablelands

BAMBUÍ

Kasrtificade pediplains

PLATEAUS IN FOLDED STRUCTURES

CHAPADA DIAMANTINA

Western Edge Mountains

Eastern Slopes

Rio Bonito Plateau

Central Pediplain

ESPINHAÇO MOUNTAIN

Alto do Rio Pardo Pediplain

CRYSTALLINE PLATEAUS

UPLIFTED PLATEAU

Central Embankment

Marginal Mountains

LOWER PLATEAU

Mountains and Pre-Coastal Embarkments

Pre-Coastal Tablelands

REJUVENATED PLATEAU

Premonte Oriental of Vitória da Conquista Plateau

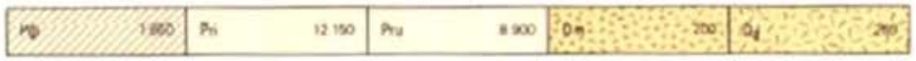
Residual Embarkments

INTERPLATEAU DEPRESSIONS

COUNTRY DEPRESSION

Rio de Contas Patamares do Médio

Paraguaçu River Patamar do Médio



Country Pediplain

DEPRESSION OF SOUTHEAST OF BAHIA

Itabuna - Itapetinga Depression

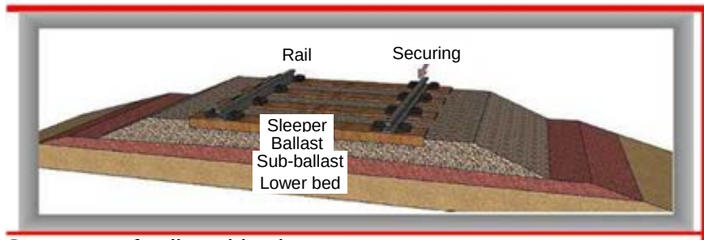
MAP AREA - 156,130 km^2

Robério Bezerra & Cynthia Brito & André Cury

Superstructure - Permanent Track

The road infrastructure consists of the earthwork and all works located below the embankment grade. The final embankment surface is called bed or road platform.

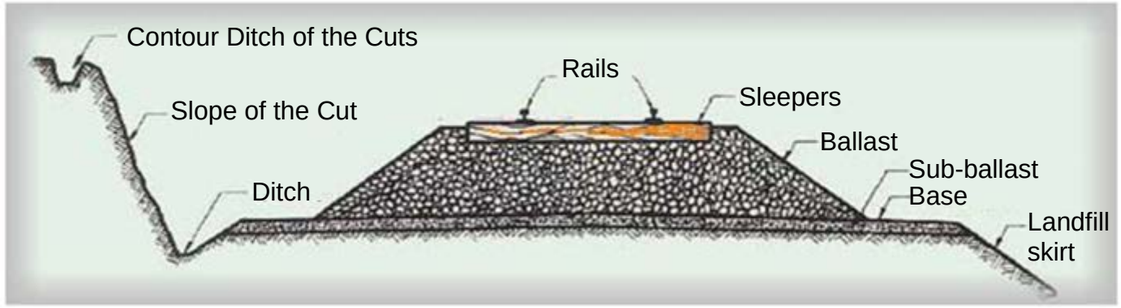
The superstructure of the railways consists of the permanent track, which is subject to wear action of vehicle wheels and the environment (weather) and is constructed to be renewed when its wear reaches the limit of tolerance required for the safety or convenience of movement and even be replaced in its main constituents when so require traffic intensity or weight gain of the rolling stock.



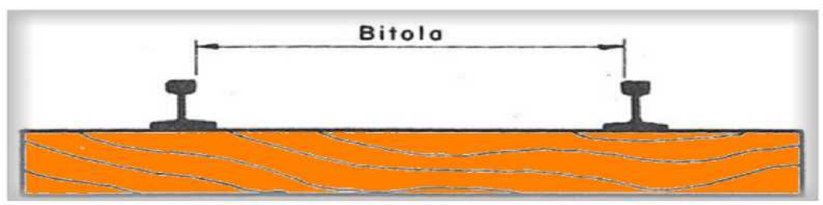
Structure of railroad bed

Permanent Track

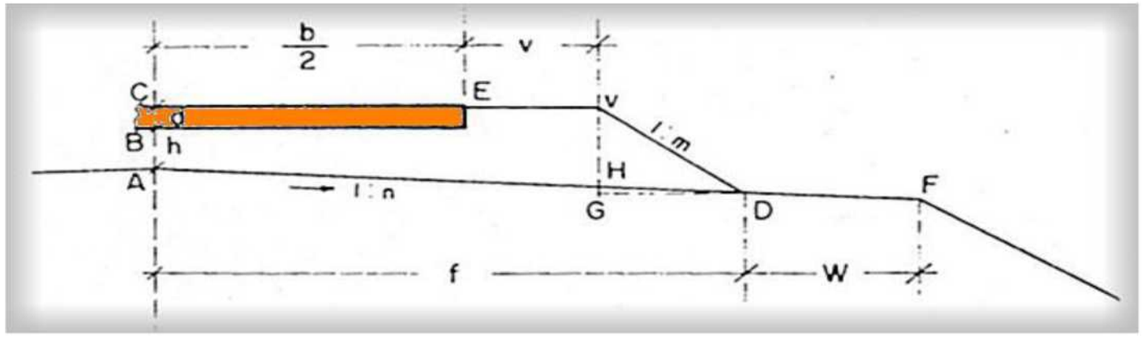
Parts of the Superstructure of a Railroad → Ballast, sleeper and rail are the three main elements of the permanent track, the last two are at the same time the support and rolling surface for rail vehicles. The sub ballast is another element that must be included in the superstructure of the permanent track.



Clearance → it is called clearance the distance between the inner faces of the two rows of rails. In Brazil, the following are the clearance used: wide (1.60 m), international (1,435 m) and metric (1.00 m). For a simple tangent line, theoretically it would have the following appearance.



Geometric characteristics → the geometry of the section of the line, mainly depends on the clearance, number of lines, ballast height, sleeper type. These elements essentially influence the platform width.



Wherein:

- ✓ b - Length of the sleeper
- ✓ d = sleeper height
- ✓ h = Thickness of the ballast

$$f = \frac{m \cdot (h + d) + 0{,}5 \cdot b + v}{1 - \frac{m}{n}}$$

$$l = 2 \cdot (f + w)$$

The width of the **"v"** shoulder varies between 15 and 40 cm, **"w"** has values from 50 cm to 1.0 m, the inclination of the slope of the ballast **"m"** is 1.5 and inclination of the platform surface **"n"** is 3%

Structure of railroad bed

Permanent Track

Track change

Rail cut

Superstructure of the rail bed

Permanent track

Structure of the rail bed

Rail grid

Sleepers arrangement

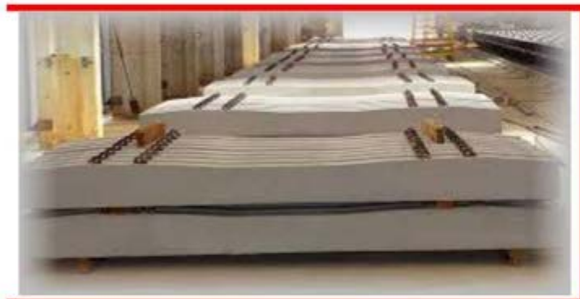
Structure of the rail bed → Side ditches

Structure of the rail bed

Permanent Track

Structure of the rail bed

Permanent track



Sleepers stock

Sleepers and rails → Fixing devices

Structure of the rail bed

Complete rail grid

Road referential geometry → It means establishing geo-referenced ***axis*** for tracks that may serve as guidance to the desired direction, in a succession of straight and curved sections that make up its representation in plan and profile, as well as the definition of cross sections suitably spaced along this axis to ensure that the movement of vehicles on it is smooth and safe. It is significantly conditioned by the physical and operational characteristics of the vehicles that will be used on it. It aims the following:

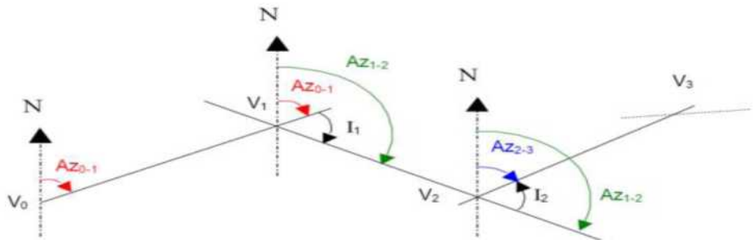
- ✓ Definition of ***design vehicles;***
- ✓ Establishing the ***design speed*** of the design;
- ✓ release geo-referenced ***polygonal*** on the topographic base that meet the strategic demands of movement;
- ✓ select horizontal curves in accordance with the straight segments of the polygonal, for the formation of ***horizontal concordance axes;***
- ✓ release in the profiles resulting from the horizontal concordance axes in its orthogonal projection on the ground, straight representative segments of **uphill and downhill ramps**;
- ✓ select ***vertical concordance curves*** with straight segments of uphill and downhill ramps;
- ✓ establish cross sections typified to represent the ***super elevation*** necessary to maintain the balance of vehicles in horizontal curved sections;
- ✓ sizing the widths of platforms to safely accommodate, under the ballast, if appropriate, the ballast or slab and any permanent track.

Design vehicle → the need to establish criteria to ensure that the usual vehicles (trains) in the country are adequately met led to the practice of defining a set of vehicles called ***rail vehicles of the design,*** with features that reasonably cover general conditions of the fleet that will operate the railway including operational vehicles for service and maintenance. In this case the design vehicle is the LRV - Light-rail Vehicle.

Design speed → the need to regulate traffic conditions on the track has conditioned the establishment of the design speed, i.e., the maximum that the design vehicle can operate safely in a track. In the case in question, it was used a design speed of 50 km/h for Comércio - Calçada section, because it is an urban section, 70 km/h for Calçada - Paripe section and 60 km/h for Paripe - São Luís section.

Polygonal → geo-referenced straight segments that materialize on the topographic basis, the preliminary horizontal axis of reference;

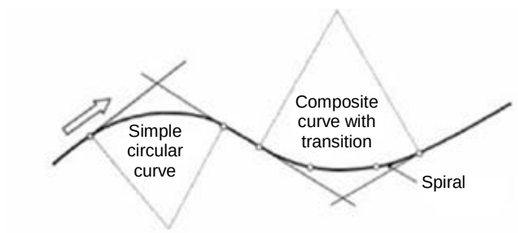
Reference Polygonal → already explained before, they are released on the topographic base, geo-referenced, to produce sequential horizontal routing, of the desired paths.

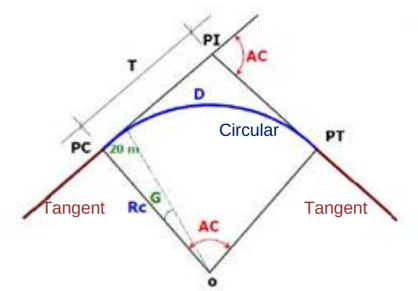


As a result, we obtain a representative spreadsheet of the route of each axis, which elements enable the drawing of the geo-referenced polygonal on the map base and can serve in the field in order to place the polygonal.

Horizontal concordance → straight segments combined with curved segments, which in succession continue to be materialized, geometrized and geo-referenced to the track route.

Based on reference polygonal of each axis, the concordance curves are selected between adjacent straight segments, which can conveniently represent the desired route. The curves normally used are circular or combinations of circular segments with spirals or clothoids, forming transition curves that provide a smoother movement of the vehicles in traffic.





Notable points of horizontal curves

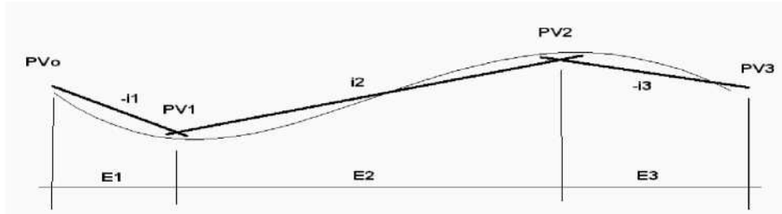
PC Stake = stake of PI - T
Stake of PT = stake of PC + D

where:

PI = point of intersection of the tangents = inflection point
AC = central angle of tangents = central angle of the curve
T = tangent of the curve
D = development of the curve = arc length between PC and PT

As a result, we obtain a spreadsheet, which elements enable the drawing of the geo-referenced horizontal concordance, on the topographic base and to serve in the field for placement of the axes of the track.

Vertical concordance → as a result of the orthogonal projection of the horizontal concordance axes on the topographic base, it gives a natural land profile along each axis of the track, which will serve for the vertical route. This route begins with the release of representative straight segments of the ramps either uphill or downhill applied on the natural land profiles, evidently limited by normative regulations for maximum or minimum ramps and can, as far as possible, equalize by approaching the balance of cut masses and embankments

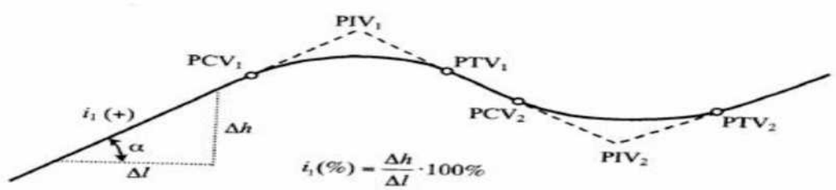


Uphill and downhill ramps → geo-referenced straight segments that materialize on the orthogonal projections of the horizontal concordance axes, in the topographic base the primary vertical axis of reference;

Vertical concordance axles → representative straight segments of uphill and downhill ramps combined with curved segments, which in succession continues materialize and define in details the orthogonal projection of the track.

The design of a track in profile is made up of straight grades, agreed two by two by vertical curves. The straight grades are defined by their slope, which is the tangent of the angle they make with the horizontal. In practice, the slope is expressed as a percentage.

In ascending grades, ramps values (i) are considered positive and in descending grades they are negative, as shown in the Figure. In order to make this convention, it is necessary to establish a direction to the profile, which is usually the same of the staking.



At the intersection of the straight grades we give the name of PIV (vertical intersection point). The tangency points are called PCV (vertical bending points) and PTV (vertical tangency point), by analogy with the circular curve of the plant design.

The choice of the ideal profile is closely linked to the cost of the track, especially the earthwork cost. The morphological aspects of the areas crossed by the track will have great influence on the choice of the profile, therefore, both in the execution of cuts and landfills. In the case of rail grades, the requirements for the maximum ramps are extremely severe because they compromise the operating conditions.

Optimization of grade due to required minimum technical characteristics is not always possible, such as: the existence of required points, concordance with other tracks, civil works jigs, minimum heights of the landfill required for flood prevention, etc.

Since the altitude differences are small compared to the horizontal distances, it is always used a vertical scale ten times larger than the horizontal to allow good visualization of the profile. Thus, when used horizontal scale 1:1,000, the vertical scale must be 1:100. In this particular case because it is a very flat area, it was used the 1:1,000 in the horizontal scale and 1: 50 on the vertical scale.

The classical concordance curves used worldwide are the 2nd degree parabola, the circular curve, a cubic parabola and ellipse.

DNIT recommends using 2nd degree parabolas when calculating vertical curves, preferably symmetrical relative to PIV, in other words, the horizontal projection of the distances from PIV to PCV and from PIV to PTV are equal to L/2.

In the particular case of this section, the grade was equalized with the vertical route of the existing paved road, in order to use it as sub-ballast of the railway superstructure.

Maximum Slopes (Maximum Grade) → based on the behavior of vehicles on ramps, we can obtain elements for determining the maximum allowable slopes. Maximum ramps up to 2% allow unrestricted movement of trains.

Transversal concordance → the purpose of this procedure is to present the indicators necessary to release the necessary alternative desire lines, in order to enable the drawing of the transversal route, of each road segment, which will compose a system that can enable the movement, with comfort and safety, of the design vehicle, defined as cars type for the category of the track**.**

The transversal concordance design is the geometric representation, in the vertical plane, of transversely arranged elements, in selected points of the longitudinal axis of the track. The ordering methodology follows the following sequence of procedures:

- ✓ Definition of platform track width to receive the complete structure of the Permanent Track;
- ✓ Definition of platform transversal slope in tangent sections and for each particular curve, considering the relevant super elevations in each radius as a function of the design speed of the project;

Definition of the width of the platform tracks → ***platform tracks*** is the space dimensioned and provided for the accommodation of the whole structure of the permanent track including slab and sub-ballast, if necessary.

Clearance- due to necessity of compliance with other tracks and existing equipment, and considering that it is not possible to use very high speeds, the international clearance was used.

Definition of transversal slope of the platform → definition of transversal slope of the platform in tangent sections will be made to ensure on the track the full flow of rainwater, as close as possible to the transversal direction. The main purpose is to remove the water in the shortest possible time to minimize the effects of running water on the ballast. The generally used slope value ranges from 2 to 3%, prevailing the latter, especially in regions of high rainfall. In curved sections is calculated, for each situation, the maximum super elevation, which will be made in accordance with the technical stability conditions of the trains type.

Slopes variations → variations of the transversal slopes required for incorporation of super elevations, along the axes and the alternations of straight and curved segments, are represented in cross sections of the permanent track, stake by stake and along the staking sequence thereof. In order to ensure, in the straight sections, the ordinary flow of water off the track, we use a minimum transversal slope of 3%.

Super elevation - it is the transversal slope imposed on the transversal arrangement of the rails along the horizontal concordance curves, to offset the effects of centrifugal force that is applied on the vehicles. It is expressed as a percentage, by the tangent of the track angle to the horizon line, or the difference in elevation between the two edges of the track.

On the occasion of the executive design will be made adjustments to the transversal geometry incorporating the super elevations.

Geometry of complementary elements → the geometrization of complementary elements was done for each component to establish its constructive configuration, and to relate each element to the geo-referenced vector axis.

Design Vehicle

Robério Bezerra & Cynthia Brito & André Cury

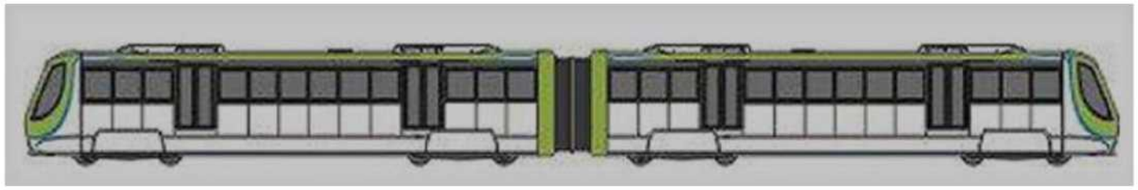
Design Vehicle

The Light-Rail Vehicles - LRV models currently manufactured have urban settings with capacity of approximately 6 passengers/m^2 with variable cars compositions and configurations for compliance with various operating characteristics, such as passenger demand, amount of stations, integration with the environment, investments, etc.

Light-rail Vehicle - LRV → it was used as a solution to the transportation of passengers on regions with average demand capacity, the Light-Rail Vehicles - LRV are being introduced and integrated into the Collective Transport System of Salvador - Ba.

The concept of introducing this system came from the need for synergy with the suburb train, currently operating in restricted space, connecting only Salvador beginning on Calçada Station, to the Paripe district, at the northern end of the limits of the municipality.

This synergy led to the conditions and key stimulus actors of the demand. The study of the demands for travel; the existing rolling stock and under operation, the characteristics of the operating sections and the prospects for expansion of the systems indicated the specification of a LRV, with electric traction.



Technical and operational characteristics → the LRVs have technical and operational characteristics that guarantee good performance in both segregated railroad, and in the midst of urban road traffic, with a carrying people capacity equivalent to 10 Bus.

They usually have the following characteristics:

- ✓ air suspension, which ensures low noise and less vibration during operation;
- ✓ air conditioning system;
- ✓ wide doors and equipped with automated ramps to facilitate access for people in wheelchairs;
- ✓ microprocessor system to control traction and electromagnetic brake, which provides smooth starts and stops and greater operational reliability;
- ✓ large passenger rooms and equipped with ergonomically designed components, displays for placement of information and media in real time, and specific location for wheelchair positioning and locking.

The introduction of this modal was due to its technical, operational, safety and comfort characteristics related to standardization, incorporating technologies and concepts that characterize urban vehicles, which operate in circumstances of short trips and successive stops, and enable operation in the form of regional passenger transport vehicle that can also be used in the very near future for metropolitan travel.

The LRVs can be towed by locomotive or loco tractors in case of assistance or need to transfer without their own propulsion.

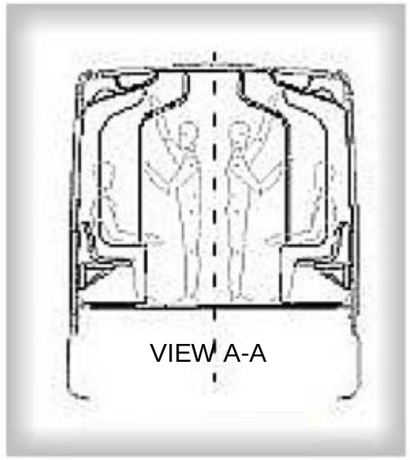
Each wagon enables the accommodation of users sitting and standing for urban displacement, or just sitting, with the use of roof racks on the upper side and near the heads compartments for luggage packaging for medium range regional displacement.

The vehicles will be equipped with a device that makes it possible to establish their identification (vehicle number), their positioning and location in relation to the operational track. These devices must be matched to the monitoring system to be deployed and used by the Operator for its Operational Control Center, and target indicators with digital display, installed in the cabins along the upper region of the front glass and both sides of the cars, in the upper region of arrangement of the windows, with the geometric center of the wagons, as well as having specific beep to indicate the imminent door closing condition of the passenger room.

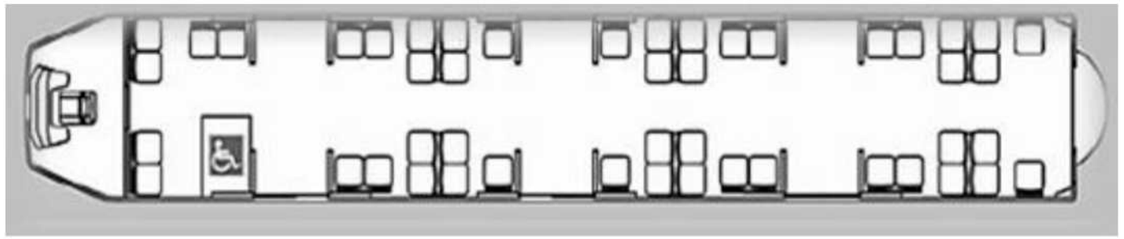
Cars with cabin will have at their ends, automatic couplers that allow mechanical, pneumatic and electrical coupling with other vehicles.

Basic features → The cars at the end of the compositions are tractors with reversible motors, which can produce energy in two-way traffic without needing to change the direction of the operation. The speed of the trains reaches up to 80 km/h in ideal conditions.

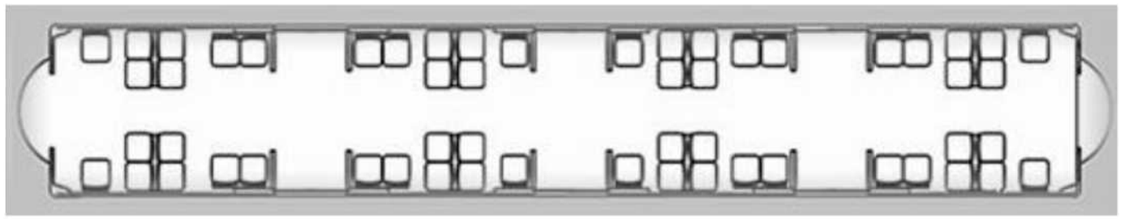
In a cross section, it can be noted positioning and accommodation of xpassengers standing and sitting:



The basic distribution of seats inside the cars with cabin is approximately as follows:



The basic distribution of seats inside the cars with no cabin is approximately as follows:



In order to make longer paths, with travel time over 60 minutes, the trains may be modified in order to increase the comfort during the travel, with armchairs in a great number and more comfortable, and no standing passengers is allowed.

Environmental conditions for operation → the vehicles may move to the open air and in tunnels, under any existing weather conditions.

Thermal comfort conditions → the vehicles guarantee, inside, thermal comfort for passengers and driver.

Indoor climate conditions → The vehicles are equipped with forced ventilation system with air cooling for passenger rooms and driving cabs.

Internal illumination levels → cars have systems that guarantee a minimum illuminance level, at any point thereof.

Acoustic comfort of vehicles → vehicles ensure acoustic comfort for passengers, for the driver and for users who are on station platforms, not producing undesirable noise levels during operation, including for people located in the regions bordering the track. The noise levels emitted by the complete vehicle, internally within the passenger room, stopped and at full speed, meet the conditions established in the Technical Standards ABNT/NBR 13067 and 13068.

Internal and ergonomics conditions of the vehicle in motion → for the safety of passengers, it will be installed supports (columns and handrail bars), ergonomically developed in order to consider the range of heights of passengers traveling standing (urban LRV).

The trains are equipped to provide smooth running and compliance with acceleration, deceleration and bumps requirements in order to ensure minimum noise generation and attenuation of vibrations, not affecting the comfort of the users.

Conditions of equipment and electronic components embedded → they are equipped with electronic equipment and processors - circuit boards or modular unit cards.

Sequential Methodology Structure

Some of the activities related to the development of the Design of the Railway Superstructure of the Permanent Track were held on the occasion of the preparation of the Preliminary Design with only conceptual purpose but must be revised and supplemented in the time of execution of Basic Design.

The methodological structure used to achieve the objectives was developed in sequential order, as follows:

Road geometry reference → activities related to the geometric reference base:

- ✓ Selection and acquisition of cartographic and topographic base to be used in the design;
- ✓ Qualitative assessment of cartographic and topographic base to be used;
- ✓ Development and geo-referenced drawing of preliminary layout on cartographic base;
- ✓ Development and geo-referenced drawing of preliminary road functional plan on cartographic base;
- ✓ Development, calculation and drawing of the elements of the road reference geometry, horizontal, vertical and cross view of the track, on the topographic base to be performed at the time of Basic Design;
- ✓ Documentary record of all material produced relating to road geometry reference of the design.

Infrastructure regularization design - sub-ballast → activities related to the development of the Infrastructure regularization design - sub-ballast:

- ✓ Assessment of characteristics of the materials to be used in the preparation of infrastructure platform;
- ✓ Development, calculation and drawing of the road reference geometry applied to the Infrastructure platform in horizontal, vertical and transverse drawings of the track, on the topographic base to be performed at the time of Basic Design;
- ✓ Development, calculation and drawing of the elements and diagrams involved in mass movements used in the regularization and preparation of the platforms to be performed at the time of Basic Design;
- ✓ Preparation of Constructive Procedures of the items related to the platform regularization services to be performed at the time of Basic Design;
- ✓ Development, calculation and qualified and quantified tabulation of the service items for Platform Regularization to be made at the time of Basic Design;
- ✓ Documentary record of all material produced for the Infrastructure regularization design - sub-ballast.

Drainage design → activities related to the development of the Drainage Design

- ✓ Identification, delimitation, area calculation and drawing of the contribution basins for crossings of thalwegs, to be performed at the time of Basic Design;
- ✓ Assessment of constituent characteristics of soils and vegetation in contribution basins for crossings of thalweg;
- ✓ Development and calculation of rainfalls on the design area to be performed at the time of Basic Design;
- ✓ Development and calculation of the Design flow rates, resulting from surface runoff at the point of thalwegs crossings in all basins that contribute to the design area to be performed at the time of Basic Design;
- ✓ Checking the capacity, sizing, drawings and tabulation of results related to Singular Hydraulic Structures, which want to use the Basic Design;
- ✓ Development, calculation and drawing of elements and diagrams of singular hydraulic structures intended to be used in the Basic Design of drainage systems;
- ✓ Development, calculation of the elements of the Reference Geometry and the Regularization Design of the infrastructure platforms, applied to the Drainage Systems in horizontal, vertical and transversal drawings of the track, on the topographic base to be executed in the Basic Design;
- ✓ Preparation of Constructive Procedures of the items related to the drainage services to be performed at the time of Basic Design;
- ✓ Development, calculation and qualified and quantified tabulation of the service items for drainage to be made at the time of Basic Design;
- ✓ Documentary record of all material produced for the Drainage Design.

In this item, the people responsible for the preliminary design established a Basic Design, only conceptual character, to guide the sequential structure of the Basic Project.

Design of railway superstructure - Permanent Track → activities related to the development of the Design of the Railway Superstructure of the Permanent Track.

- ✓ Assessment of the characteristics of the existing platform infrastructure;

- ✓ Assessment of the characteristics of the materials to be used as ballast and sub-ballast on the permanent track of the railroad;
- ✓ Assessment of the types of the existing rails on the market and the choice of which will be used;
- ✓ Development and selection of grid typology and clamping and support devices of the permanent track, to be used;
- ✓ Structural sizing and typical ballast drawings;
- ✓ Structural sizing and typical sub-ballast drawings;
- ✓ Development, calculation and drawing of the elements and diagrams of grid support structures and turnouts;
- ✓ Development and calculation of the elements of the Reference Geometry and the Regularization Design of the Infrastructure Platform applied to the Permanent Track in horizontal, vertical and transversal drawings of the track, on the topographic basis;
- ✓ Preparation of Constructive Procedures of items related to the services on the Permanent Track;
- ✓ Development, calculation and qualified and quantified tabulation of service items of the Permanent Track;
- ✓ Documentary record of all material produced on the Permanent Track.

Special and Complementary Designs → activities related to the development of Special and Complementary Designs.

- ✓ Assessment of preparation needs of Special or Complementary designs to the deployment activities of the Permanent Track;
- ✓ Assessment of preparation needs of Special or Complementary designs to the operating and communication activities of the Railway System subject matter hereof;
- ✓ Assessment of preparation needs of Special or Complementary designs to the operating installation activities of the Railway System subject matter hereof;
- ✓ Assessment of preparation needs of Special or Complementary designs to the signaling activities and safety of the Railway System subject matter hereof;
- ✓ Development, calculation and qualified and quantified tabulation of items for Special and Complementary service;
- ✓ Documentary record of all material produced on the Special and Complementary Designs.

Presentation of Studies and Designs → activities related to the presentation of Studies and Designs.

The main reference to relate the design data is the center of the track, in it or with it, the following information is recorded:

Studies and sizing → activities related to studies and sizing's.

- ✓ Results of tabulated studies or in text form, establishing the minimum CBR to be used for the materials applied in the regularization layer of the infrastructure platform considered as sub-ballast - CBR = 30% (minimum accepted for this function);
- ✓ Results in text form of the floor rail sizing, based on data previously obtained;
- ✓ Results in text form defining the reference grade for deployment of the railroad.

Graphics formalizing of the Design → activities related to the graphic formalization of the design.

- ✓ General floor plan in scale incorporating the route throughout its length;
- ✓ Texts, drawings, images and tables that relate to the design and which have been or may be used during the preparation, evaluation, construction and in the process of receipt of the works, the delivery opportunity and formally documented record;
- ✓ Extensions of the rail design, indicating the start and final stake.

Permanent Track - Comércio - Calçada

Preliminary Design – Volume II

Robério Bezerra & Cynthia Brito & André Cury

Volume II - Railway Superstructure - Comércio - Calçada

Item	Content List
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E _02	Conditions for deployment
E_03	Deployment of the enterprise
E_04	Rails
E_05	Ballast
E_06	Dimensioning of Railway Superstructure
E_07	Geometric conditioning of Boarding and Disembarkation Stops - PED
E_08	Geometrical and Structural Conditioning of the Level Passages - PN
E_09	Geometric Design of permanent track
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Permanent Track - Comércio-Calçada

Preliminary Design – Volume II

Desire Line

Robério Bezerra & Cynthia Brito & André Cury

Desire Line

The desire line established in the Needs Program for Metropolitan Train Design, in the section Comércio - Calçada, is actually a natural extension of the route of the majority of passengers who currently runs the suburban train in the route Paripe - Calçada. This guide complements the desire to travel of those who go towards Comércio or everywhere looking for some place of Cidade Alta.

The spaces available for deployment of this complementary line are restricted to shared use of Av. Oscar Pontes and Av, da França, with road traffic currently in direction Calçada - Comércio, by establishing a railroad corridor with right of way of 8.00 m along the existing highway median strip where the old connection railroad used to pass towards the Port of Salvador, between Av. Oscar Pontes and Av. Jequitaia, to the facilities of Cesta do Povo, in front of São Joaquim, continuing from there located in the center of Av. Oscar Pontes, to the facilities of Moinho de Salvador, and from there by the center of Av. da França, to the Barges Station in front of Mercado Modelo.

The need, from a desire line established depend on the demand, to find a georeferenced vector line that could be used as a reference for the deployment of a Permanent Railway track, connected to the existing lines that terminate at Calçada Station, to the central part of Comércio, in the vicinity of the Tourism Maritime Station, conditioned the designers to establish alternative procedures, capable of identifying and selecting the most convenient route, considering qualified and quantified weights, oriented towards a rapid deployment, causing the least possible inconvenience to the local user population and for passage and at prices capable of fitting the budgetary limits available. In order to achieve these objectives, the following activities were listed:

- ✓ Assess locational conditions for new route for the deployment of Permanent Track, in dual line, for compliance with the conventional desire line connecting Calçada station to the central zone of Comércio;
- ✓ Assess alternative conditions of use, in this section of the LRV - Light-Rail Vehicles, powered by electricity;
- ✓ Assess the locational conditions for deployment of mandatory stops, for boarding and disembarkation at the locations indicated by demand studies and confirmed in the Program of Needs made by the State, also incorporating the indications made by the Municipal Government of Salvador;
- ✓ Assess alternatives locational conditions of the route being part of studies and indications of PMS and establish a confrontation between them and the alternative chosen by the State Government;
- ✓ Assess the accessibility conditions for users of Comércio towards the designed stations;
- ✓ Assess the impact of the deployment of the track on the current users using vehicles and on foot.

They tried to assess the alternatives studied by the PMS, to find an intermediate path, which could meet the requirements of a rail corridor capable of operating with a train every 10 minutes to meet a demand of about 50,000 passengers. This alternative should reconcile the requirements of a corridor with road crossings, vehicle access to the premises and the movement of pedestrians along the entire section. The following were main interference and conditions:

- ✓ Conditions for access to facilities of the Tourism Maritime Station;
- ✓ Conditions for access to the facilities of the Internal Revenue Service - Customs;
- ✓ Conditions for access to facilities of the Passengers Maritime Station;
- ✓ Conditions for access to Administrative Port Facilities - CODEBA;
- ✓ Conditions for access the operational areas of the Port of Salvador;
- ✓ Conditions for access to the premises of the Federal Police;
- ✓ Compatible with the access structures for the Port through Expressway;
- ✓ Special treatment of the railway level crossing - PN above Av. Oscar Pontes, in front of the container terminal;
- ✓ Conditions for access to the connection bridge - Salvador Itaparica, if applicable;
- ✓ Conditions for access the facilities of the Waterways Station of Bom Despacho;
- ✓ Conditions for access the area of Feira de São Joaquim;
- ✓ Conditions for access the facilities of Cesta do Povo;
- ✓ Special treatment of the railway level crossing - PN above Av. Oscar Bridges, opposite to Feira de São Joaquim;
- ✓ Special treatment of the railway level crossing - PN above Av. Jequitaia, opposite to Calçada Station;
- ✓ Conditions for exit accessibility and/or incorporation with Rua da Grécia;
- ✓ Conditions for exit accessibility and/or incorporation with Rua Pinto Marins;
- ✓ Conditions for exit accessibility and/or incorporation with Rua da Argentina;
- ✓ Conditions for exit accessibility and/or incorporation with Rua da Polônia;
- ✓ Conditions for exit accessibility and/or incorporation with Rua da Netherlands;
- ✓ Conditions for exit accessibility and/or incorporation with Rua da Espanha;
- ✓ Conditions for exit accessibility and/or incorporation with Rua da Noruega;
- ✓ Conditions for exit accessibility and/or incorporation with Rua da Suécia;
- ✓ Conditions for exit accessibility and/or incorporation with Rua Estado de Israel;
- ✓ Conditions for exit accessibility and/or incorporation with the crossing Frederico Pontes;
- ✓ Conditions for exit accessibility and/or incorporation with streets and small-size crossings.

Part of these conditions was solved with the location of the route in the middle of the existing paved track, forming a raised construction site of 20 cm bounded by concrete guides, 12.00 m wide, on which the permanent track would be implemented and afforestation under of landscape restoration on both sides of this construction site.

The accessibility for entrances and exits would be offered along the tracks by lanes of 7.00 meters wide, with two traffic lanes, since the range of changing conditions are considered in appropriate places, since traffic is always in the direction Calçada - Comércio. All strategy would be directed to the appropriate choice of return places for entrance and exit.

In order to establish a confrontation of locational characteristics aimed at achieving the objective of the Enterprise, evidently associated with the availability of time and financial resources, without forgetting the quantified and qualified evolution of the demand, related to the operational structure of the traffic (train, road vehicles and pedestrians), now and in the future, therefore, we will comment on some conditions related to the selected desire line:

- ✓ Route that facilitate compliance with the urban road system, designed and planned;
- ✓ Locational path that causes the least inconvenience to the user population installed along the track;
- ✓ Locational path that minimizes the environmental impact along the track;
- ✓ Locational path that avoids interference and/or relocation of existing drainage systems;
- ✓ Locational path that avoids interference with public service systems (telephone, water, gas, fiber optics, etc.), underground in the existing network;
- ✓ Locational path that avoids interference with public service systems (electricity, telephone, etc.), overhead in the existing network;
- ✓ Locational path that avoids disruption of traffic;
- ✓ Locational path that avoids disruption of economic activities (commercial, industrial, etc.), installed along the path;
- ✓ Use of non-destructive technology of existing streets, the deployment of railroad superstructure;
- ✓ Use of construction processes and procedures to prevent or minimize vibration and noise;
- ✓ Use of construction processes and procedures that fit within the right of way;
- ✓ Use construction processes and procedures to ensure linearized progressive development of the works, in the direction Calçada - Comércio, in order to allow the construction traffic of the works, on tracks from General Construction Site, in the area of Calçada Station;
- ✓ Use of construction processes and procedures for the implementation of temporary fences, in order to prevent or minimize vibration and noise and offer security guarantees;
- ✓ Use of construction processes and procedures to ensure safety conditions to the existing traffic;
- ✓ Use of processes and procedures that enable multiple construction fronts in order to minimize the construction time.

Some route adjustments and even in typical sections were performed in order to suit the details of Urban Design, however, keeping the direction of the Desire Line.

It is presented the following chart with the path of the ***"Desire Line,"*** selected for the design, due to confrontation of alternatives, subsidized by technical and socio-economic restrictions and requirements.

Desire Line → Comércio – Calçada

Conditions for Deployment of the Enterprise

Interventions due to the needs of the Program, as previously mentioned, were oriented to the establishment of an infrastructure capable of providing physical support and operational conditions for deployment of a double-track railway, with international clearance, electrified and ballasted with embedded crushed stone.

Permanent Track → the final surface of the prepared ground for deployment of support infrastructure of the railroad makes the so called ***platform,*** which can be structured with natural or treated soil, in the case of cuts and embankments, or in the case of Permanent Tracks elevated by reinforced concrete structures.

On the railway, the platform is the support of the track structure that receives, through the ballast, the pressure due to the movement of trains, provides space for the facilities necessary for railway operation, such as overhead network poles for communication, power or for surface or underground network systems of conductor cables.

The platform has as main purpose providing support for the track superstructure that do not suffer deformations or can negatively influence the operation under traffic conditions conditioned by the line layout. In order to make it happen, the platform must have certain strength characteristics provided by physical characteristics without guarantee by the support conditions of the foundations.

Very rigid platforms are not suitable because they can lead to destruction of the ballast, by progressive crushing due to repetitive passage of loads.

Ballast → it has the function of increasing the platform bearing capacity, allowing distribution over sub-ballast, and other types of existing foundations, if any, efforts resulting from the loads of the vehicle, producing a suitable pressure for its capacity.

The ballast must provide a cushion to some extent elastic, in order to mitigate the resulting vibrations due to passage of vehicles and form a smooth and continuous surface to the rails, removing small irregularities in the platform or sub-ballast surface.

Qualities of ballast → it must have sufficient strength to the efforts transmitted by the rails and the elasticity needed to mitigate the shocks.

Methodology for dimensioning of the ballast layer → the first step is to define the basic parameters of the Permanent Track, such as clearance, size, maximum total load per vehicle, separation between two consecutive wheels and operational speed. From these elements, using appropriate mathematical formulation:

- ✓ Determine the dynamic load (Pv);
- ✓ Determine the pressure on the lower part of the ballast ***(Pm);***
- ✓ Determine the allowable pressure ***(Pap)*** in the existing support or platform;
- ✓ Determine the height of the ballast layer.

Dimensional elements - Limits for sizing the section → in this case, the thickness of the ballast was limited by geometric constraints of Urban Party in 20 cm.

The platform bearing capacity must not be exceeded by the pressure transmitted by the ballast, which will be structured sufficiently to support the required loads.

Constructive aspects → the choice of material for ballast must comply with the economic criteria, subject to the provisions of technical standards;

The ballast or sub-ballast should only be released on the platform properly regulated, leveled, compacted, bulged and have adequate drainage condition;

The conventional use elements were replaced in this design with a new technology design that is being used because of restrictions of urban crossing already referred to above. This technology prevents and minimizes the noise problems (a reduction from 8 to 12 dBV) and structural consequences of crushing the ballast crushed stone due to dynamic repetition action of the traffic, and the resulting operational and maintenance problems arising from it. It also avoids the effects of vibration from the traffic of vehicles traveling on the railroad.

This is actually a concrete slab in which the rail are supported is inserted and protected by a plastic jacket and, if necessary, by membranes and anti-vibration and protection for electrified circuits.

It should be added to it, the fact that this technology determines the best components that require maintenance guarantees of geometric precision.

The route of the rail connection Comércio - Calçada, for the passage in question was used in the past by railway to link Calçada - Facilities of the Port of Salvador. The rails still exist and are partially covered by urban debris or some unique buildings.

Utilization conditions → the Permanent Track, in this section does not present utilization conditions and should be completely removed.

There are no evident route alternatives, since the existing one features excellent geometric characteristics, with respect to the curves and their corresponding minimum radii or even maximum ramps.

The use of lower bed is full and absolute, with only the need to thoroughly clean the interior of the entire intervention range with removal of the existing grid (sleepers and rails), the surface soil (thickness of 30 cm). The rest of the route will be deployed directly over the existing asphalt layer of Av. Oscar Pontes and Av. da França, serving as sub-ballast for the new Permanent Track.

In some places where the ballast of the permanent track is supported in places where there were median strips, these will be subject matter of special treatment with removal of the surface layer in a thickness of 30 cm and replaced with properly compacted layer of 20 cm of crushed stone and 10 cm of rolled concrete.

In this sense, the purpose is to perform the ultimate topographic location of the axis of the railway, after completion of the cleaning of the construction site, promote the removal and settlement of the sub-bed in the sections where there was superstructure of the old railroad, adding material where necessary and implement a sub-ballast layer using the "crushed stone" (final crushing product), with a thickness of 20 cm compacted and complemented with 10 cm of rolled concrete.

The geometric realignment of the track with the necessary corrections in the horizontal and vertical routes will be made by incorporation of new radii and super elevation required for every radius amplitude related to the design speed and operation speed.

In the section where the superstructure will be supported on the floor of the existing track, equalization of the horizontal and vertical geometric positioning was made. The designed ramps and radii fall completely under current legislation, mainly considering the characteristics required by LRV - Light-rail Vehicle, which will be used and have milder geometric requirements.

Robério Bezerra & Cynthia Brito & André Cury

Deployment

The strategy to be followed for the construction of works, offers, in this situation, several possibilities and different alternatives. However, given the existence of three (3) completely different situations of foundation conditions, it was considerable adequate describes them separately and order the installation process sequentially, due to the new technology used for the superstructure, incorporating non-ballast track instead of the traditional ballast with crushed stone and sleepers.

We need to properly sequence the constructive guidance to ensure the continuity and process linearity and establish that construction starts obligatorily on the Calçada Station and has continued and uninterrupted advance toward to Comércio Station.

The sequential construction continues from Calçada, it was conditioned by the location of the Highway Median Strip in the inner area of this Station, where deposits of materials purchased for the execution of the works will be deposited, favoring the mobilization of construction, minimizing the movement of load vehicles on the surrounding road system.

Another reason for this directional orientation, also of great importance, is the ability to use the sections of built tracks for transportation of materials toward the fronts of services on the new seated rails. The relationship between mobility and transportation between the Construction Site - Work Fronts would always be made through railway, already built, minimizing the disruption to local traffic along the section under construction.

This strategic procedure would ensure that the construction sequence would only interfere with the road system in the evolution of the process, always leaving free the subsequent section, and with no changes to the development and movement of traffic.

If you choose, at the time of construction, for multiple work fronts, these should always be for contiguous sequential segments, thus avoiding works fragments randomly spread, creating difficulties to traffic and inconvenience to users.

Treatment and preparation of the lower bed → the installation sequence of the Permanent Track, considering the technology of the Non-Ballast Track, begins through the treatment process and preparation of the lower bed to accommodate geometrically and qualitatively in terms of support, the required infrastructure.

In the case of the section - Comércio - Calçada, the route was developed alongside an avenue paved with asphalt concrete, and mixed traffic of cars, trucks and buses, continuing in the middle of a median strip between Av. Jequitaia and Eng. Oscar Pontes. Following through the Av. Jequitaia towards Calçada Station, through the parking lot of Largo da Calçada, crossing the Gate in the right side of Calçada station, front view, to the interior of the maneuvers yard.

In the section in which the Permanent Track is deployed on the existing asphalt coating, no type of lower bed preparation is necessary, since it is paved with granular material sub base (20 cm), graded crushed stone base (20 cm) and hot-machined asphaltic concrete coating, 10 cm thick, constituting an excellent sub ballast, whose bearing capacity requirements vary a minimum CBR = >= 20% to a maximum of 30%. Considering the granular sub base that requires CBR >= 20%, the graded crushed stone base CBR >= 80% and the coating on asphaltic concrete with structural coefficient >= 2, we are supporting the railway superstructure in a sub ballast significantly more qualified than the standard requirements.

In order to improve concrete superstructure connection with the asphalt sub ballast, it is made a base asphaltic bonding painting (rate of 0.5 L/m^2), preceded by sweeping and cleaning.

Construction of the Superstructure of the Permanent Track → From stake 0 to stake 127, the ballast will be deployed with rails embedded in the inner track, the construction site created with 12 m wide, the growing direction of the axis staking. In this segment there are in some situations, landscaped and wooded construction sites will be removed and will have the existing lower bed properly and structurally prepared to serve as sub ballast.

The stake 156 to 167, because it is a crossing on Av. Jequitaia, also paved with the same characteristics as described in Section 01, the preparation procedure is the same as described for that section. In this segment there are no construction sites.

From stake 127 to stake 156, it will be necessary the grid removal with rails and sleepers from an old existing railway line linking Calçada Station to the facilities of Port of Salvador, for loading operations. The crushed stone of the old ballast will be used in the regularization of the lower bed mixed with the local residual soil. Either way is provided in this section to removal of 50 cm considered from the grade line designed below the rail head, for replacement of the lower bed in 30 cm and filling with material, with the characteristics required for sub ballast (CBR >= 30 %), using ***"crushed stone,"*** in addition to 10 cm with rolled concrete, thus leaving the surface completely prepared in terms of structural quality and geometric conformation.

From stake 167 to 171, the end of the section, the ballast with embedded rails will be deployed in the inner track of the construction site created with 8 m wide, in the growing direction for staking the axis. In this segment there is a floor covering with stone block, with the same structural behavior of asphalt concrete, dispensing only, asphaltic bonding paint, because it is not necessary in this case

Evidently, these activities will only be performed when the sidings for temporary segregation planks of the right of way encompassing the boardwalk (12.00 m), are completed and approved, with regard to safety requirements.

Construction and Installation of Boarding and Disembarkation Stops → it will be built and deployed facilities for boarding and disembarkation stops in the following sections:

- ✓ Stake 0 +10 to Stake 3 + 10 will be prepared and installed the Comércio Stop;
- ✓ Stake 36 to 39 will be prepared and installed França Stop;
- ✓ Stake 89 to 92 will be prepared and installed Porto Stop;
- ✓ Stake 135 to 138 will be prepared and installed São Joaquim Stop.

Construction of Level Passages **-** It will be built Level Passages, structured in concrete, in the following sections:

- ✓ PN_01, in front of Rua da Holanda;
- ✓ PN_02, in front of Rua da Noruega;
- ✓ PN_03, in front of Rua da Suécia;

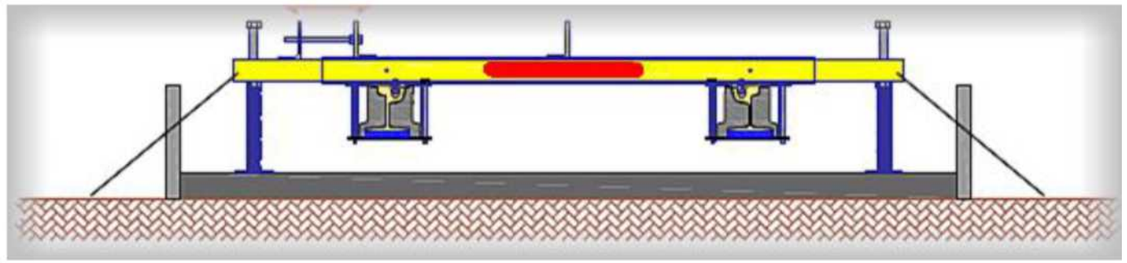
- ✓ PN_04 in front of the facilities of Fuzileiros Navais;
- ✓ PN_05, in front of Rua Estado de Israel;
- ✓ PN_06, in front of the Container Terminal;
- ✓ PN_07 and PN_08, in front of Feira de São Joaquim;
- ✓ PN_09 and PN_10, in Largo da Calçada;

Installation Process of the Permanent Track → the installation process of the track, to compose the Permanent Track, can be done by starting up the operations of geometric markings for georeferencing the design axis.

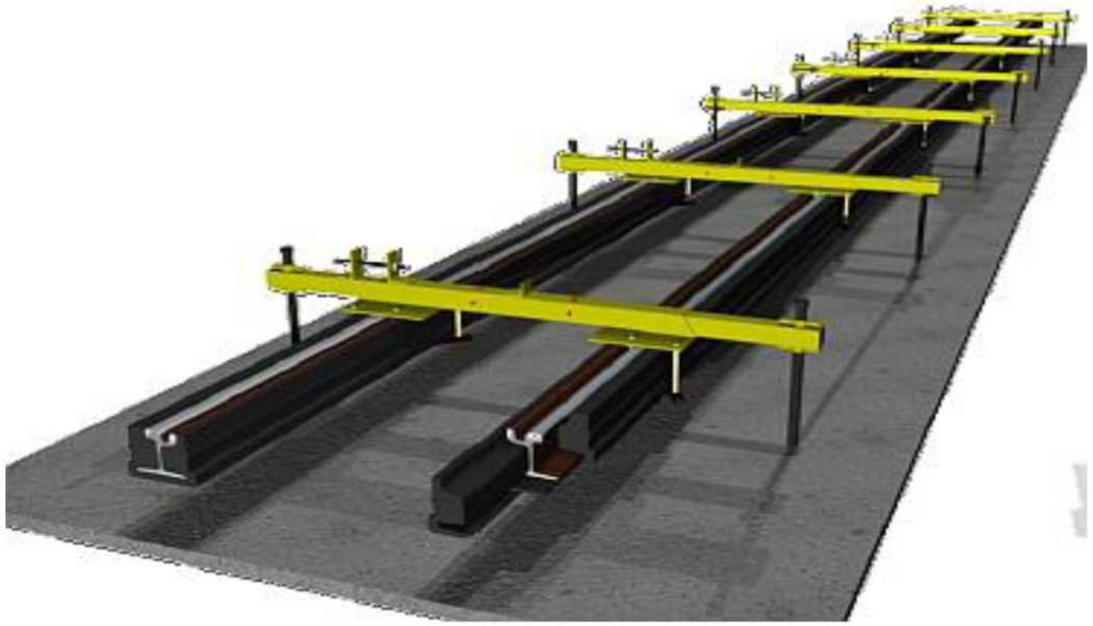
Then, it follows with the location of the reference vector of the Permanent Track, using total topographic stations from the analytical graph axes established in the design. At this moment, it will be located only the axes in its horizontal development in order to enable the positioning and mounting of alignment jigs and anchoring the rails.

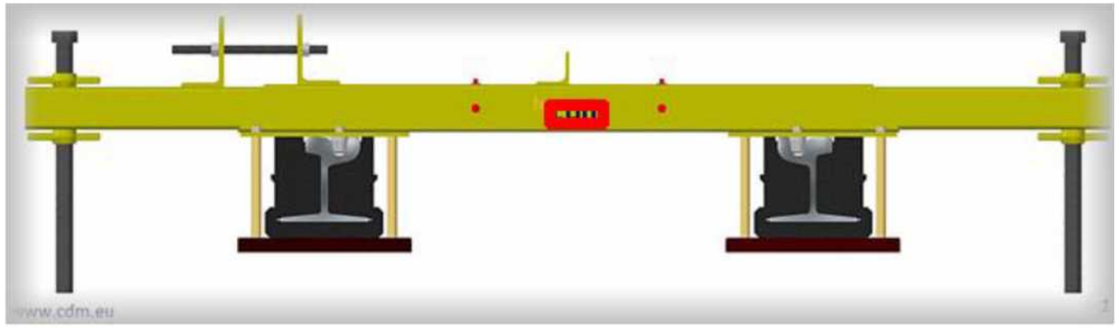
Operations for precision geometric marking and checking the height and alignment

After completed the preliminary mounting phase of the jigs, it will be made new topographical markings to enable the adjustments using the alignment reference frames of horizontal and vertical dimensional elements, arranged in the service notes to establish the radii of curvature, super elevation, super width, if necessary, and sequence of ramp points with the respective distributions of the super elevation. These adjustments marked in the reference frames are transmitted with the use of hot-type screws to establish the heights and distances of each rail in relation to the horizontal and vertical axis of the design.

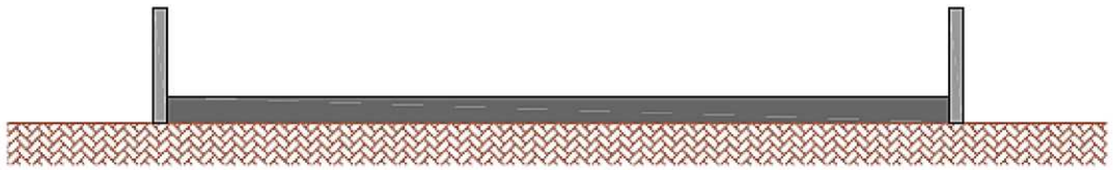


Operations for fixing and alignment of rails coated in the jigs.

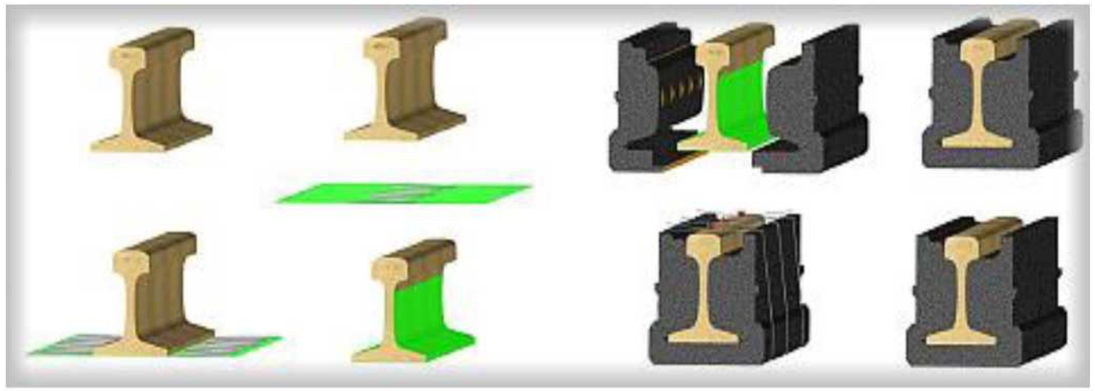




After concluded the markings, set the final axis established on the occasion of preparation of the executive design, there must be a new cleaning of the area that will receive the concrete and where the application of bituminous bonding paint was made. Then, the side forms are seated and secured for concreting.



In the sections of straight segments, the welding of the rails will be made. The operation for encapsulation of the rail in the jacket can be made preferably at the construction site or even on the works site.

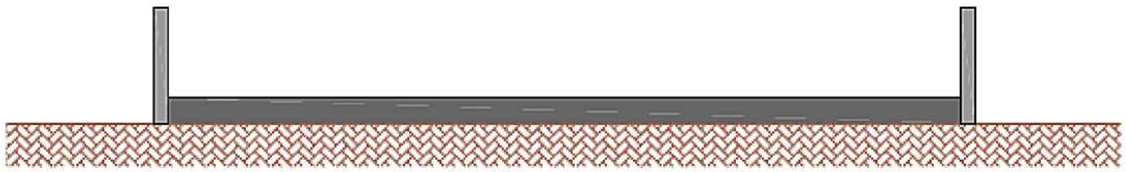


In curved sections, you need to bend the rails with the curvatures defined in geometric design. The bending of the rails, when necessary, will be made at the Central Workshop or in the Construction Site.

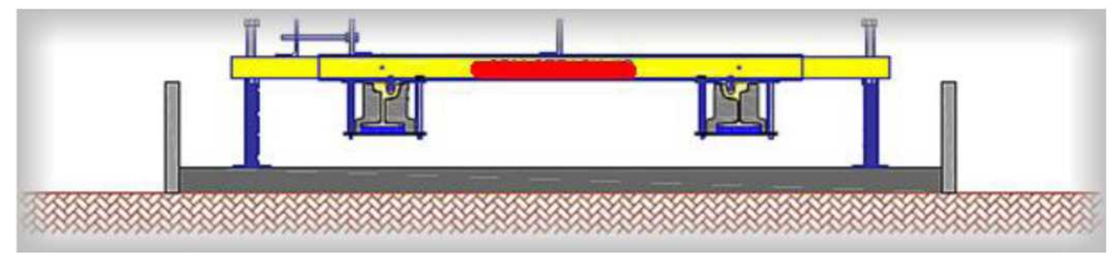
Following the installation, it is considered the need to place blankets, they must bed fixed on the sub-ballast, and press firmly with roller.

The preparation of foundations on the sub ballast, if necessary, will be made using a concrete layer regularization

On this layer are fixed the dies in order to concrete the slab.

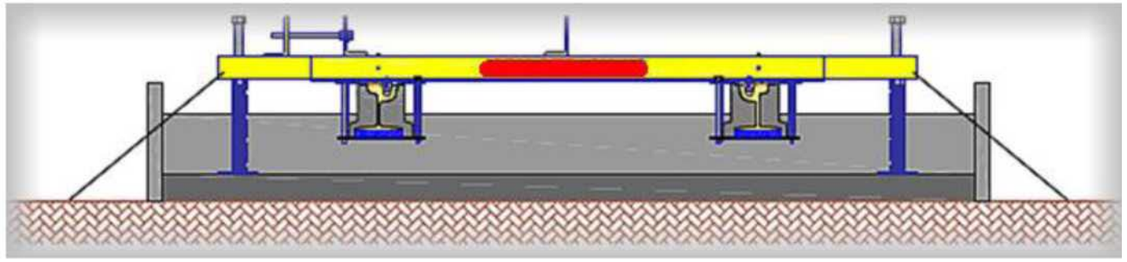


As a result, after removal of the dies, the final finishing to receive the rails.

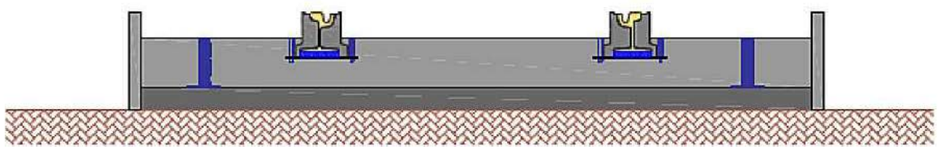


After the grid is completely fixed, aligned and leveled, you can program the concreting activities. For concreting activities, the rails must be protected with a plastic film.

The concrete may be fully or even partially, in case of using another types of coatings (articulated, precast plates, etc.).

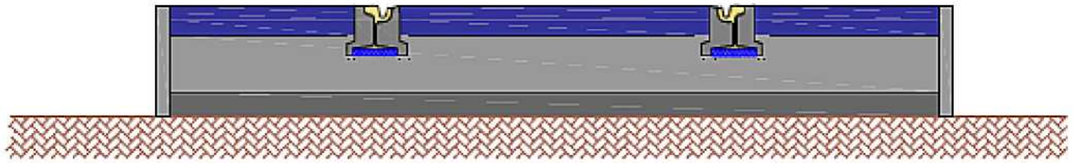


After total or partial concrete, you may remove the alignment jigs.



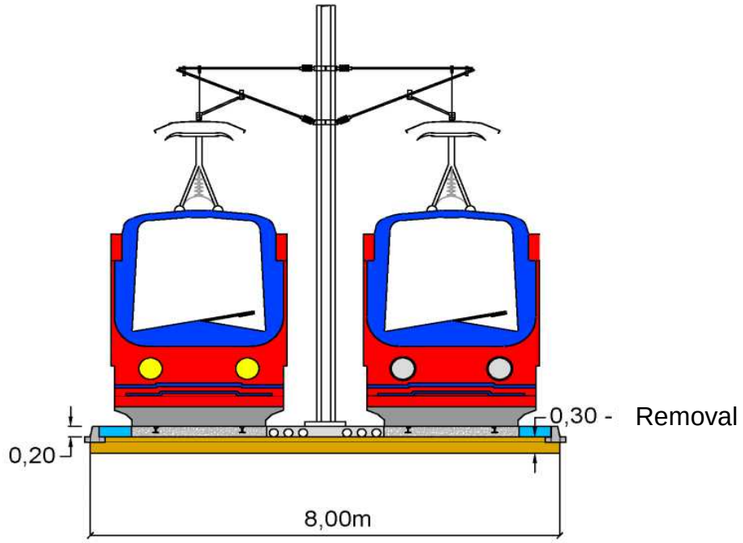
In spaces of the tracks or at the sides, they put up all complementary elements such as ducts, grids, etc.

Then is made the cleaning and final finishing of the concrete layer to receive the desired type of coating.

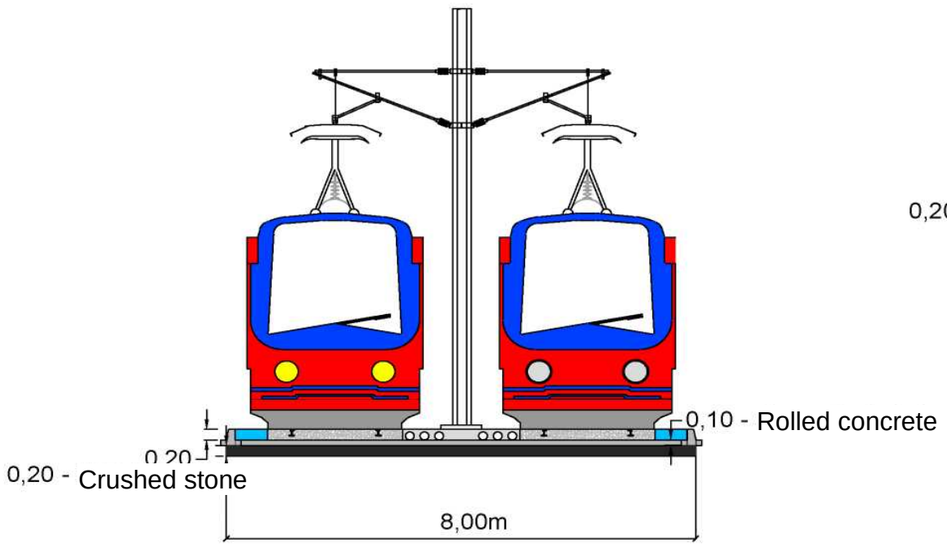


PERMANENT TRACK SEATED ON CONSTRUCTION SITES

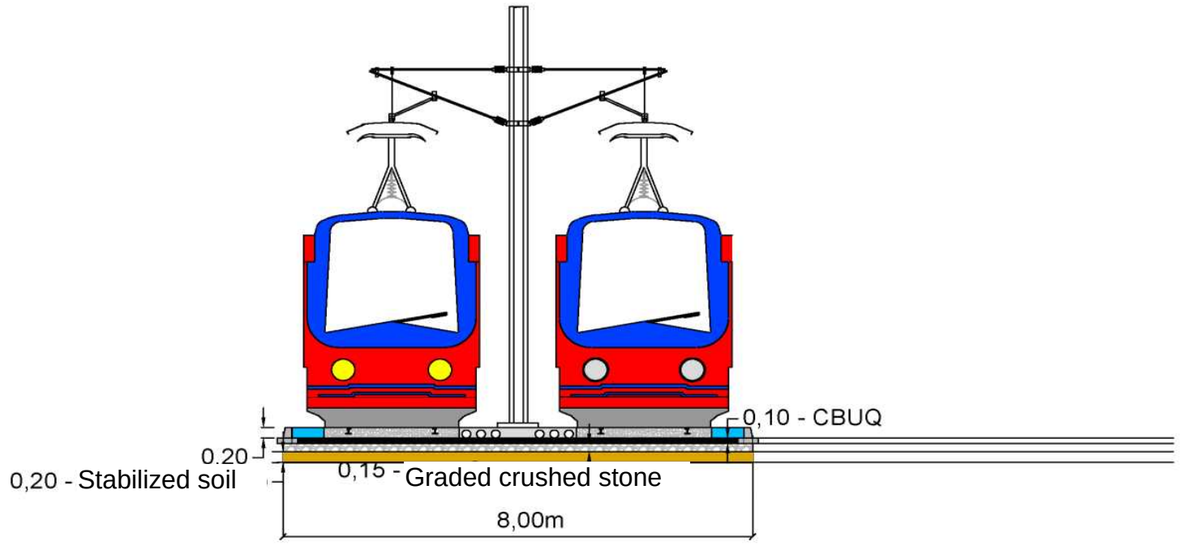
Removal of Construction Sites



Filing



PERMANENT TRACK SEATED ON EXISTING PAVEMENT



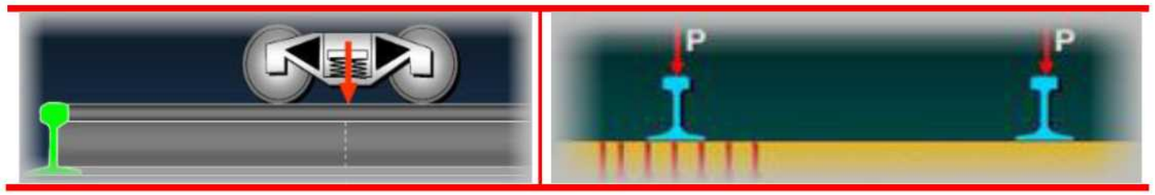
CAPTION					
			SHEET	WORK:	DEPARTMENT OF URBAN DEVELOPMENT
DRAWING		/ /	01/01	SECTION - COMÉRCIO - CALÇADA	
CHECKING		/ /	SCALE	MUNICIPALITY	
APPROVAL		/ /	1:1,000	SALVADOR	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA				
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT	LIGHT-RAIL VEHICLE LRV
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			LOWER BED CONDITIONS	
NOTES					

Rails → Comércio - Calçada

Rail is the element of the superstructure that forms the bearing surface for the wheels of railway vehicles, at the same time, working as support and guide, which condition the trajectory of the vehicles in their displacement. They are beams, which receive loads from trains and transmit them to the ballast.

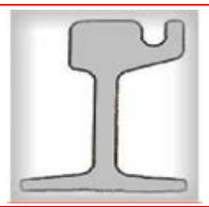
The rails have undergone great evolution throughout the history of rail transport, in view of the development of steel technology. The shape and length of the pieces have evolved, gradually, until they reach the modern sections and weights per meter, supporting large loads through shafts, of modern trains.

The evolutionary process with respect to geometry related to the structural components of resistance to efforts and wear, in addition to difficulties in fixing this profile led to the current profile, designed by the English engineer Vignole (1836), which basically consisted of three parts: head, core and skid. This type, which features a profile in I, containing on top a head intended for contact with the wheels and receipt the cargo, a resistant structural element - the Core and the Skid for the support, fixation and final distribution surface of the load to the sleepers.

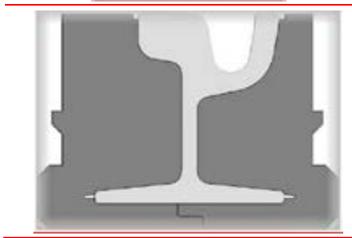


Selecting the rails

Among the various market alternatives, we tried to select the rail that could produce weight per meter compatible with loads distributed by the design vehicle, in this case, the LRV. The most recommended rail, because of its protection features to slip resulting from the actions of sharing traffic was Neck type

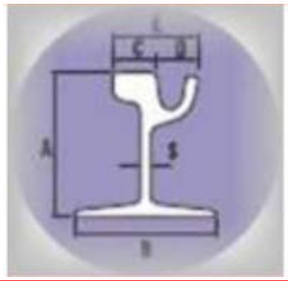


In urban transport by trams was used the so-called "slot rail", whose die allowed the paving of the streets to involve the rail, without preventing the railway wheel from being supported, conveniently and were guided by it. The wheel flanges passing in the slot.



The neck rails embedded in concrete ballast are encapsulated in a case made of synthetic material, which enables removal of the rail, when needed and reduces noise and vibration effects.

The rails after encapsulated are geometrically adjusted and completely surrounded by the ballast concrete



Since we will use encapsulated rails embedded in concrete ballast, the tensions distributed of the rail for ballast, considering a wheel load of the LRV = 50 kN, are approximately 15 kgf/cm^2:

Trilho de garganta

	Weight		Height A		Skid B		Head C		Core D		Overall width E	
	kg/m	lb/yda	mm	pol/pulg.	mm	pol/pulg.	mm	pol/pulg.	mm	pol/pulg.	mm	pol/pulg.
51Ri1 (Ri52-13)	51.37	103.56	130	5.12	150	5.91	56.0	2.21	42.0	1.65	113	4.45
53Ri1 (Ri52-13)	52.97	106.78	130	5.12	150	5.91	56.0	2.21	36.0	1.42	113	4.45
59Ri1 (Ri59-10)	58.97	118.88	180	7.09	180	7.09	56.0	2.21	42.7	1.68	113	4.45
59Ri2 (Ri59-13)	58.14	117.20	180	7.09	180	7.09	56.0	2.21	42.0	1.65	113	4.45
60Ri1 (Ri60-10)	60.59	122.14	180	7.09	180	7.09	56.0	2.21	36.7	1.44	113	4.45
60Ri2 (Ri60-13)	59.75	120.45	180	7.09	180	7.09	56.0	2.21	36.0	1.42	113	4.45
62Ri1 (NP4aM)	62.37	125.73	180	7.09	180	7.09	56.0	2.21	34.5	1.36	113	4.57
57Ri1 (Ph37)	56.54	113.98	182	7.17	150	5.91	52.5	2.07	60.5	2.38	113	5.00

Ballast

The increase of speed in the rails, in order to provide a faster transportation between metropolitan centers and as an alternative for connections to subway or road systems, is becoming increasingly important worldwide.

With the increasing volume of traffic, and availability requirements of railways, it is growing the demand for superstructure systems that require low maintenance and operation and have long useful life, ensuring traffic safety and travel comfort.

New technologies are emerging to replace the classical superstructure with granular material ballast, especially in the higher speed traffic, to ensure a better geometric conditioning, and extend periods of corrective maintenance, especially in urban sections, where the noise and vibration caused by conventional superstructures have caused disorders, which are no longer tolerated.

The alternative technologies targeted were developed to solve these problems and ensure in the section where require higher speeds and where the presence of buildings occupied by residential, commercial and industrial activities, provides for a minimum disturbance.

The increase of the speed of travel also changes the shape and character of the efforts to which traffic roads are exposed. Since the cargo handled at higher speeds generates forces and higher frequency interference originating from the rolling process, it significantly increases effort, causing deformation resulting from dynamic excitation that can generate movements or even crush the granulated material (conventional ballast crushed stone) that due friction, break and damage considerably the functionality of the superstructure, changing the line position of geometry in the ballast bed.

The ***solid floor tracks*** have emerged, and are in wide use, to ensure lower maintenance costs, longer useful life, improved geometric accuracy of the track, to obtain a safer and smoother traffic, even considering the speed increase. This differential treatment of the superstructure has been used on a significant scale in urban crossings, because they are subject totally or partially to the shared traffic. As a rule, the maintenance cost is approximately the double compared to those equipped with solid floor tracks.

The track equipped with ***solid floor***, since it incorporates a continuous support system, widely resistant to bending and traction, with clearly defined support conditions and homogeneous stiffness conditions, the efforts of the sub-ballast are uniformly transmitted presenting very smaller distribution rates.

The tracks of ***solid floor*** with solid construction to replace the rail ballast ensure the lasting position of the railway as well as the fulfillment of comfort criteria, with a minimum maintenance costs.

This constructive type of ballast, the ***solid floor,*** enables the dissipation of greater side acceleration forces.

The route can be marked in a narrower range and speed in curves can be higher. This type of support requires a smaller height superstructure in comparison with the conventional ballast. This benefits especially at minimum scaling of cross sections avoiding higher height differences in the level crossings or even when it requires shared traffic.

The solid floor track, constructive type, requires a sensitive substrate for deformations and terrain accommodation. The substructure for this type of track must be prepared to meet the requirements, the use of better quality earthworks materials.

Currently, in ***solid floor*** tracks over structures on the ground, they require low deformation support, suitably dimensioned in layers, formed by a granular sub-ballast covered with an asphalt layer.

Direct support in the asphalt sub-ballast or, more rarely, made of concrete.

Some of these solid floor systems are installed on a "top-down" principle, i.e., the horizontal and vertical position of the rails is regulated in the grids, in pre-molded plates or capped jackets before they are permanently fixed with concrete *in-situ*.

Basic forms, sitting on an asphalt base sub-ballast, require no differentiation over conventional ballasts. On the contrary, the higher rigidity of the concrete slab dissipating and distributing smaller and more uniform tensions when passing the train, acting on the high elasticity of the asphalt sub-ballast of structural coefficient k = 2, causes less dynamic loads on the substrate, remembering that both have better qualities than the superstructure with conventional ballast of structural coefficient k = 1.

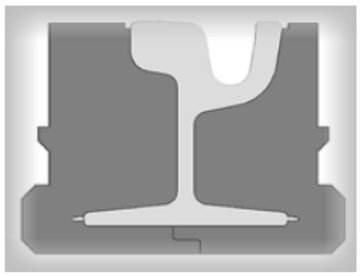
In populated areas, the occurrence of vibration and noise generated by the rail traffic should be reduced, so that the limits established by law are met, in particular in order not to affect the quality of life of residents, traders and commerce or production processes in industrial units. To this end, the solid floor superstructure system is installed on support plates on elastic supports.

The elastic support of the support plate promotes a decoupling between the track superstructure and the substrate, because of this there is a strong decrease of the accelerations resulting from the rail traffic that are transmitted to the substrate.

The primary objective is the reduction of high frequency energy.

The choice of the designer, among the alternatives presented, was the design in which the rail is completely encapsulated by a pre-casted elastic profile with its shape and stiffness adapted to the rail profile. In this design the encapsulation jacket is produced with rubber granules and resin pellets.

This process enables uncoupling the rail, from its surroundings, when necessary, ensuring an electrical and vibration insulation. Its installation is done by "Top-down" system ensuring that the rail is continuously supported by not using sleepers and/or tie rods and any form of additional fixation, transmitted to the surroundings.



Compared to the other alternatives discussed, it enables smaller thickness of the concrete slab and does not require mechanical fasteners, significantly reduces the cost and frequency of maintenance operations. It has been widely used in multimodal platforms for safety and maintenance reasons, and as the rail is continuously supported on the slab, it has less wear.

The vibrations amplitude control can be obtained by adjusting the stiffness of the tie pad under the skids of the rails, for different insulation levels and, when necessary, may be adjusted to solid supports using blankets.

The installation can be done at a rate of up to 100 m of simple track per day, by staff, and their features do not depend on the weather.

Sizing

The first methods of analysis for determination of vertical forces, in railways, considered only a force equivalent to a static train.

The evolution of sizing techniques, aimed at the need for consideration of the dynamic behavior associated with the passage of trains, leading many authors to develop empirical formulas based on increase coefficients (a), which applied to static charges, intended to model their dynamic effects.

$Q_D = \alpha\ Q_E$			
and Pihera (1915)	**Driessen 1936)**		**Schramm (1942)**
$\alpha = 1 / 1 - V^2/35{,}000$	$\alpha = 1 + V^2/30{,}000$	$\alpha = 1 + V^2/45{,}000$	$\alpha = 1 – 4.5.10^{-5}.V^2 - 1.5.10^{-7}.V^3$
For: **V** < $\sqrt{35{,}000}$ = 187 km/h	For: V ≤ 120 km/h	For: F > 120 km/h	

Over time, they have been developed numerous methods for sizing the railroad, with the first models targeted to determine the thickness of the ballast through simplified mathematical formulations and from the 1960s, abacuses were introduced involving the cohesive properties of the soil.

Later, the development of railway systems (high-speed), resulted in the need to improve the analytical models that due to the complexity of the associated calculations (nonlinear cases), only became possible with the development of systems in the last decades of the twentieth century, emerging ***"mechanistic" procedures*** *and* replacement of modulus of elasticity by the ***modulus of "resilience".***

While evolving the process of analysis and methods for sizing, we began to feel, in the reverse direction, the results of the reduction of natural materials that were commonly used in railway construction.

The difficulty in finding materials with minimum qualities for use in railway substructure layers and environmental consequences of bentonite deposits exploration, led to the study and characterization of alternative materials in the use of rail structures, such as stabilized soil with lime or cement, graduated crushed stone treated with cement and asphalt.

Bituminous mixtures - as a subject matter of this design, support largely the superstructure on an existing paved road with hot-machined asphaltic concrete, with a thickness of about 10 cm, graded crushed stone base, with a thickness of about 20 cm and granular soil sub base also with a thickness of 20 cm, we will make some considerations in order to provide technical support for this option.

The bituminous mixture are widespread used materials in road engineering associating to the characteristics of granular materials, the cohesive properties of the bitumen, which mixture has a high resistance. There are several types of bituminous mixtures, applied according to their structural function and performance. This solution provides materials with the following characteristics: stability, durability, flexibility, fatigue strength, adhesion, waterproofness and workability.

In order to characterize these mixtures, it is necessary knowledge of the resilient modulus, the Poisson's ratio and volumetric mass. The bituminous mixtures, although behave as viscous-elastic materials require a linear elastic analysis, in order to evaluate their long-term behavior, according to structural deterioration processes.

The properties of the bituminous mixture for use when sizing the layers of the substructure of the railway are summarized in the table, and the values are in the range of features associated with this type of material for this specific function, it is possible to make several types of bituminous mixtures due to the technologies and advanced study in their production.

Mixture type	E (MPa)	Poisson's Ratio (-)	Density kg/m^3
MB	6,000	0.35	2,300

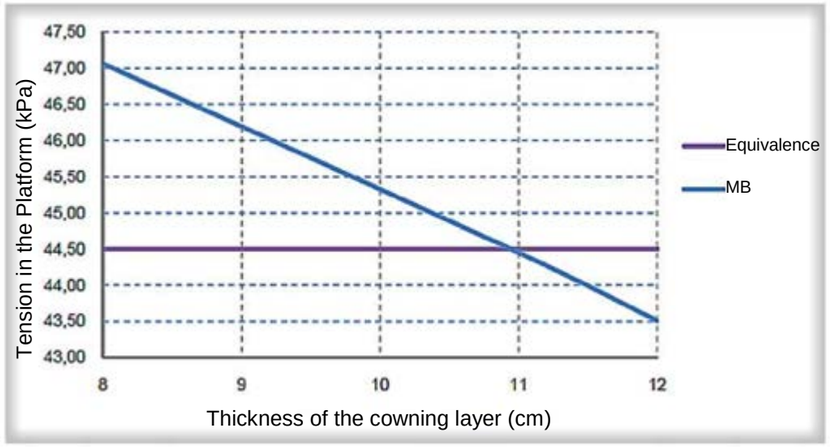
Mechanical properties of the bituminous mixture

Use of existing asphaltic pavement as sub-ballast layer - the use of bituminous mixtures in place of the granular sub-ballast layer refers to the implementation of a structural equivalence process. This method consists in varying the thickness of sub-ballast by drawing a graph as a function of the vertical tension in the top of the platform. Thus, it is possible to determine the minimum thickness of the bituminous sub-ballast layer to observe a strain on the platform equal to the reference value of the standard model.

In the graph, there is a decrease in the tension of the platform with increase of thickness of the sub-ballast. If we consider a platform with foundation soil of about 80 kPa, the structural equivalence process for obtaining the thickness of bituminous sub-ballast, have the following situation:

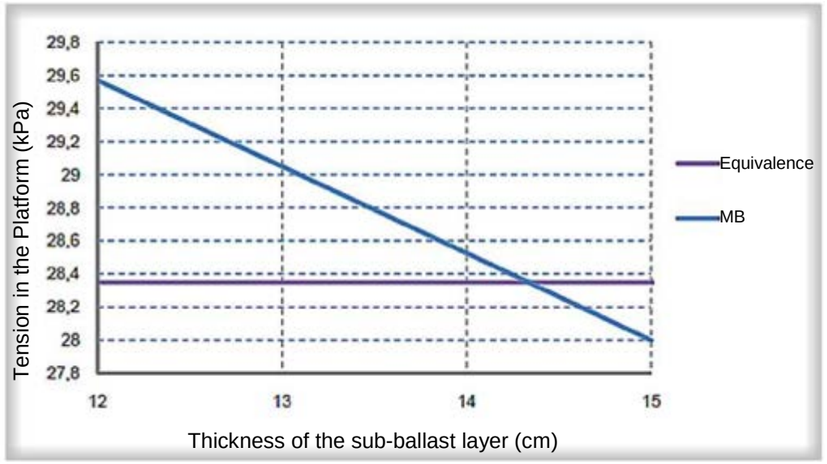
The minimum thickness of the bituminous sub-ballast to use the sizing of this type of solution, the foundation conditions being equal to or greater than 80 kPa, would be 11 cm.

Taking into account the method for determining the thickness of the bituminous sub-ballast layer through equivalence in terms of tensions on top of the platform, this solution must have a useful lifespan equal or greater than, when compared to the standard model. In this case, it only has to analyze the behavior of cyclical actions of bituminous sub-ballast layer.



By applying fatigue models, we can easily determine the admissible number of cycles to the rupture of this layer.

The analysis of the use feasibility of bituminous sub-ballast in platforms with lower quality (50 KPa) is solely due to economic factors. The same process will occur by varying the bituminous sub-ballast layer and maintaining a crowning layer from 35 to 40 cm in the soil. The graph shows the values of simulations performed and results in a value of 15 cm.



Support conditions of the lower bed → since we have a structured floor with 10 cm of Hot-rolled Bituminous Concrete (structural coefficient - k = 2.0), 20 cm graded crushed stone base (structural coefficient k = 1.0) and 20 cm of granular soil sub base (structural coefficient k = 0.9), quality proven by daily use including heavy duty vehicles, we consider it is possible handily to use the existing pavement as sub-ballast whose requirements do not exceed the 30% of CBR.

Hot-rolled Bituminous Concrete	K = 2.0		10 cm
Graded crushed stone base	K = 1.0	**CBR >= 80 %**	15 cm
Granular sub base	K = 0.9	**CBR >= 20 %**	20 cm
Stake 0 to 130 - Stake 162 to 167		Existing pavement to be used as sub-ballast of the permanent track	

The section in soil will be excavated to a depth of 30 cm and filled with ***"crushed stone"***, with a thickness of 20 cm and 10 cm of rolled concrete, which presents CBR values greater than those required for sub-ballast.

Soil of old railroad removal				30 cm
Replacement of the lower bed	K= 0.9	**Crushed stone**	**CBR >= 30 %**	20 cm
Rolled concrete				10 cm
		Sub bed in soil to be replaced by sub-ballast of the permanent track		

In the internal section of Calçada Station there is a coating flooring in stone blocks with structural coefficient k = 1.0, which can also be used as sub-ballast.

Stone blocks	K = 2.0		10 cm
Regularization sand	K = 1.0		5 cm
Granular sub base	K = 0.9	**CBR >= 20 %**	20 cm
Stake 167 to 183		Existing pavement to be used as sub-ballast of the permanent track	

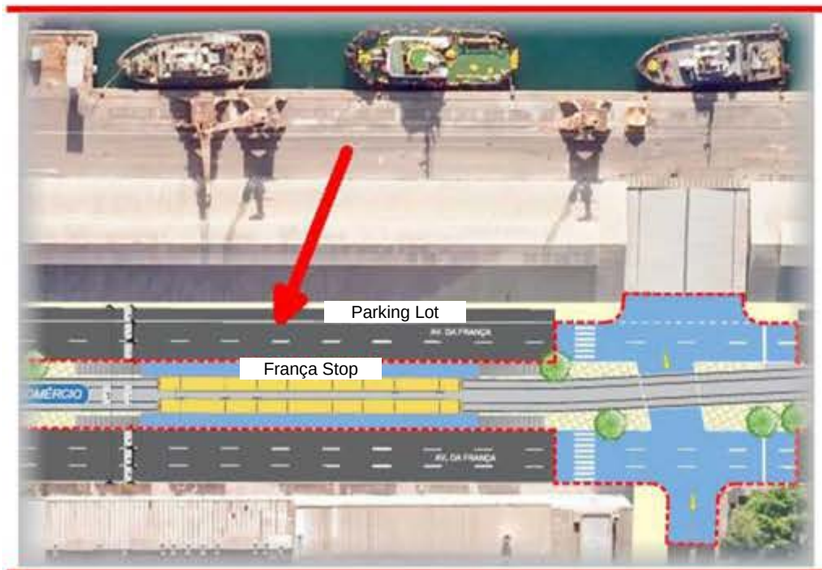
In order to support the final sizing, at the time of preparation of the executive design, the lower bed support conditions will be confirmed by spaced samples along the track, maximum 200.00 m, for readings of recoverable deflections using the " ***Benkeiman Beam"*** in paved sections with hot-rolled bituminous concrete and stone blocks. The section in the soils will be subjected to sampling for the determination of the California Bearing Ratio - CBR, also with minimum spacing 200.0 m, and can also be used with accuracy advantages, readings of ***"Benkelman Beam".*** More modern tests may be used.

Boarding and Disembarkation Stops

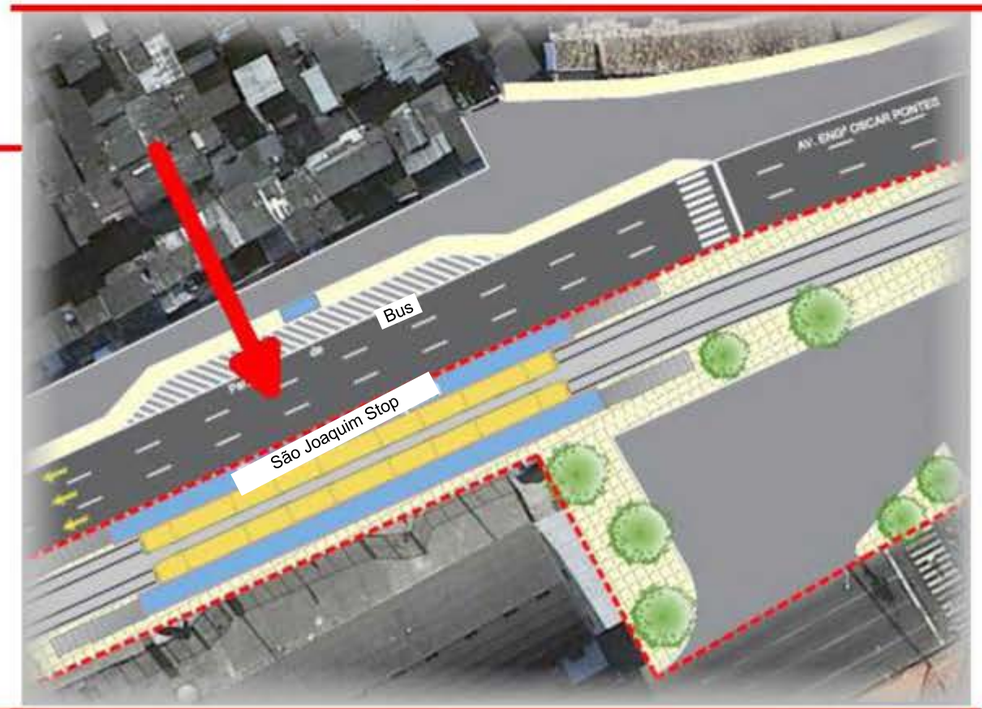
As a result of the Study of Demands, it was made a selection of the main boarding and disembarkation points along this section. For deployment of the Stops was necessary conditioning suitable geometrical spaces for deployment of facilities and equipping the following Stops:

Comércio Stop

Porto Stop

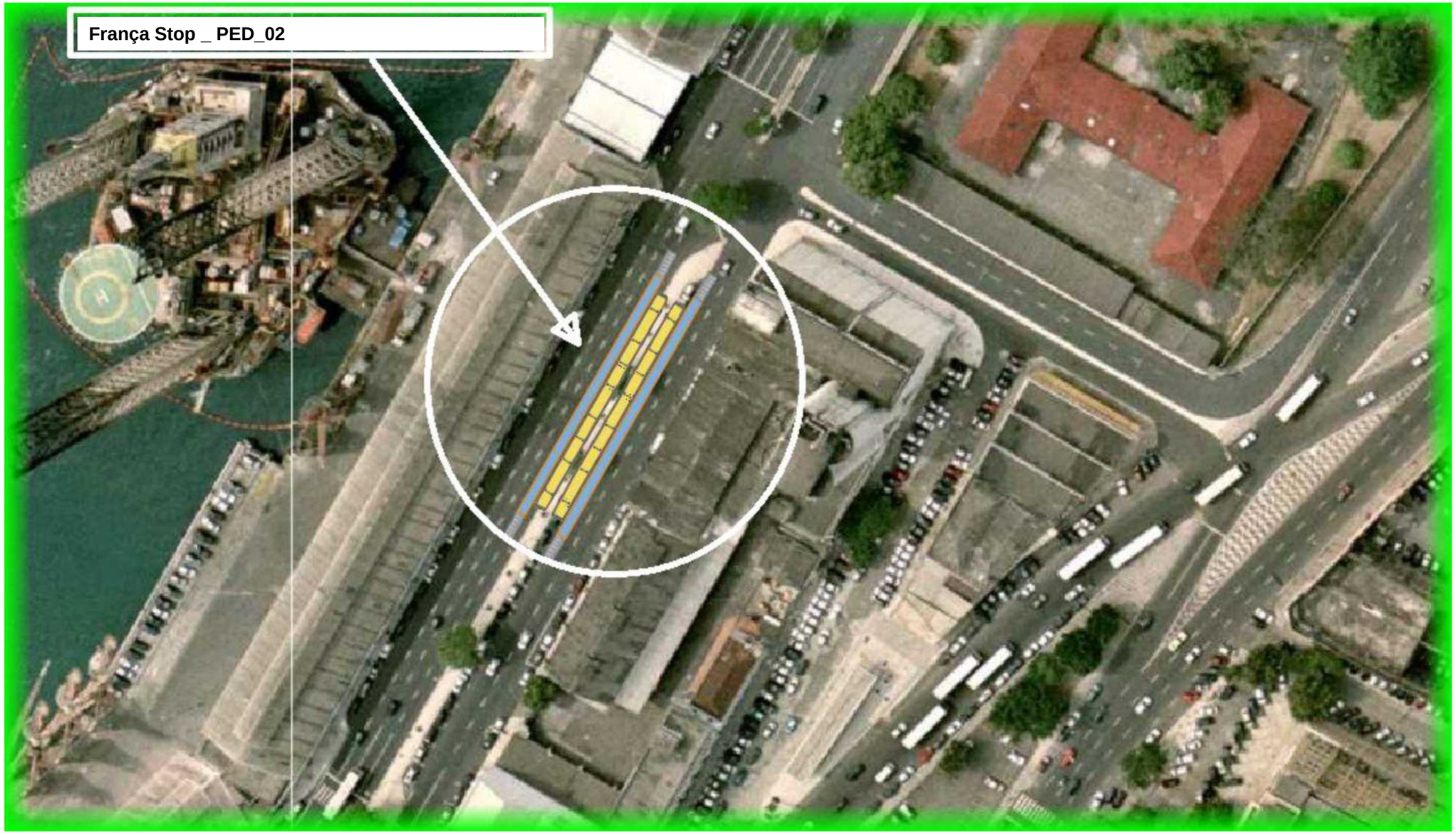


França Stop



São Joaquim Stop

Comércio Stop _ PED_01

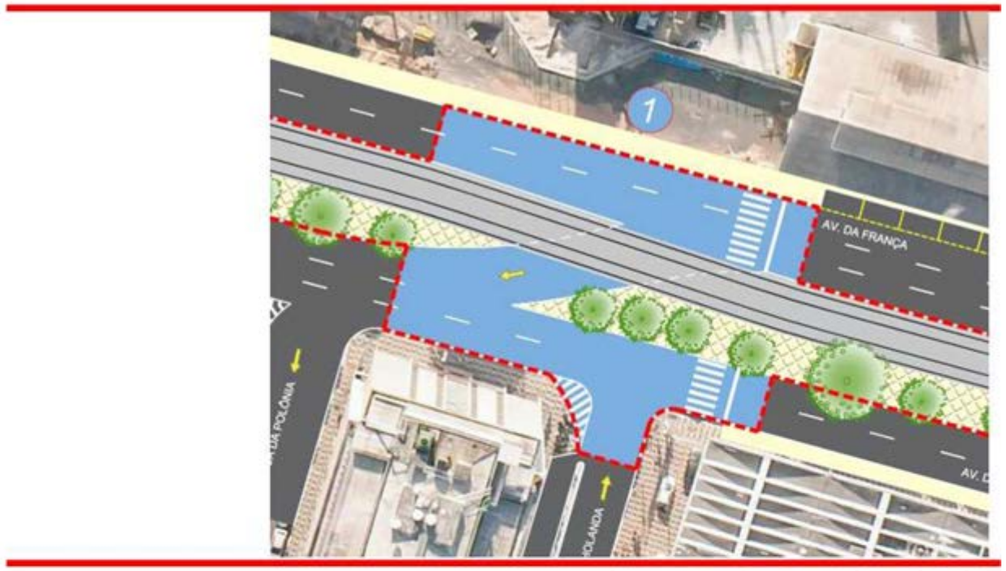

França Stop _ PED_02

Porto Stop _ PED_03

W
São Joaquim Stop _ PED_04

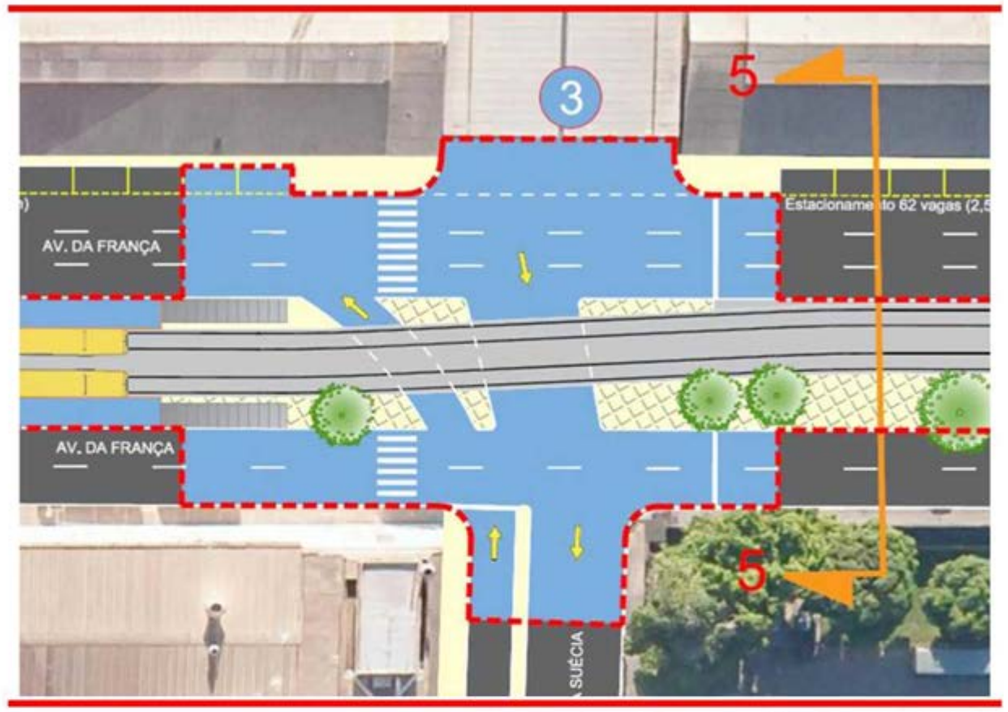
Level Passages

The urban condition of the section Comércio-Calçada conditioned a need for sharing in some sections, the passage of road vehicles on the bed of the Railway Permanent Track, resulting in the following Level Passages that are defined in Volume 1 of the Preliminary Design.



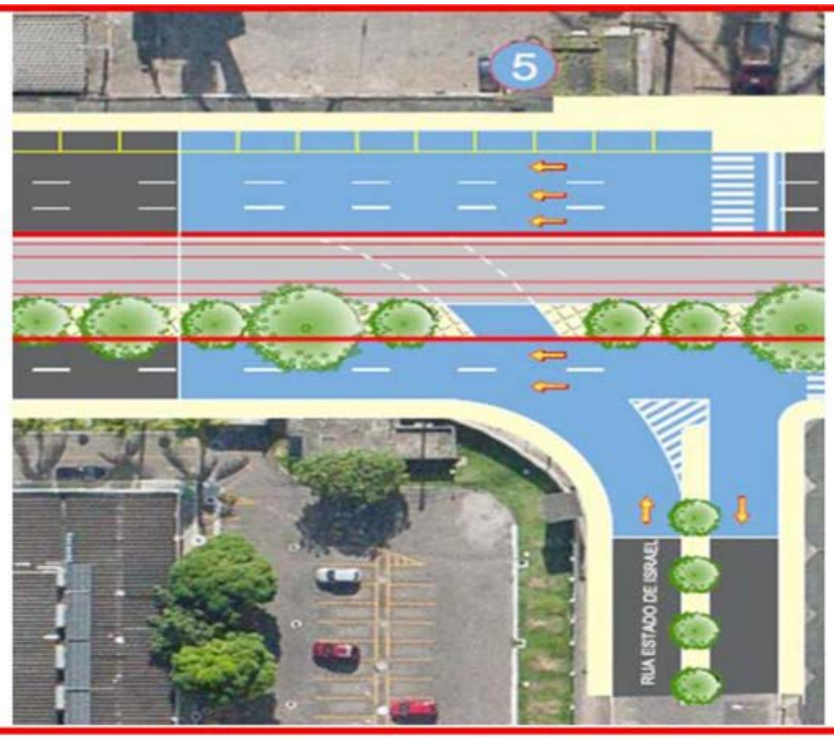
Level Passage 01 - Rua da Holanda

Level Passage 02 - Rua da Noruega



Level Passage 03 - Rua da Suécia

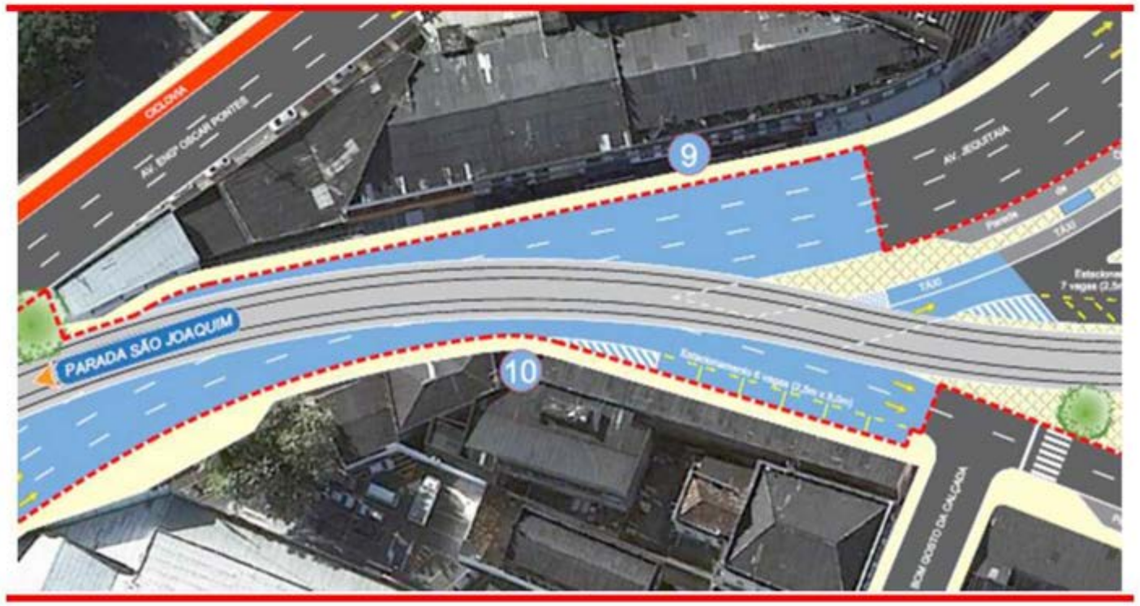
Level Passage 04 - Fuzileiros Navais



Level Passage 05 - Rua Estado de Israel

Level Passage 07 and 08 - Feira de São Joaquim

Level Passage 06 - Av. Eng. Oscar Pontes



Level Passage 09, 10 and 11 - Largo da Calçada

The coating structure of these level passages will be Portland cement concrete.

Route geometrization

The geometrization of Comércio - Calçada Section was conditioned by the guidelines established by the urban party, which introduced meanderings intended for accommodation of stations and level passage. Thus, it was necessary to add more restrictive curves that limited the design speed at 50 km/h. The following is the analytical calculation spreadsheet of the horizontal concordance.

Axis 01	Horizontal Concordance - circular curves																08/14/2015
Elements of Polygon					Elements of the Circular Curve												Distance
code	X (m)	Y(m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC/PT
1_0	552,697.4382	8,566,000.0027			1_0	0	0.00									
1_1	552,766.5103	8,566,068.0903	96.99	45°, 24' 40"	PCe	4	1.95	3º, 48' 50"	15.03	451.5580	30.06	0º, 03' 48"	5	12.01	PT	81.95
1_2	552,786.4716	8,566,090.5754	30.07	41°, 35' 50"	PCd	5	12.01	3º, 48' 50"	15.03	451.5580	30.06	0º, 03' 48"	7	2.07	PT	0.00
1_3	552,966.6791	8,566,268.2146	253.04	45°, 24' 40"	PCd	18	8.94	6º, 26' 45"	11.14	197.7500	22.25	0º, 08' 42"	19	11.19	PT	226.87
1_4	552,984.1927	8,566,281.9683	22.27	51°, 51' 25"	PCe	19	11.19	6º, 26' 45"	11.14	197.7500	22.25	0º, 08' 42"	20	13.43	PT	0.00
1_5	553,161.1767	8,566,456.4298	248.52	45°, 24' 40"	PCe	31	6.29	15°, 20' 46"	24.52	182.0000	48.75	0º, 09' 27"	33	15.04	PT	212.86
1_6	553,238.6352	8,566,590.2403	154.61	30°, 03' 55"	PCe	39	5.13	2º, 51' 58"	20.00	799.4713	39.99	0º, 02' 09"	41	5.12	PT	110.09
1_7	553,256.9185	8,566,625.8172	40.00	27°, 11' 57"	PCd	41	5.12	2°, 51' 58"	20.00	799.4713	39.99	0º, 02' 09"	43	5.12	PT	0.00
1_8	553,592.7307	8,567,205.9373	670.31	30°, 03' 54"	PCd	73	7.93	37°, 28' 27"	47.49	140.0000	91.57	0°, 12' 17"	77	19.50	PT	602.82
1_9	553,761.6104	8,567,275.7541	182.74	67°, 32' 21"	PCe	80	13.22	36°, 07' 27"	81.53	250.0000	157.62	0º, 06' 53"	88	10.85	PT	53.72
1_10	553,871.3230	8,567,455.3859	210.49	31°, 24' 54"	PCe	94	9.78	5º, 43' 29"	10.02	200.5030	20.03	0º, 08' 34"	95	9.81	PT	118.93
1_11	553,880.0148	8,567,473.4539	20.05	25°, 41' 25"	PCd	95	9.81	5º, 43' 29"	10.02	200.5030	20.03	0º, 08' 34"	96	9.84	PT	0.00
1_12	553,957.3522	8,567,600.0780	148.37	31°, 24' 54"	PCe	100	6.30	14°, 06' 46"	61.89	500.0000	123.16	0º, 03' 48"	106	9.46	PT	76.46
1_13	554,129.6962	8,568,153.3374	579.48	17°, 18' 08"	PCe	131	10.06	10°, 47' 02"	16.99	180.0000	33.88	0º, 03' 48"	133	3.94	PT	500.60
1_14	554,157.4110	8,568,395.8946	244.14	6º, 31'06"	PCe	142	11.08	25°, 03' 26"	40.00	180.0000	78.72	0º, 03' 48"	146	9.80	PT	187.15
1_15	554,101.1286	8,568,563.7275	177.02	341°, 27' 40"	PCd	151	1.55	28°, 14' 08"	45.27	180.0000	88.70	0º, 03' 48"	155	10.25	PT	91.75
1 _16	554,122.3883	8,568,688.1429	126.22	9°, 41' 49"	PCd	155	10.95	48°, 03' 24"	80.25	180.0000	150.97	0º, 03' 48"	163	1.93	PT	0.70
1_17	554,218.3618	8,568,748.6890	113.48	57°, 45' 13"	PCe	163	11.64	14°, 53' 10"	23.52	180.0000	46.77	0º, 03' 48"	165	18.41	PT	9.71
1_18	554,371.5032	8,568,913.6761	225.11	42°, 52' 03"	1_18	176	0.00									201.59

With respect to the vertical geometry, the main restriction was the grades of Av. da França and Av. Oscar Pontes. The following is the analytical calculation spreadsheet of vertical concordance to be adjusted and adequate at the time of the basic design from the final location of the axis.

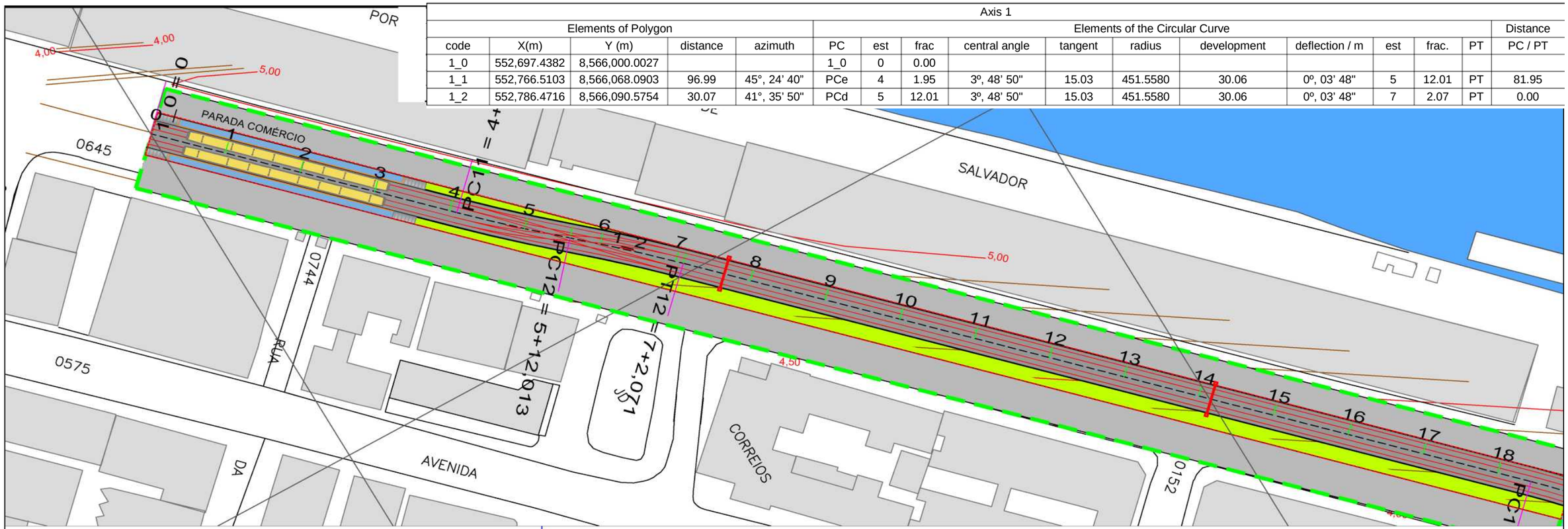
Grade Parameters Axis _ 1 Asymmetric Curve

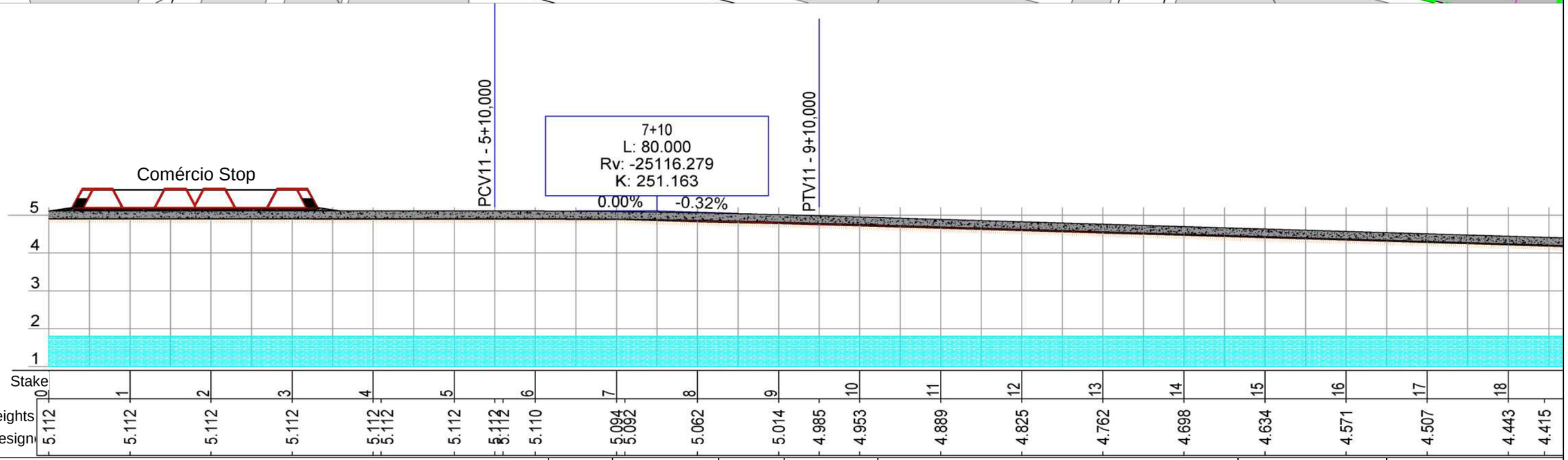
Design Condition	
Minimum	M
Desirable	D

Axis	Operating Speed	Design Speed	Visibility Distance	Vertical Radius Convex		Vertical Radius Concave	Condition
1	62	70 '	69	1.1	68	1.320	m

P	C	V	slope	distance	Y_1	PIV			Y_2	Rv_1	E	Rv_2	P	T	V
stake	fraction	height	%	PCV / PTV	m	stake	fraction	height	m	m	m	m	stake	fraction	height
						0	00.00	5,112							
5	10.00	5,112	0.00	110.00	40.00	7	10.00	5,112	40.00	-25,120	-0.032	-25,120	9	10.00	4,985
28	13.50	3,764	-0.32	383.50	49.00	31	02.50	3,607	34.00	21,912	0.055	10,550	32	16.50	3,685
44	10.00	4,216	0.23	233.50	30.00	46	00.00	4,284	30.00	-201,327	-0.002	-201,327	47	10.00	4,343
50	05.00	4,452	0.20	55.00	30.00	51	15.00	4,511	30.00	44,702	-0.010	44,702	53	05.00	4,530
60	07.50	4,621	0.06	142.50	50.00	62	17.50	4,652	50.00	-51,326	-0.024	-51,326	65	07.50	4,587
69	00.00	4,491	-0.13	72.50	40.00	71	00.00	4,439	40.00	10,816	0.074	10,816	73	00.00	4,682
73	00.00	4,682	0.61	0.00	97.50	77	17.50	5,275	52.50	-13,597	-0.350	-3,942	80	10.00	4,519
80	10.00	4,519	-1.44	0.00	20.00	81	10.00	4,231	30.00	2,398	0.083	5,395	83	00.00	4,216
92	05.00	4,122	-0.05	185.00	30.00	93	15.00	4,107	30.00	12,587	0.036	12,587	95	05.00	4,235
102	00.00	4,811	0.43	135.00	30.00	103	10.00	4,938	30.00	-15,930	-0.028	-15,930	105	00.00	4,953
109	00.00	4,993	0.05	80.00	30.00	110	10.00	5,008	45.00	30,541	0.015	68,717	112	15.00	5,104
112	15.00	5,104	0.21	0.00	45.00	115	00.00	5,200	30.00	-52,730	-0.019	-23,436	116	10.00	5,200
151	15.00	5,200	0.00	705.00	30.00	153	05.00	5,200	45.00	-8,745	-0.051	-19,677	155	10.00	4,943
155	10.00	4,943	-0.57	0.00	40.00	157	10.00	4,714	30.00	16,904	0.047	9,509	159	00.00	4,708
160	12.50	4,702	-0.02	32.50	30.00	162	02.50	4,696	30.00	-8,790	-0.051	-8,790	163	12.50	4,485
170	10.00	3,520	-0.70	137.50	30.00	172	00.00	3,309	30.00	8,544	0.053	8,544	173	10.00	3,309
			0.00	50.00		176	00.00	3,309							

Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_0	552,697.4382	8,566,000.0027			1_0	0	0.00									
1_1	552,766.5103	8,566,068.0903	96.99	45°, 24' 40"	PCe	4	1.95	3º, 48' 50"	15.03	451.5580	30.06	0º, 03' 48"	5	12.01	PT	81.95
1_2	552,786.4716	8,566,090.5754	30.07	41°, 35' 50"	PCd	5	12.01	3º, 48' 50"	15.03	451.5580	30.06	0º, 03' 48"	7	2.07	PT	0.00





CAPTION

Axis, Neck Rail, Neck Rail, Permanent Track

Construction sites

Higher Point

Lower Point

Limit of Urbanization

Limit of Intervention

Crossing for Public Services Networks - Ø = 0.60 m

Level Passages

DRAWING		/ /	SHEET 01/10
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK: SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY SALVADOR

SUBJECT FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY

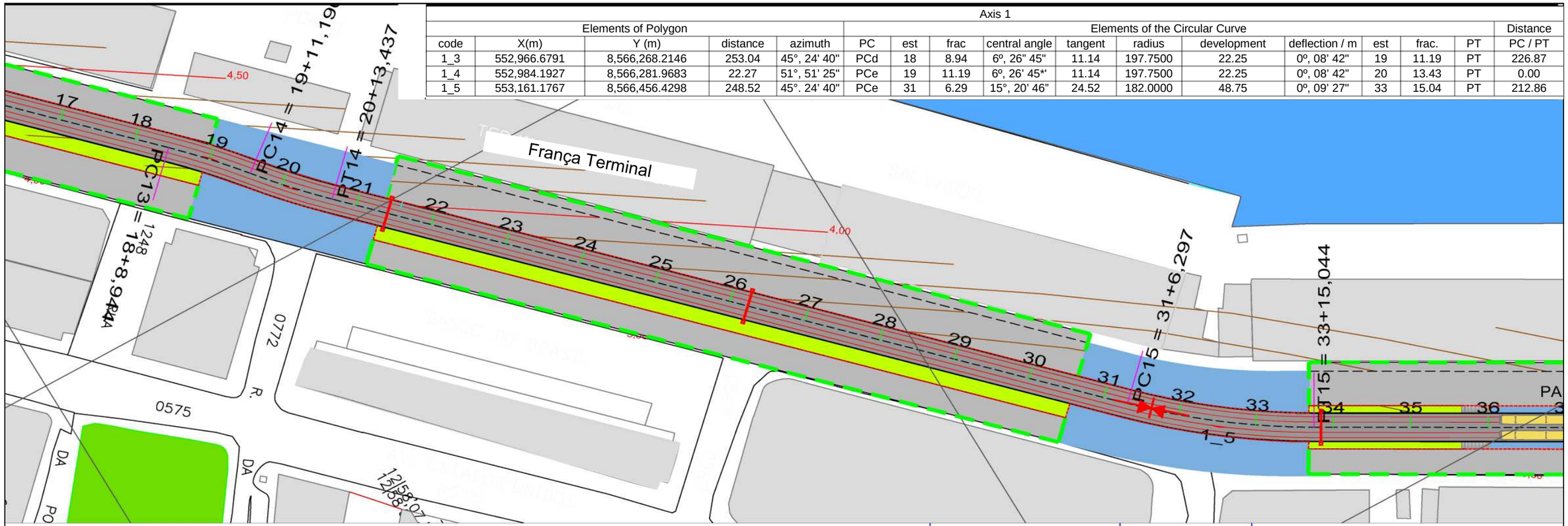
DEPARTMENT OF URBAN DEVELOPMENT

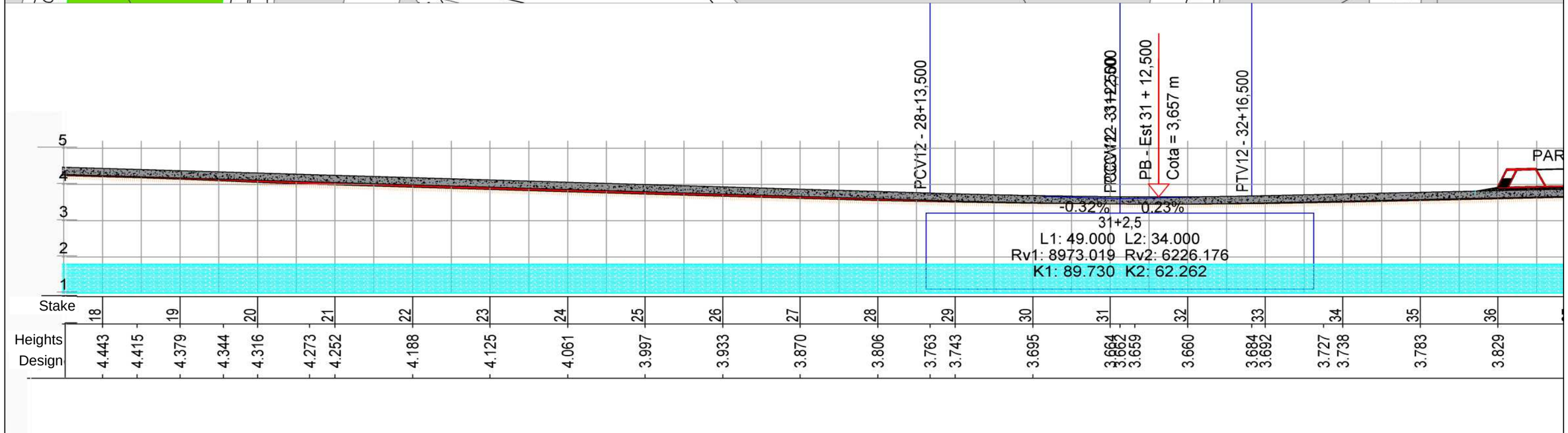
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV

Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_3	552,966.6791	8,566,268.2146	253.04	45°, 24' 40"	PCd	18	8.94	6º, 26" 45"	11.14	197.7500	22.25	0º, 08' 42"	19	11.19	PT	226.87
1_4	552,984.1927	8,566,281.9683	22.27	51°, 51' 25"	PCe	19	11.19	6º, 26' 45*'	11.14	197.7500	22.25	0º, 08' 42"	20	13.43	PT	0.00
1_5	553,161.1767	8,566,456.4298	248.52	45°. 24' 40"	PCe	31	6.29	15°, 20' 46"	24.52	182.0000	48.75	0º, 09' 27"	33	15.04	PT	212.86





CAPTION

Construction sites
Limit of Urbanization
Limit of Intervention
Axis
Neck Rail
Neck Rail
Permanent Track
Higher Point
Lower Point
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

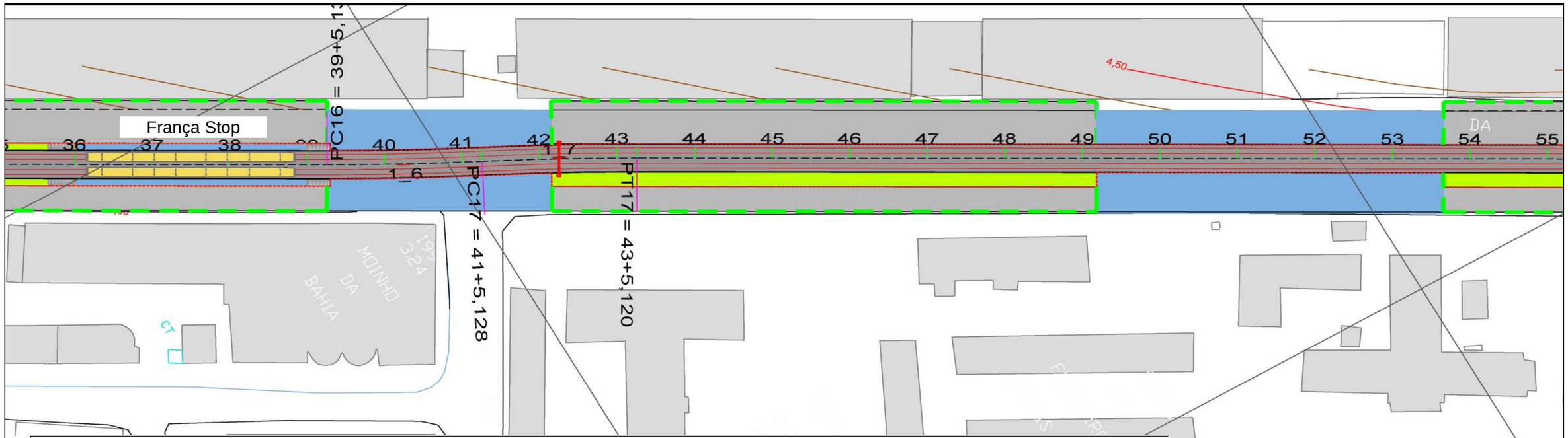
DRAWING		/ /	SHEET 02/10	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

DEPARTMENT OF URBAN DEVELOPMENT

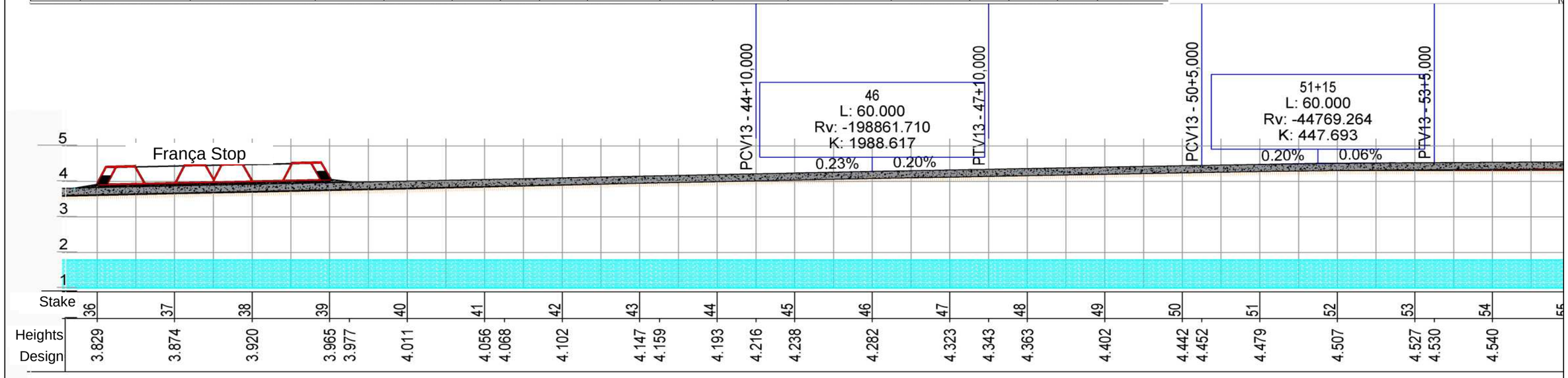
BAHIA GOVERNO DO ESTADO

CJB

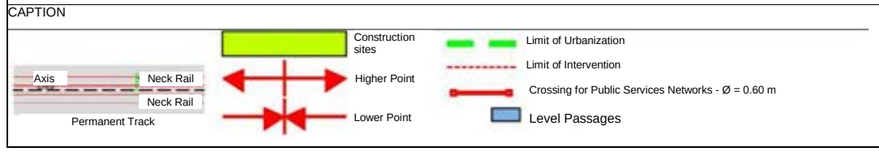
LIGHT-RAIL VEHICLE
LRV



Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_6	553,238.6352	8,566,590.2403	154.61	30°, 03' 55"	PCe	39	5.13	2º, 51' 58"	20.00	799.4713	39.99	0º, 02' 09"	41	5.12	PT	110.09
1_7	553,256.9185	8,566,625.8172	40.00	27°, 11' 57"	PCd	41	5.12	2º, 51' 58"	20.00	799.4713	39.99	0º, 02' 09"	43	5.12	PT	0.00



CAPTION



			SHEET 03/10
DRAWING		/ /	
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

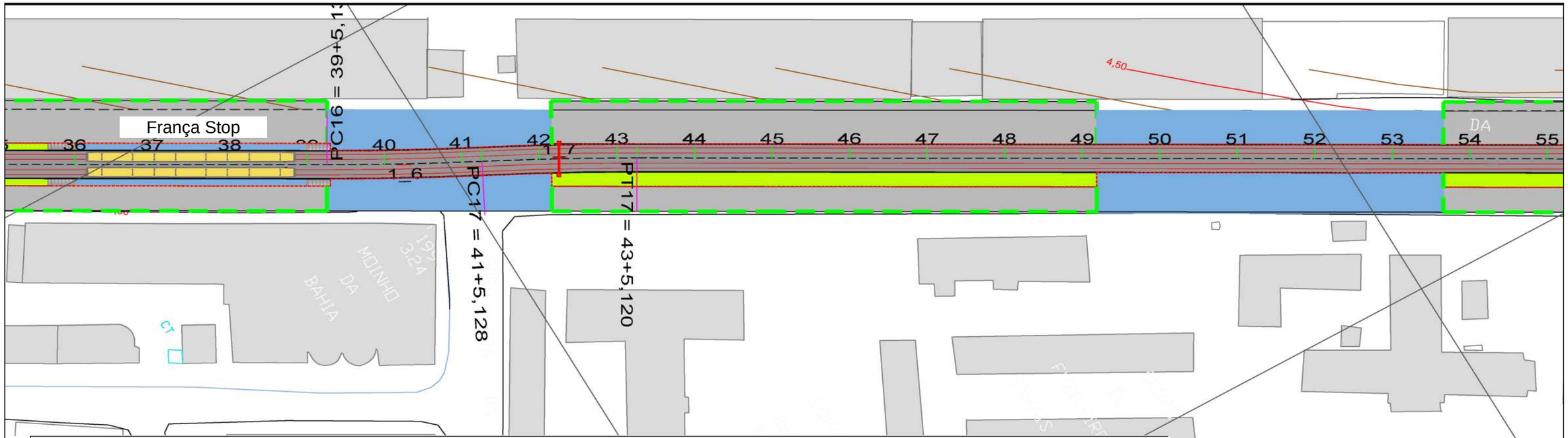
SUBJECT
FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY

DEPARTMENT OF URBAN DEVELOPMENT

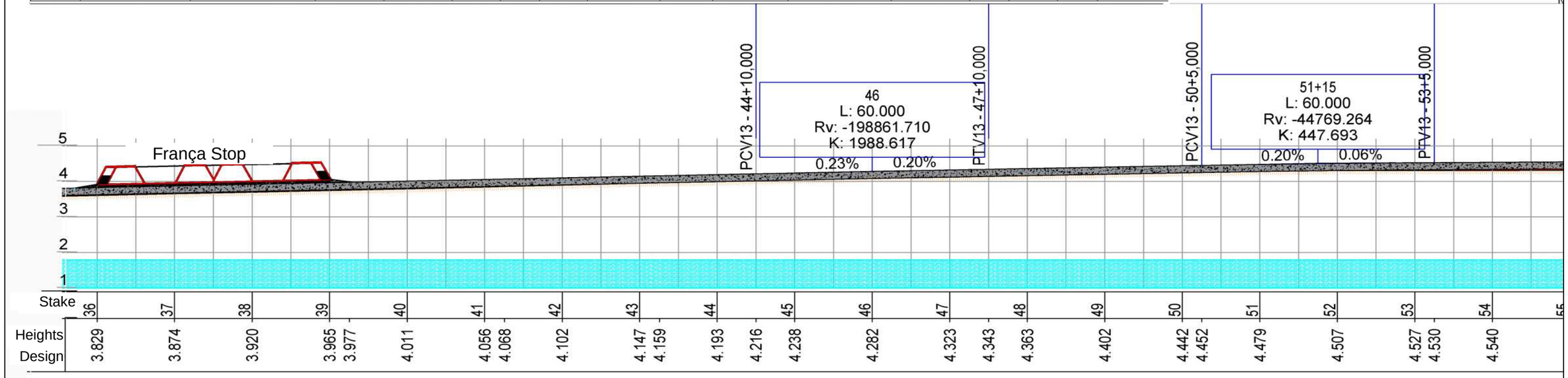
BAHIA GOVERNO DO ESTADO

CJB

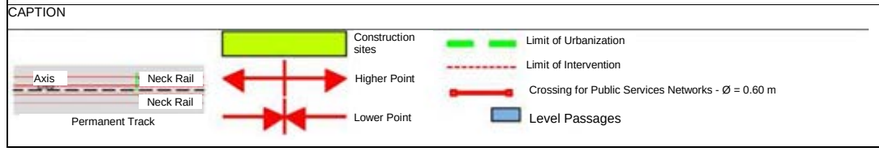
LIGHT-RAIL VEHICLE
LRV



Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_6	553,238.6352	8,566,590.2403	154.61	30°, 03' 55"	PCe	39	5.13	2º, 51' 58"	20.00	799.4713	39.99	0º, 02' 09"	41	5.12	PT	110.09
1_7	553,256.9185	8,566,625.8172	40.00	27°, 11' 57"	PCd	41	5.12	2º, 51' 58"	20.00	799.4713	39.99	0º, 02' 09"	43	5.12	PT	0.00



CAPTION



			SHEET 03/10
DRAWING		/ /	
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

SUBJECT
FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY

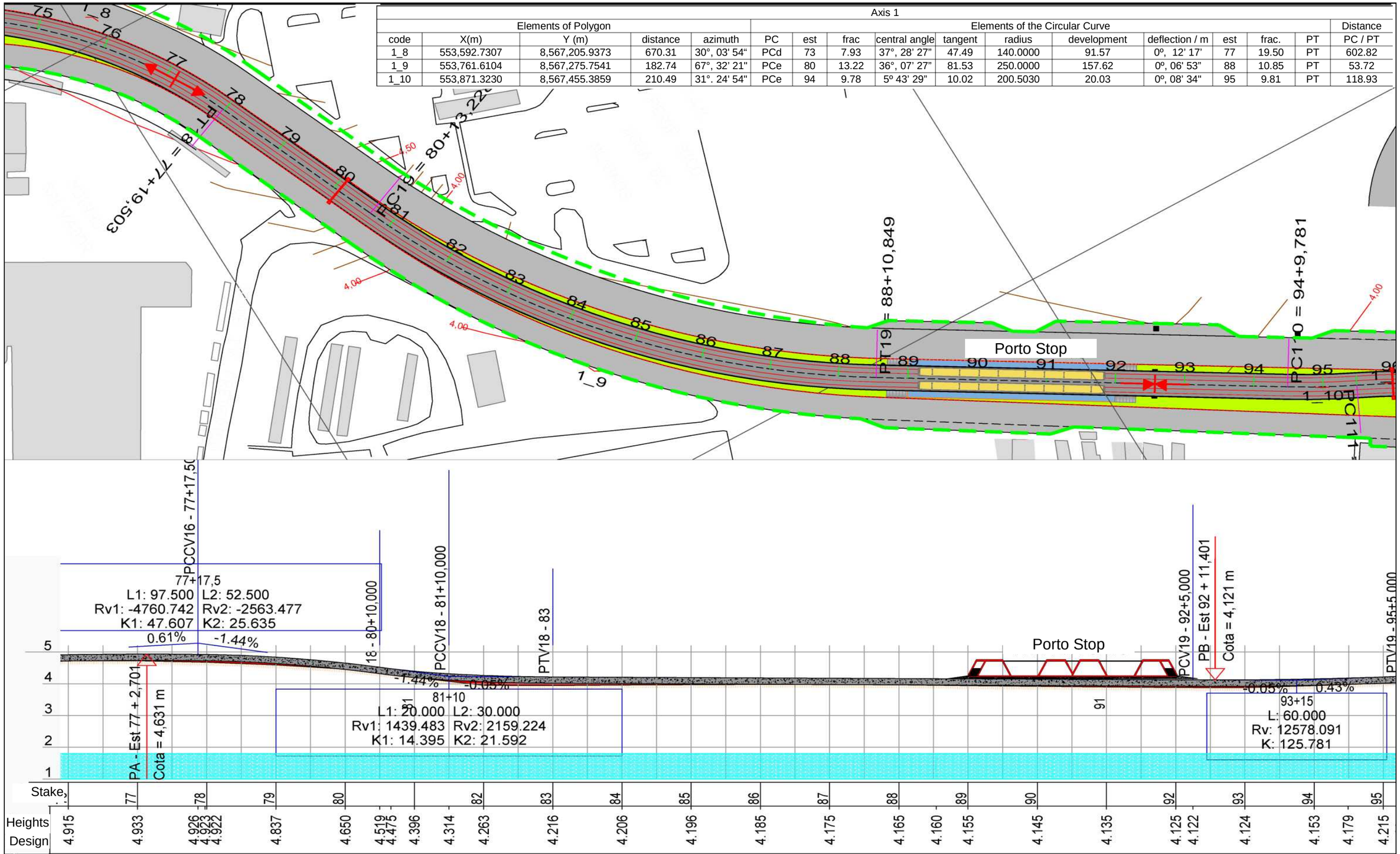
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV

Axis 1																	
Elements of Polygon					Elements of the Circular Curve												Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_8	553,592.7307	8,567,205.9373	670.31	30°, 03' 54"	PCd	73	7.93	37°, 28' 27"	47.49	140.0000	91.57	0º, 12' 17'	77	19.50	PT	602.82
1_9	553,761.6104	8,567,275.7541	182.74	67°, 32' 21"	PCe	80	13.22	36°, 07' 27"	81.53	250.0000	157.62	0º, 06' 53"	88	10.85	PT	53.72
1_10	553,871.3230	8,567,455.3859	210.49	31°. 24' 54"	PCe	94	9.78	5º 43' 29"	10.02	200.5030	20.03	0º, 08' 34"	95	9.81	PT	118.93



CAPTION

Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point
Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

DRAWING		/ /	SHEET 05/10	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

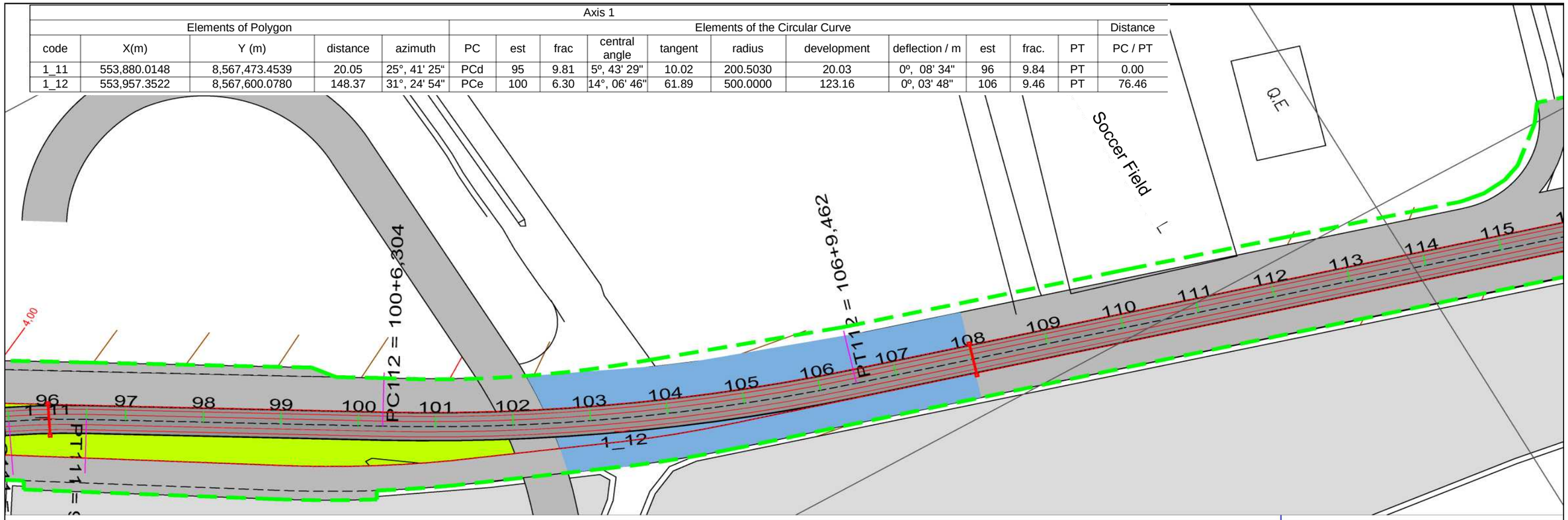
DEPARTMENT OF URBAN DEVELOPMENT

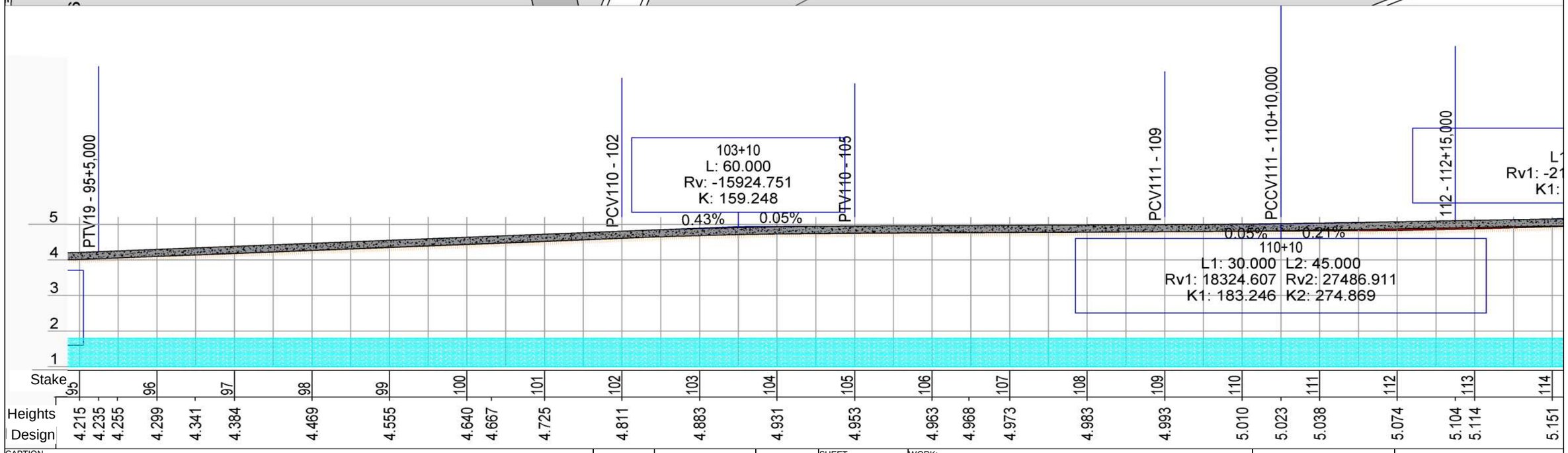
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV

Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_11	553,880.0148	8,567,473.4539	20.05	25°, 41' 25"	PCd	95	9.81	5º, 43' 29"	10.02	200.5030	20.03	0º, 08' 34"	96	9.84	PT	0.00
1_12	553,957.3522	8,567,600.0780	148.37	31°, 24' 54"	PCe	100	6.30	14°, 06' 46"	61.89	500.0000	123.16	0º, 03' 48"	106	9.46	PT	76.46





CAPTION

Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point

Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

DRAWING		/ /	SHEET 06/10
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

SUBJECT
FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY

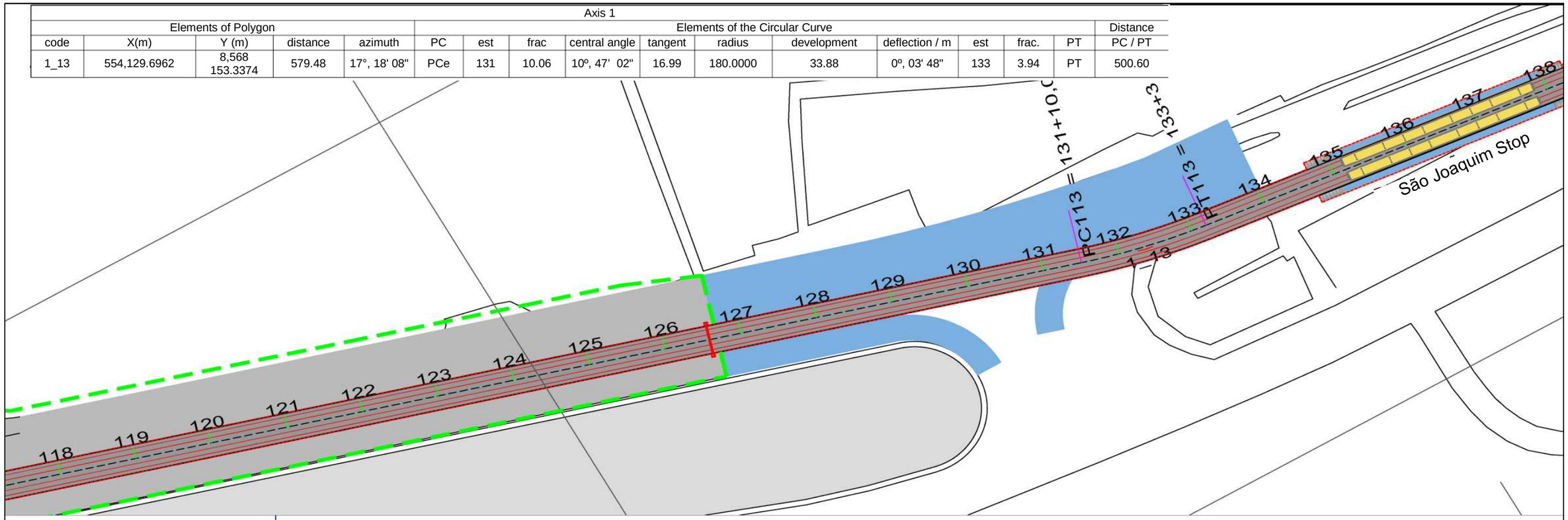
DEPARTMENT OF URBAN DEVELOPMENT

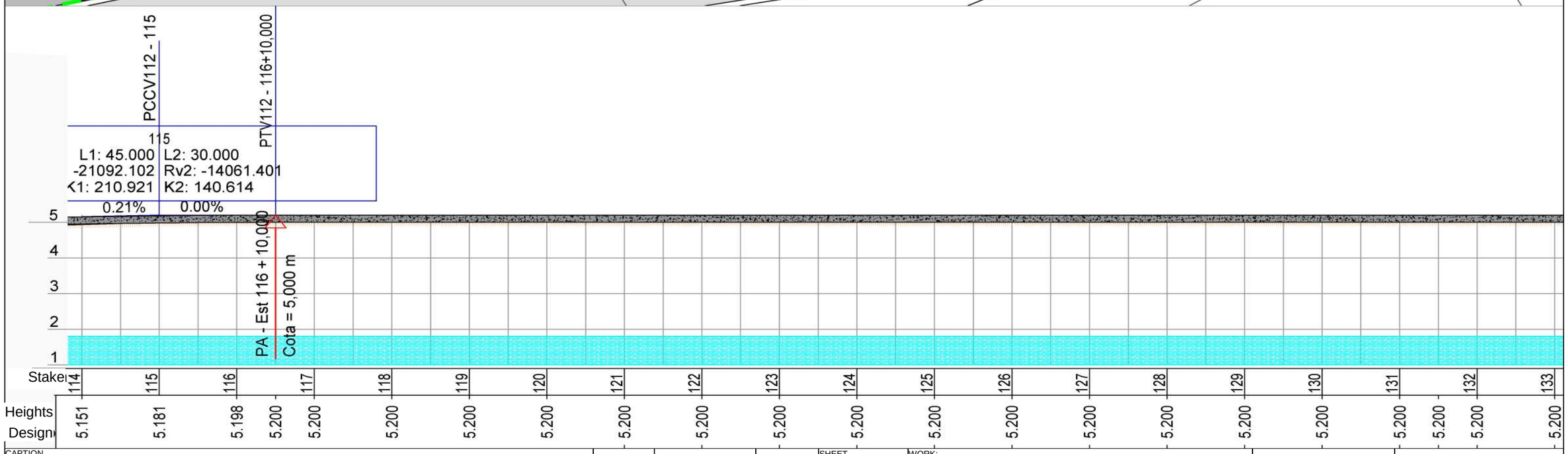
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV

Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_13	554,129.6962	8,568 153.3374	579.48	17°, 18' 08"	PCe	131	10.06	10º, 47' 02"	16.99	180.0000	33.88	0º, 03' 48"	133	3.94	PT	500.60





CAPTION

Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point
Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

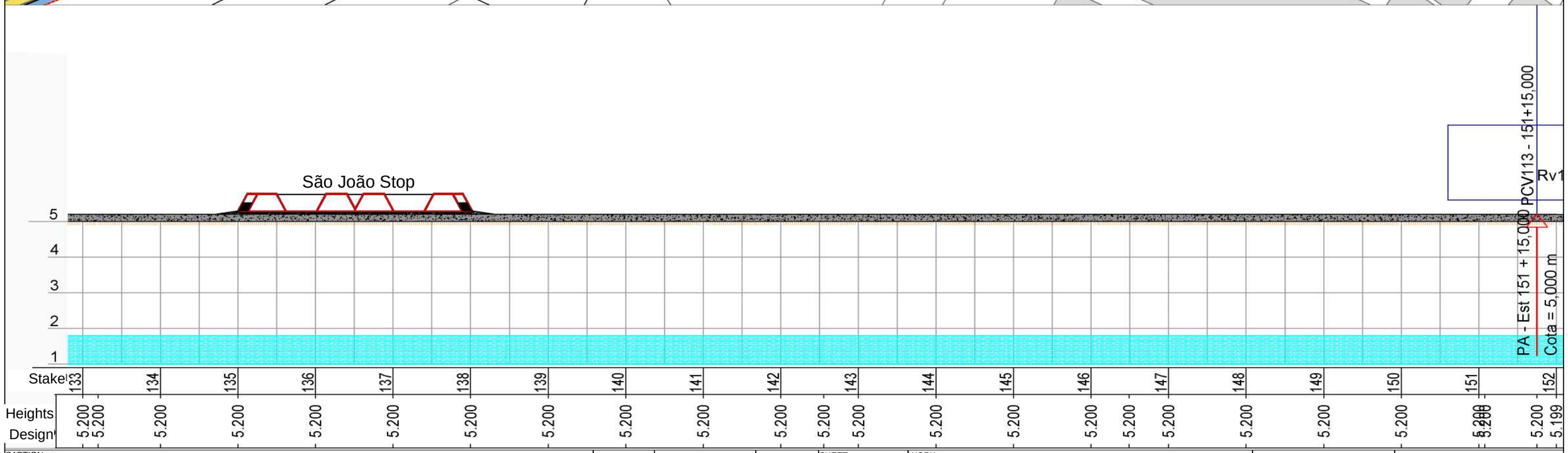
DRAWING		/ /	SHEET 07/10	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point

Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

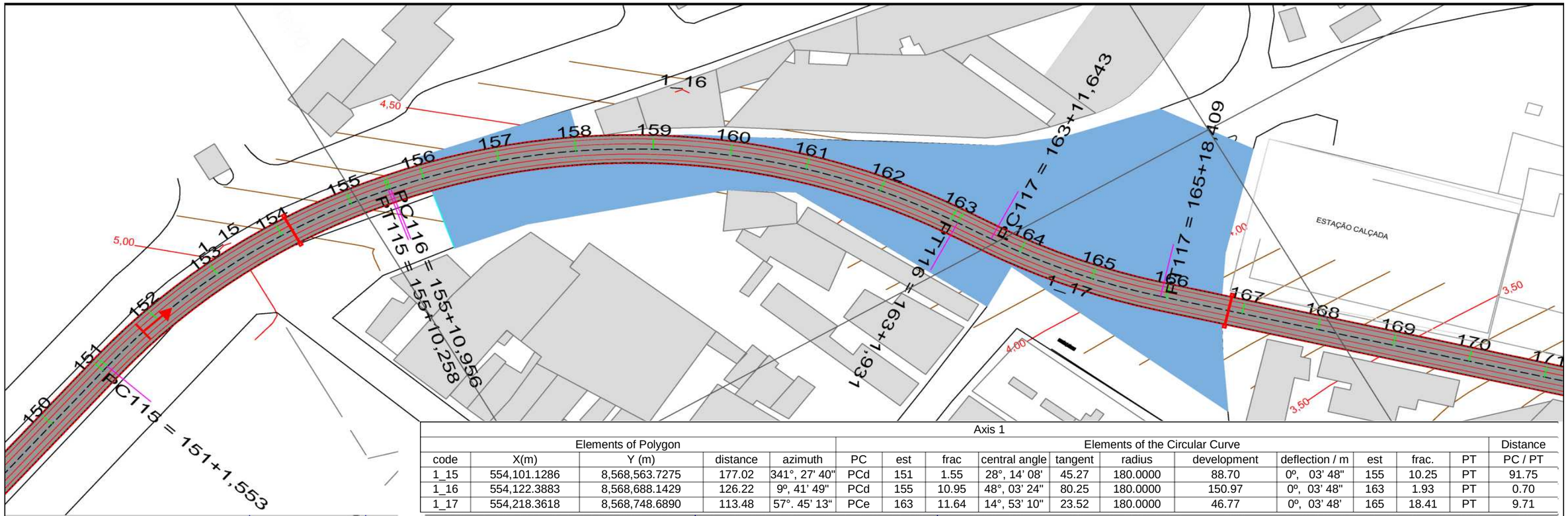
DRAWING		/ /	SHEET 08/10	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

DEPARTMENT OF URBAN DEVELOPMENT

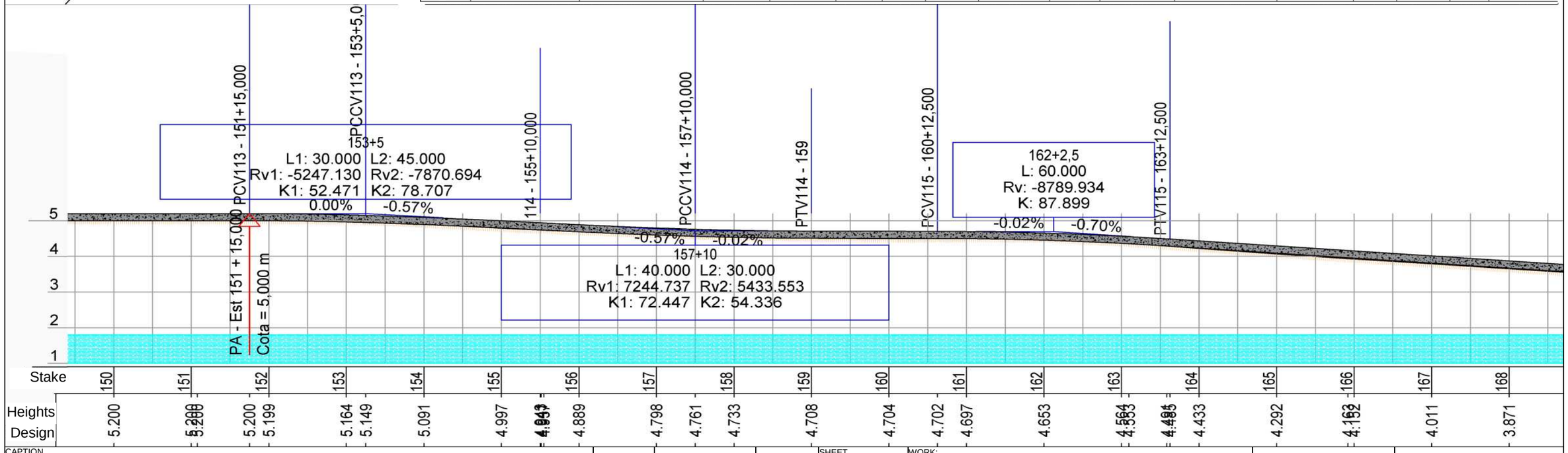
BAHIA GOVERNO DO ESTADO

CJB

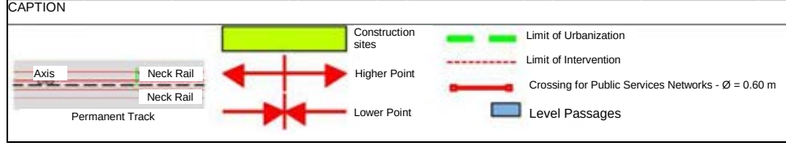
LIGHT-RAIL VEHICLE
LRV



Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_15	554,101.1286	8,568,563.7275	177.02	341°, 27' 40"	PCd	151	1.55	28°, 14' 08'	45.27	180.0000	88.70	0º, 03' 48"	155	10.25	PT	91.75
1_16	554,122.3883	8,568,688.1429	126.22	9º, 41' 49"	PCd	155	10.95	48°, 03' 24"	80.25	180.0000	150.97	0º, 03' 48"	163	1.93	PT	0.70
1_17	554,218.3618	8,568,748.6890	113.48	57°. 45' 13“	PCe	163	11.64	14°, 53' 10"	23.52	180.0000	46.77	0º, 03' 48'	165	18.41	PT	9.71



CAPTION



DRAWING		/ /	SHEET 09/10
CHECKING		/ /	SCALE
APPROVAL		/ /	Drainage - 1:1,000 Sections – 1:100
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

SUBJECT
FLOOR PLAN OF HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY

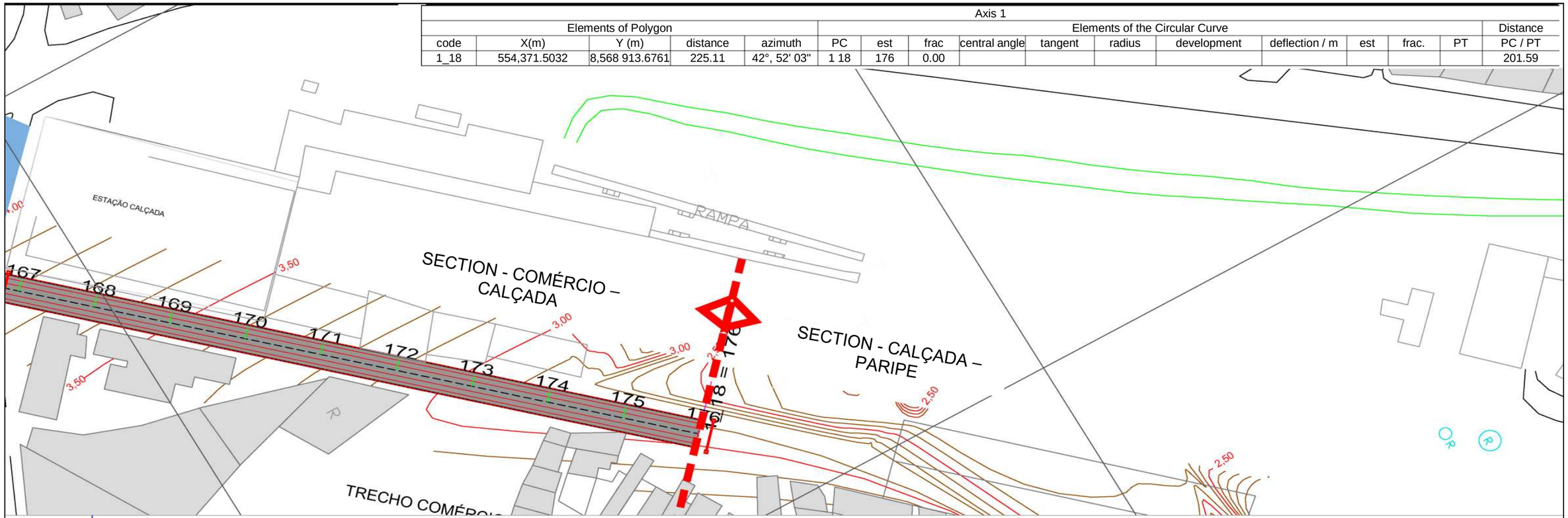
DEPARTMENT OF URBAN DEVELOPMENT

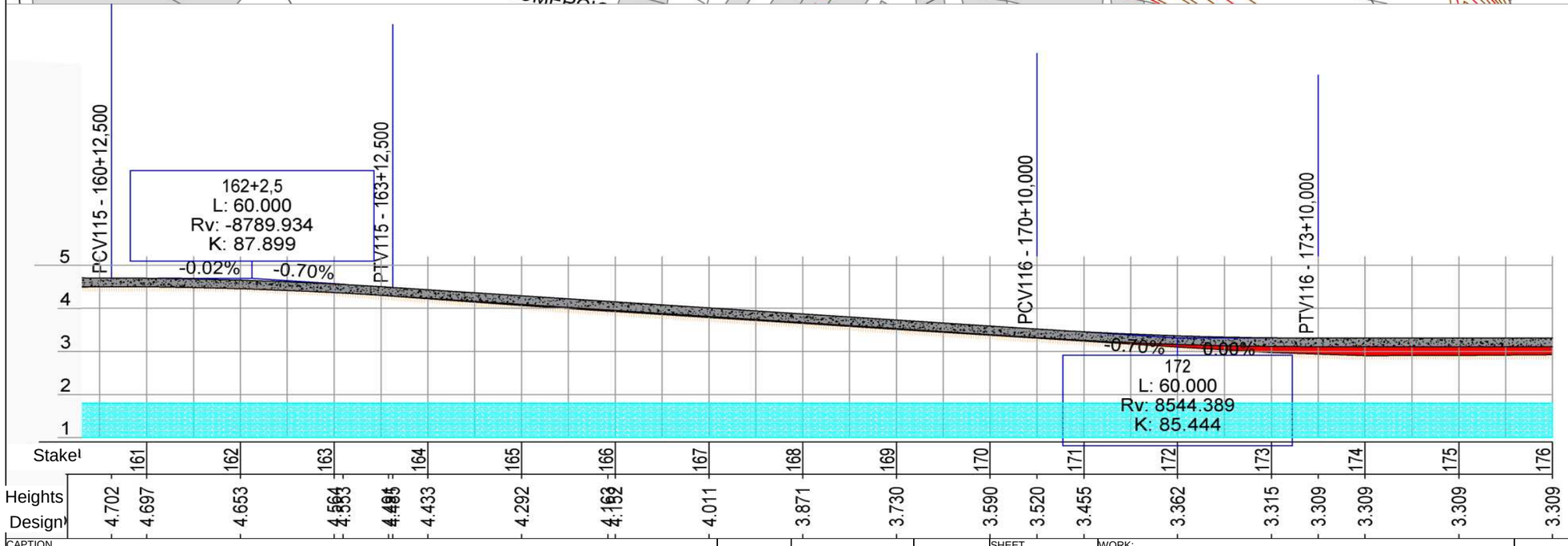
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV

Axis 1																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC / PT
1_18	554,371.5032	8,568 913.6761	225.11	42°, 52' 03"	1 18	176	0.00									201.59





CAPTION

Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point

Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

DRAWING		/ /	SHEET 10/10
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

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Drainage systems

The design of drainage systems was focused primarily on the assessment of the existing structures, concerning gully holes of the grot and the sizing and location of new ditches and gully holes of grade, the route for rail connection Comércio - Calçada.

In order to better understand the local situation, we need clarification about fundamental concepts of hydrology and hydraulics:

Rainfall → By quantifying and qualifying the precipitation, the designer seeks to understand the intensity amount, frequency and duration of the rain to better target retarding devices.

When the Government has no mathematical formula to quantify the intensity of the rain, the designer prepares Rain Equations using weather information units of the region or nearby, in order to obtain the rain data after undergoing specific treatment for statistical adjustment result in rain equations for local use when evaluating the intensities.

For sizing the hydraulic structures, the designer must determine the rainfall of greater intensity can be expected to occur with a given frequency. The practical use of such data requires to establish an analytical relationship between the magnitudes, characteristic of a precipitation, which are the ***intensity*** (i), the ***duration*** (t) and ***frequency*** (P).

The rain equation, particularly from each location is obtained from rain gauges' records, establishing for each period of rain, the maximum intensities. The general representation of an equation of heavy rain has the following form:

$$i = \frac{B1 * (T^{\alpha + \frac{\beta}{T^{\gamma}}})^{\delta}}{(t + c)^{b}}$$

Where α, β, γ, δ are constant regional parameters and depend only on the return period;

B, b, c are parameters that describe local characteristics and ***i*** is the maximum intensity of rainfall (mm/min). ***t*** is the duration (min) and ***T*** is the return period (year);

The ***duration*** t of the rain usually takes the same amount of ***concentration time,*** which in turn is defined as the time required to drain the entire area contributing to the design section, or section of interest. On the other hand, the ***return period*** T is a statistical concept slightly more elaborated, defined as the time at which a certain event lasts on average to be equaled or exceeded. In case of rain equations, the return period refers only to heavy rain, so the average time in which a heavy rain could be equaled or exceeded again. The intensity of rainfall and its probability distribution dependent on the return time (T), also its duration "t".

Since the return time translates the concept of risk and is materialized as a safety factor, it should be fixed by Regulatory Entities of drainage services, by economic criteria, trying to find the minimum of the construction cost of the work and the amount of losses caused by its eventual failure over its useful life.

However, there are difficulties in assessing the costs involved for setting the recurrence or return time, a fact that has led designers to define the standard values or established indicators by the practice of Engineering, and reported in the literature on tables that consider the useful life; structure type; repair conditions; risks to third parties; the occupation of the subject area and hydrological uncertainties or even establishing a relationship between risk and useful life of the enterprise.

Concentration time → this is the time spent by the drop of water that precipitates at the head of a watershed to reach the cross section of interest. The estimated time of concentration can be made by different methods and mathematical formulations that take into account the situations in which each method is proposed.

After understood these fundamental concepts, the following assessments that resulted in the design of the structure and details of the drainage systems were made:

- ✓ Assessment of contribution areas to the drainage systems
- ✓ Assessment of existing capacity of drainage systems
- ✓ Design and geometry of the drainage systems

Assessment of the contribution areas to the drainage systems → the assessment of the contribution areas was made on a cartographic base - SICAR - RMS, adjusted within the limits of the topographical range raised, for delimitation of the contributors' basin, as well as to identify the flow direction. It should be clarified that in reality the contribution area throughout the track is limited to the right of way with normal width of 12.00 m.

The implementation of a construction with a height of 20 cm, within which the permanent track will be implemented, in order to protect pedestrians circulating and the superstructure, particularly the electrification poles of the track and lighting, accidents caused by traffic of automotive vehicles in marginal routes and along the track, also affects the contribution space of the rainwater.

The whole area traversed already have drainage systems operating regularly. However, as a caution measure, it was projected at low points of the rail grade, which coincide with the existing avenues, openings in the separation device, to allow dewatering by trapping boxes designed in these points, conducted by concrete cell galleries, until the release point at sea.

Estimation of flows → because of the small scale of the contribution areas, it was used the formulas of rational method to transform rain in flow.

$$Q = C \cdot i \cdot A$$

Wherein:

Q = flow (volume/time);
C = runoff coefficient (dimensionless);
i = rain intensity (length/time);
A = area of the tributary basin (length^2)

Unique hydraulic structures → the rainwater network is composed of galleries in grot and grade gully holes.

There are several criteria and parameters assumed for the sizing of natural hydraulic structures for conducting rainwater, or thalweg transposition.

In the professional exercise of the designs we have developed, set the minimum speed of 0.75 m/s, whereas lower speeds hinder the self-cleaning of pipes and, on the other hand, the maximum speed was set at 7.0 m/s since higher speeds would expose other devices to abrasion and erosion processes. Another important aspect is considering the steady state of the pipes working as free conduits. Drainage systems are designed as free conduits minimizing possible disorders related to over pressure in the pipes.

GC _ Driving galleries → they are devices intended for channeling water in linear systems, usually in the form of networks covering the tubular and cell galleries in its various dimensions' types and diameters. They are sized using appropriate mathematical formulation using the hydraulic principles. The most common example is the tubular and concrete cell galleries or those mall of PVC, for driving the water within the soil and usually under or beside the tracks.

VC _ Driving ditches → they are devices, intended for channeling water in linear systems, encompassing open and closed rectangular galleries and rectangular or trapezoidal ditches. They are sized using appropriate mathematical formulation using the hydraulic principles. The most common example is the rectangular galleries made of bricks, designed to conduct water on the soil surface. If we used only in places such as lateral galleries, the paths between the rails support slab and the track segregation guides, whether they are conventional curbs or preventive safety barriers to traffic accidents.

CC _ Uptake boxes → they are structures to promote the first collection of water flowing in the urban tracks. They are usually located along the side ditches, geometrically defined or resulting from cross slopes of the tracks. They are dimensioned to withstand a swallowing capacity equal to or greater than the amount of water generated and conveyed in adjacent contribution segments of each control section

DE _ Special devices → sometimes we are required by local circumstances to incorporate in the designs, a family destined to unique special hydraulic structures to house specific nature components, but can occur even with rarefied repetition.

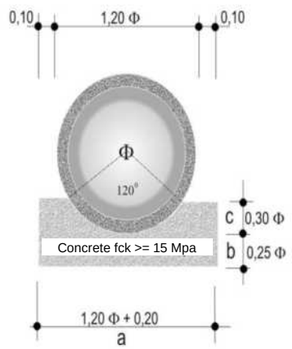
Since there is the possibility that existing systems can be damaged or clogged, requiring structural restoration and cleaning, it was designed specific collection and driving systems to the final destination for release - the sea.

It will be required implementation of new grade gully holes in order to do the crossings. It was also designed an extensive network of ditches, to drain the run-offs from the slopes, perhaps not captured by the existing drainage system, thus ensuring the protection of the permanent track.

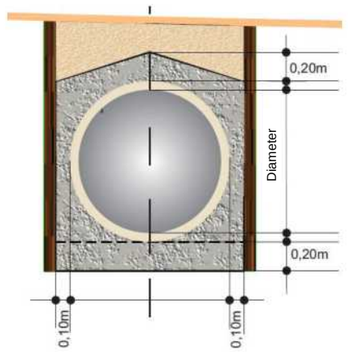
Assessment of capacity of existing drainage systems → the objective assessment of these devices is impossible since they have been deployed in past years to meet the urban road systems. The Municipal Government has no record of entries, reason why we cannot assess the capability of each of them. Faced with this situation and the insignificance of rain contribution on the right of way, it was reasonable to design uptake, driving and exclusive devices for launching at sea.

Design and geometry of the drainage systems → the following were the devices used, besides the use of the geometry of the permanent track as side channel:

Concrete tubular galleries → minimum mandatory coverage 1.00 m on the top generatrix of the pipe;



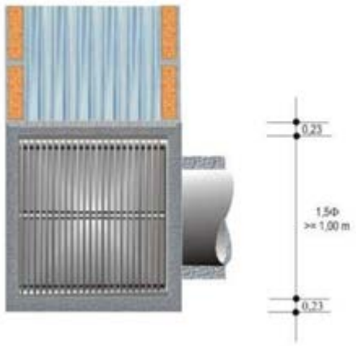
Sections not subject to direct traffic



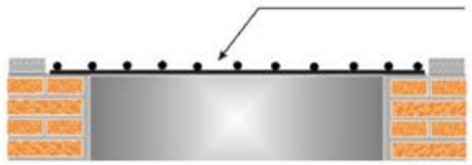
Sections subject to direct traffic

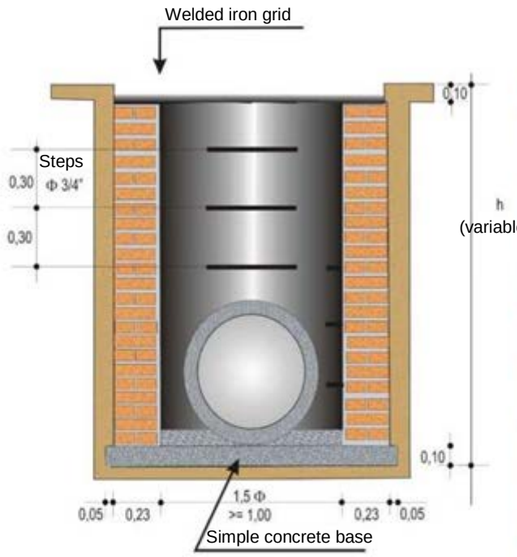
Uptake and junction boxes →

Ditch



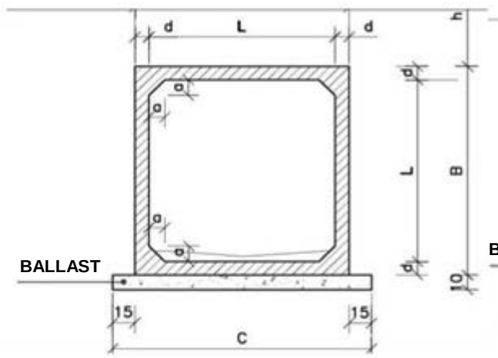
Iron grid

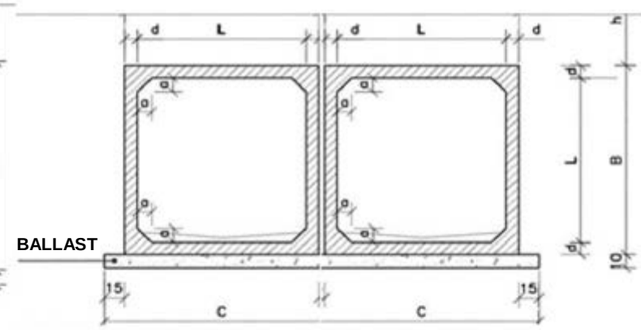


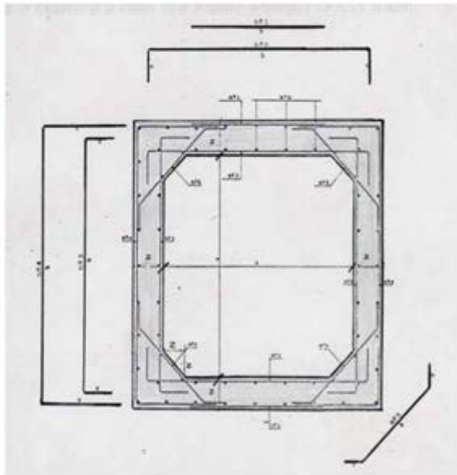


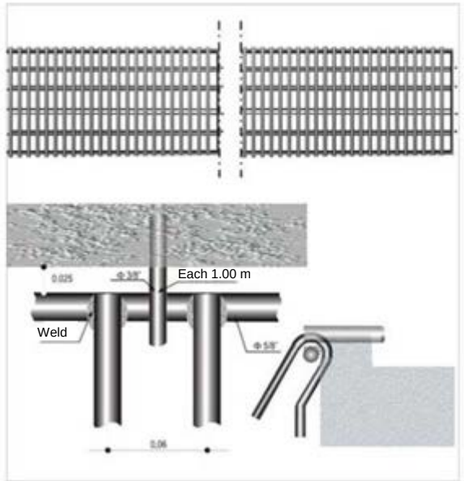
Simple cell

Multiple cells





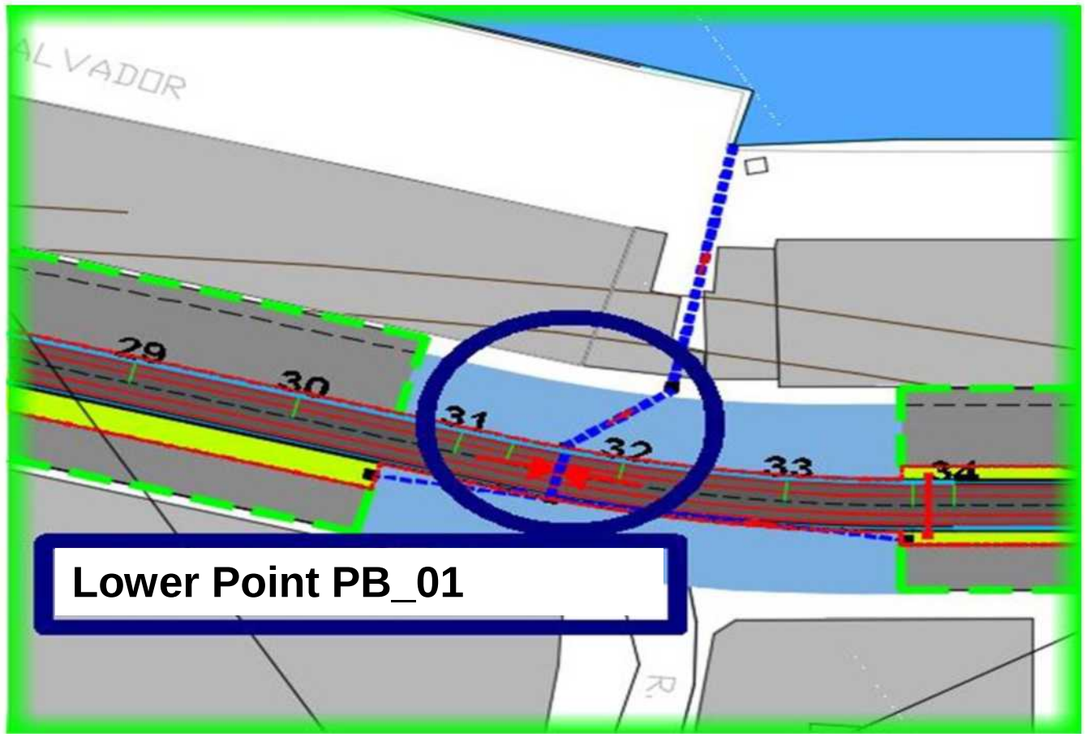




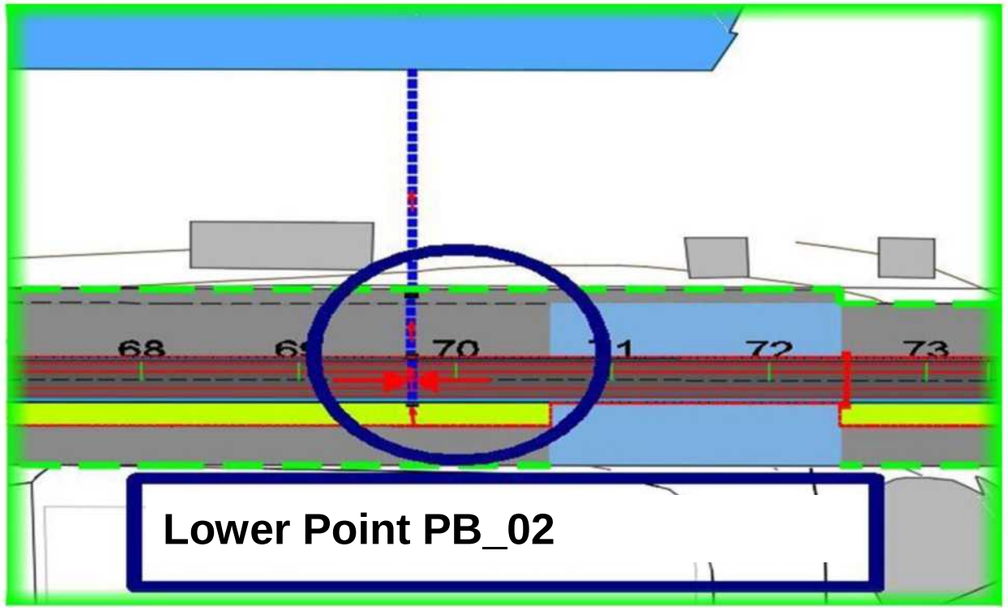
The following is the analytical calculation spreadsheet of cell galleries of the section - Comércio-Calçada:

Sizing - Cell Galleries									
attention = repeat the last height of the channel in S column to correct the final bottom coordinate									
Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q=C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
PB 01	0.76%	10.00	364.16	8.00	2,330.61	2.56	1.00	1.00	0.91
PB 02	2.15%	10.00	364.16	13.00	3,787.24	4.28	1.00	1.00	0.88
PB 03	0.13%	10.00	364.16	20.00	5,826.52	1.63	4.00	1.00	0.89
PE 01	0.73%	10.00	364.16	7.80	2,272.34	2.51	1.00	1.00	0.91
PE 02	0.71%	10.00	364.16	7.75	2,257.78	2.48	1.00	1.00	0.91
PB 04	0.72%	10.00	364.16	7.80	2,272.34	2.50	1.00	1.00	0.91

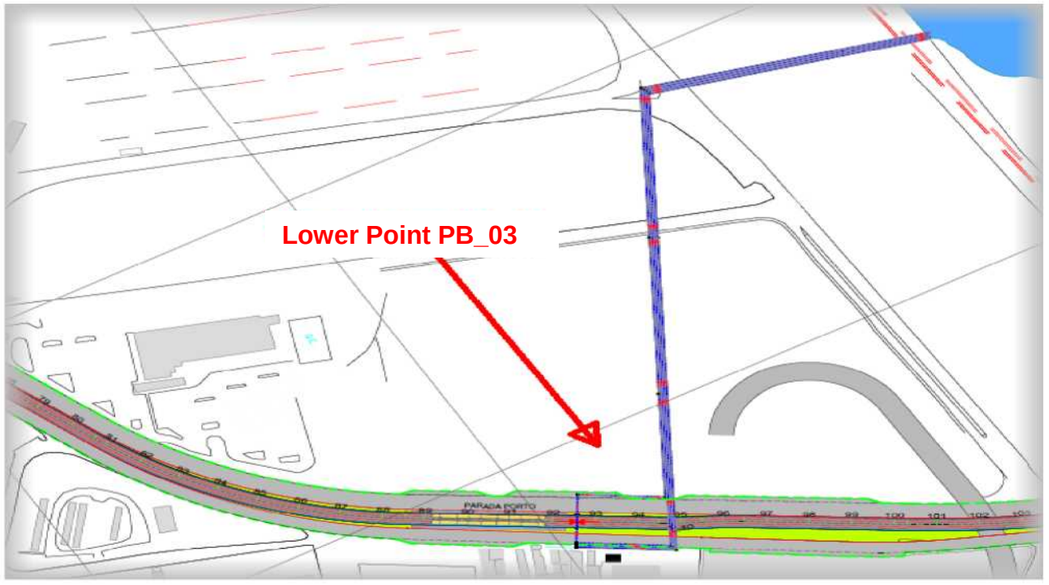
The Lower Point 01 - located directly in front of Rua da Noruega near stake 32, it was noted the deployment of concrete cell galleries with sufficient flow section to drain the contribution area generated by the deployment of the permanent track, as well as possible excess contribution from the streets upstream, which cannot be drained by the system deployed over the years in the city. The final sizing of these galleries, in the opportunity of Basic and Executive Design should consider the dimensional limitations resulting from the release limitations related to the maximum tide and the existing grade of Av. da França, at this point, height of 3,657 m, conditioned by low slope due to release of an approximately 60 m long, restricted to a gallery height of 1.00 m only.

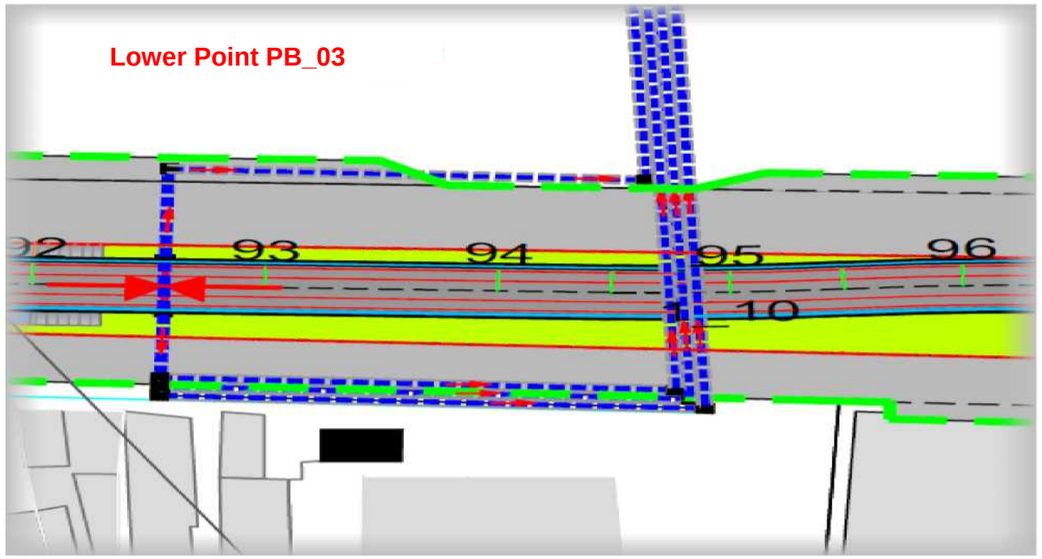


The Lower Point 02 - located directly in front of Rua Estado de Israel near stake 70, it was noted the deployment of concrete cell galleries with sufficient flow section to drain the contribution area generated by the deployment of the permanent track, as well as possible excess contribution from the streets upstream, which cannot be drained by the system deployed over the years in the city. The final sizing of these galleries, in the opportunity of Basic and Executive Design should consider the dimensional limitations resulting from the release limitations related to the maximum tide and the existing grade of Av. da França, at this point, height of 4,482 m, conditioned by low slope due to release of an approximately 57 m long, restricted to a gallery height of 1.00 m only.

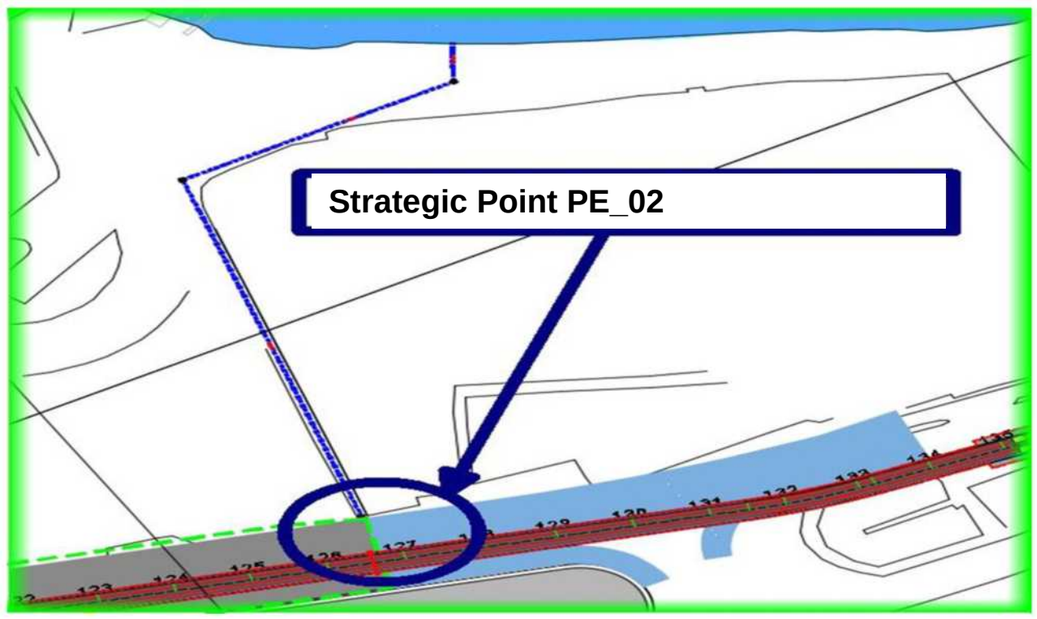


The Lower Point 03 - located next to Oscar Pontes crossing near stake 95, it was noted the deployment of concrete cell galleries with sufficient flow section to drain the contribution area generated by the deployment of the permanent track, as well as possible excess contribution from the streets upstream, which cannot be drained by the system deployed over the years in the city. he final sizing of these galleries, in the opportunity of Basic and Executive Design should consider the dimensional limitations resulting from the release limitations related to the maximum tide and the existing grade of Av Oscar Pontes, at this point, height of 4,121 m, conditioned by low slope due to release of an approximately 470 m long, restricted to a gallery height of 1.00 m only.

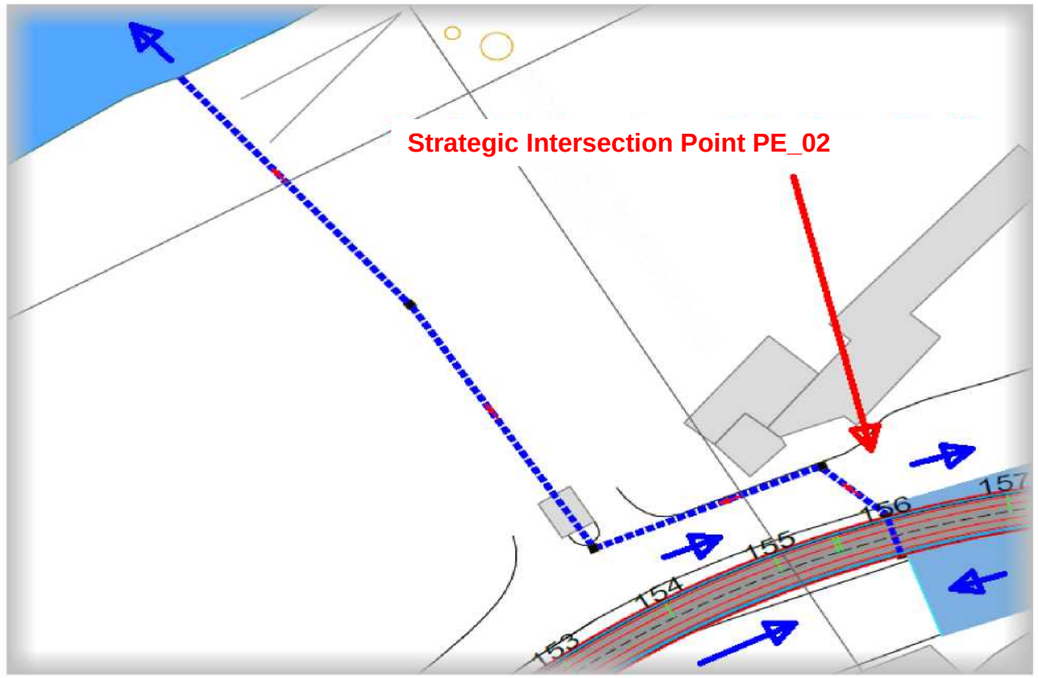




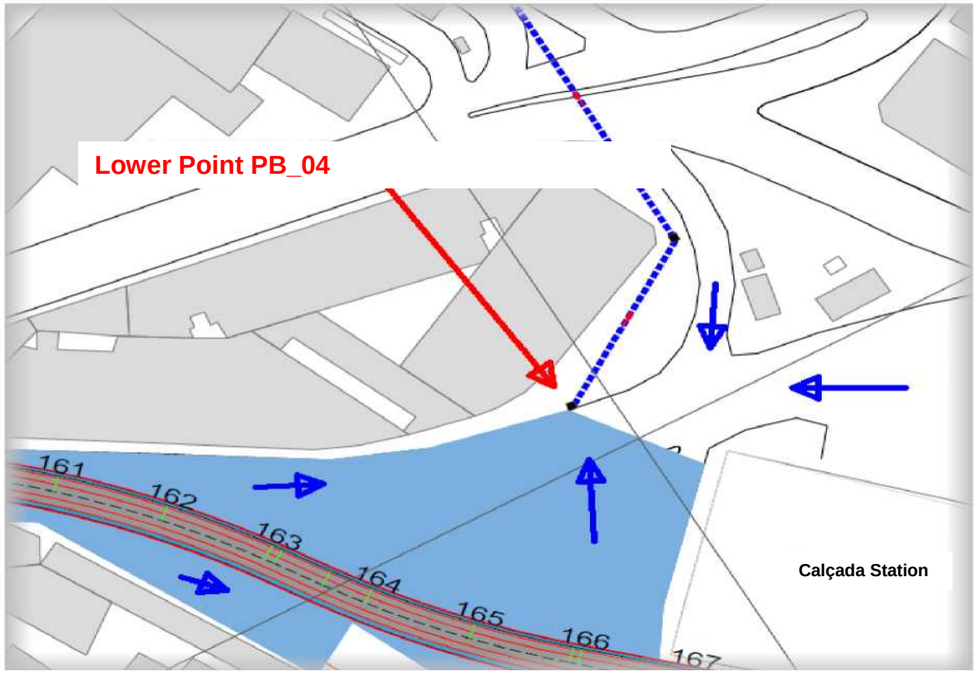
At the Strategic Interception Point - PE_01 - located directly in front of Feira de São Joaquim near stake 127, it was noted the deployment of concrete cell galleries with sufficient flow section to drain the contribution area generated by the deployment of the permanent track, as well as possible excess contribution from the streets upstream, which cannot be drained by the system deployed over the years in the city. he final sizing of these galleries, in the opportunity of Basic and Executive Design should consider the dimensional limitations resulting from the release limitations related to the maximum tide and the existing grade of Av Oscar Pontes, at this point, height of 5,000 m, conditioned by low slope due to release of an approximately 240 m long, restricted to a gallery height of 1.00 m only.



At the Strategic Interception Point - PE_02 - located between Av. Oscar Pontes and Av. Jiquitaia near stake 156, it was noted the deployment of concrete cell galleries with sufficient flow section to drain the contribution area generated by the deployment of the permanent track, as well as possible excess contribution from the streets upstream, which cannot be drained by the system deployed over the years in the city. he final sizing of these galleries, in the opportunity of Basic and Executive Design should consider the dimensional limitations resulting from the release limitations related to the maximum tide and the existing grade of Av Oscar Pontes and Av. Jiquitaia at this point, height of 4,889 m, conditioned by low slope due to release of an approximately 175 m long.



The Lower Point 04 - located in the center of Largo da Calçada directly in front stake 165, it was noted the deployment of concrete cell galleries with sufficient flow section to drain the contribution area generated by the deployment of the permanent track, as well as possible excess contribution from the streets upstream, which cannot be drained by the system deployed over the years in the city. These galleries. The final sizing of these galleries, in the opportunity of Basic and Executive Design should consider the dimensional limitations resulting from the release limitations related to the maximum tide and the existing grade in front of Largo da Calçada, at this point, height of 2,600 m, conditioned by low slope due to release of an approximately 180 m long, restricted to a gallery height of 1.00 m only.

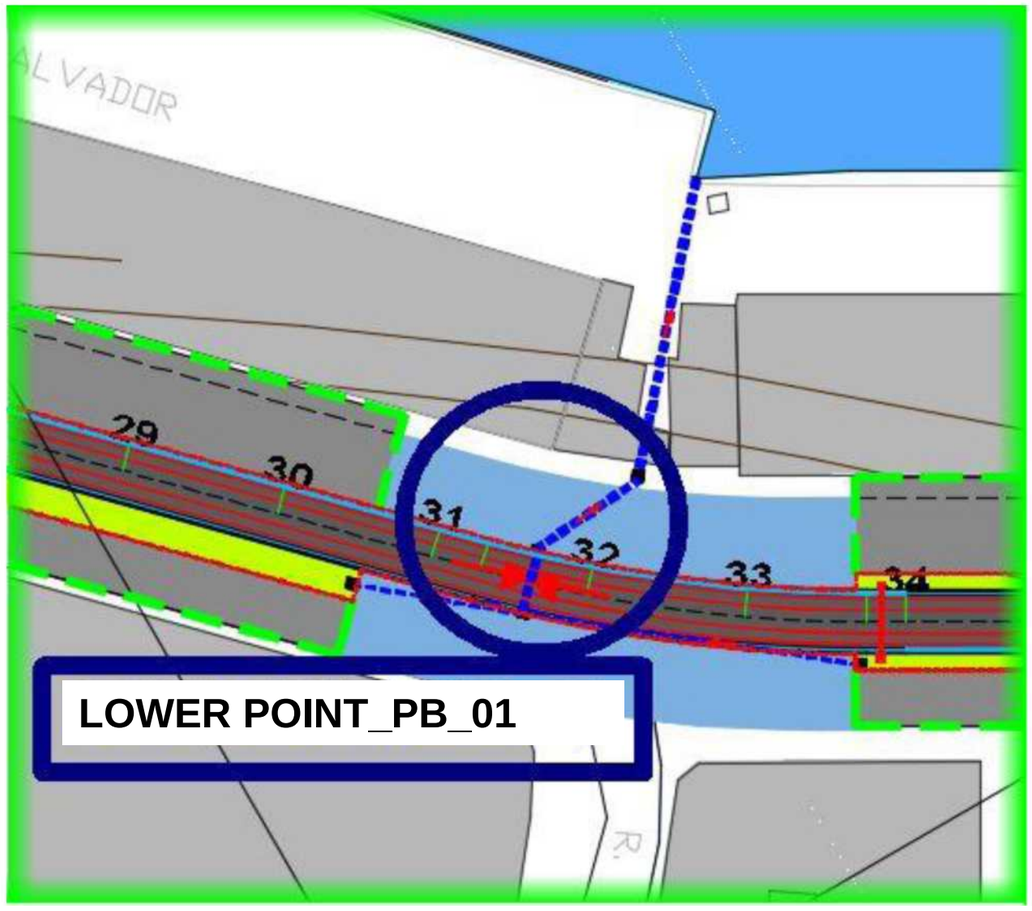


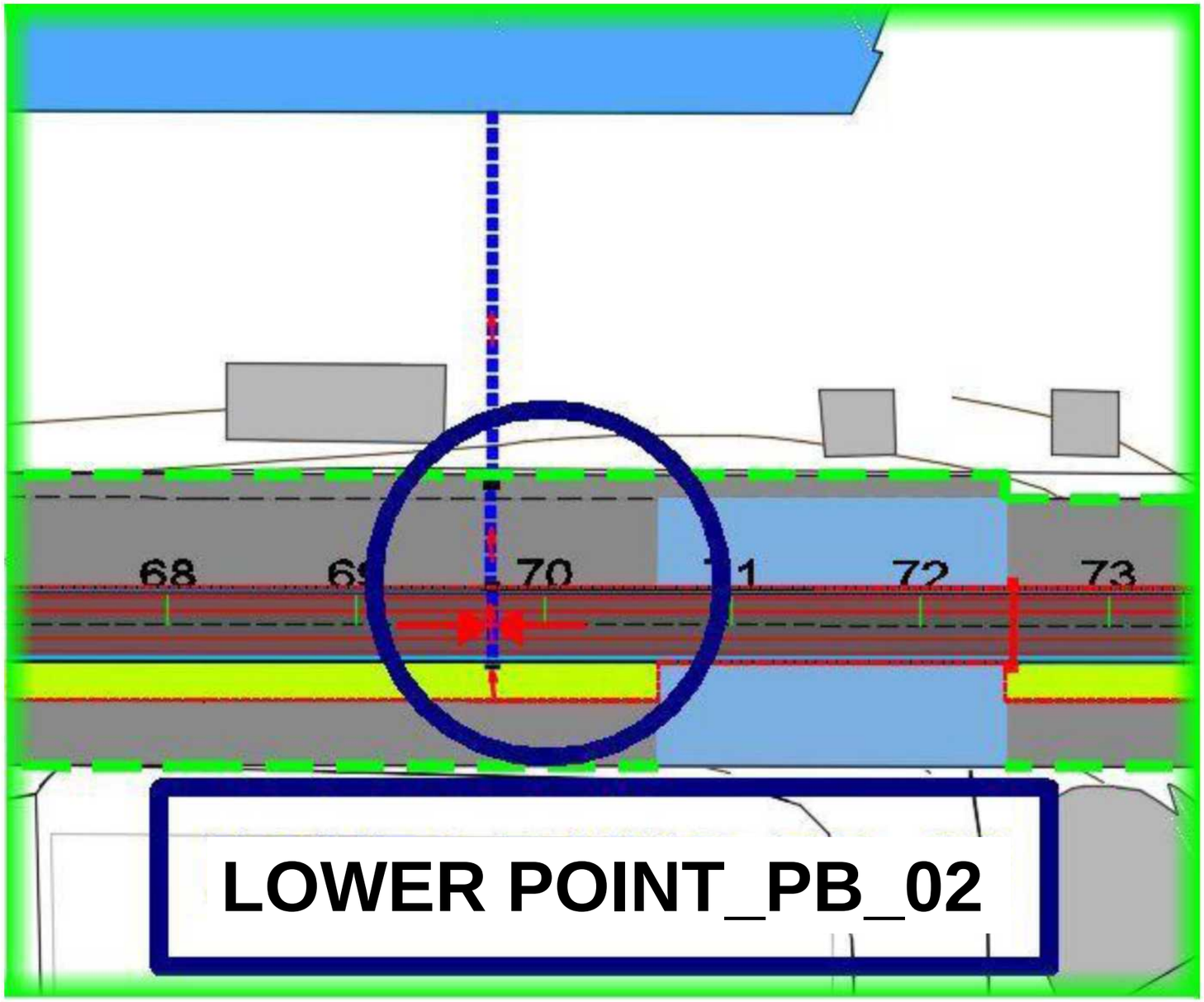
The drainage of the construction site of the permanent track was designed in rectangular parallel channels, one on each side of the railway, ever flowing at low points where cell galleries were indicated, considering the limits of the contribution areas, the high points on each side of the permanent track.

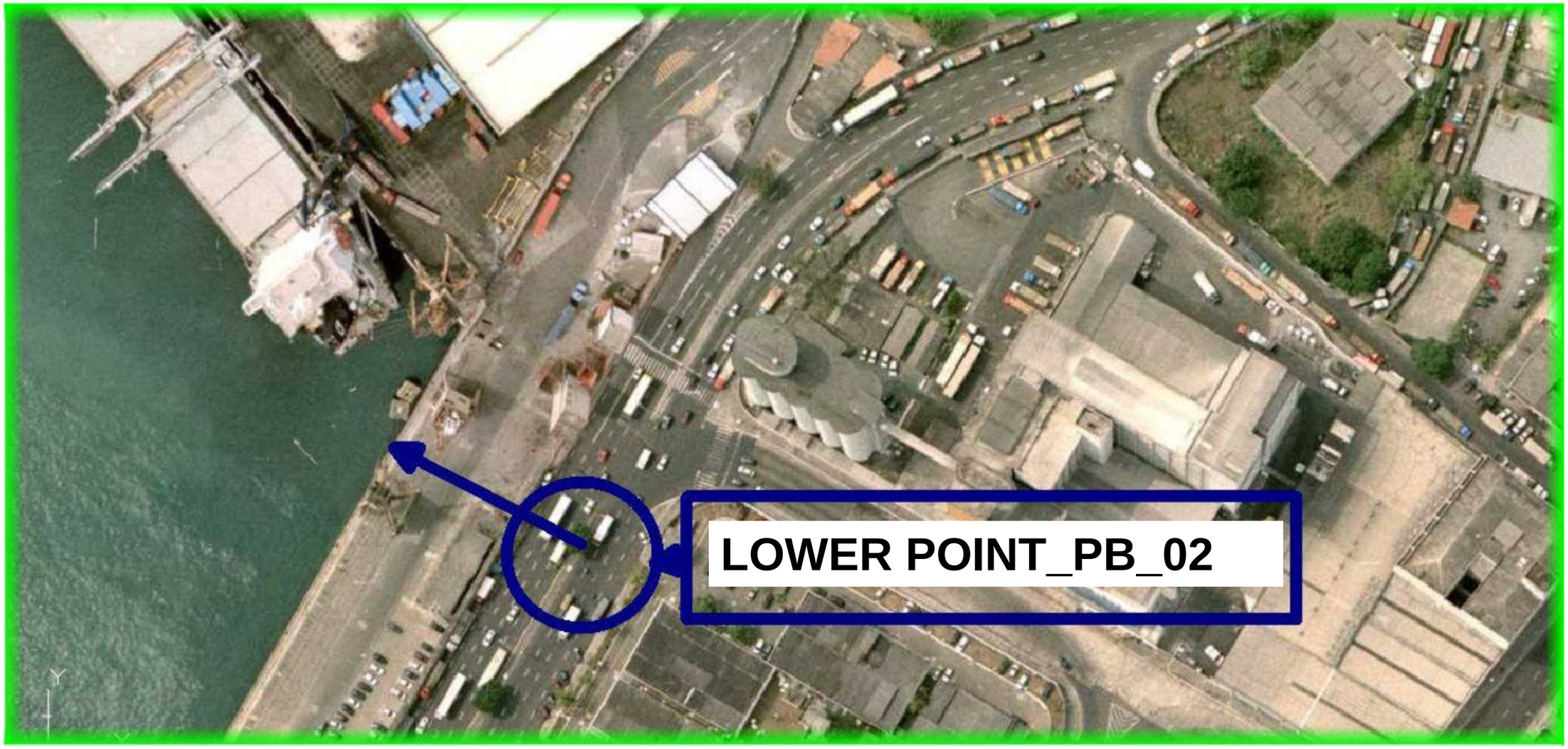
At each connection or derivation point of the drainage system were designed reception or junction boxes when applicable, besides the traditional maintenance and cleaning boxes with maximum spacing of 100 m.

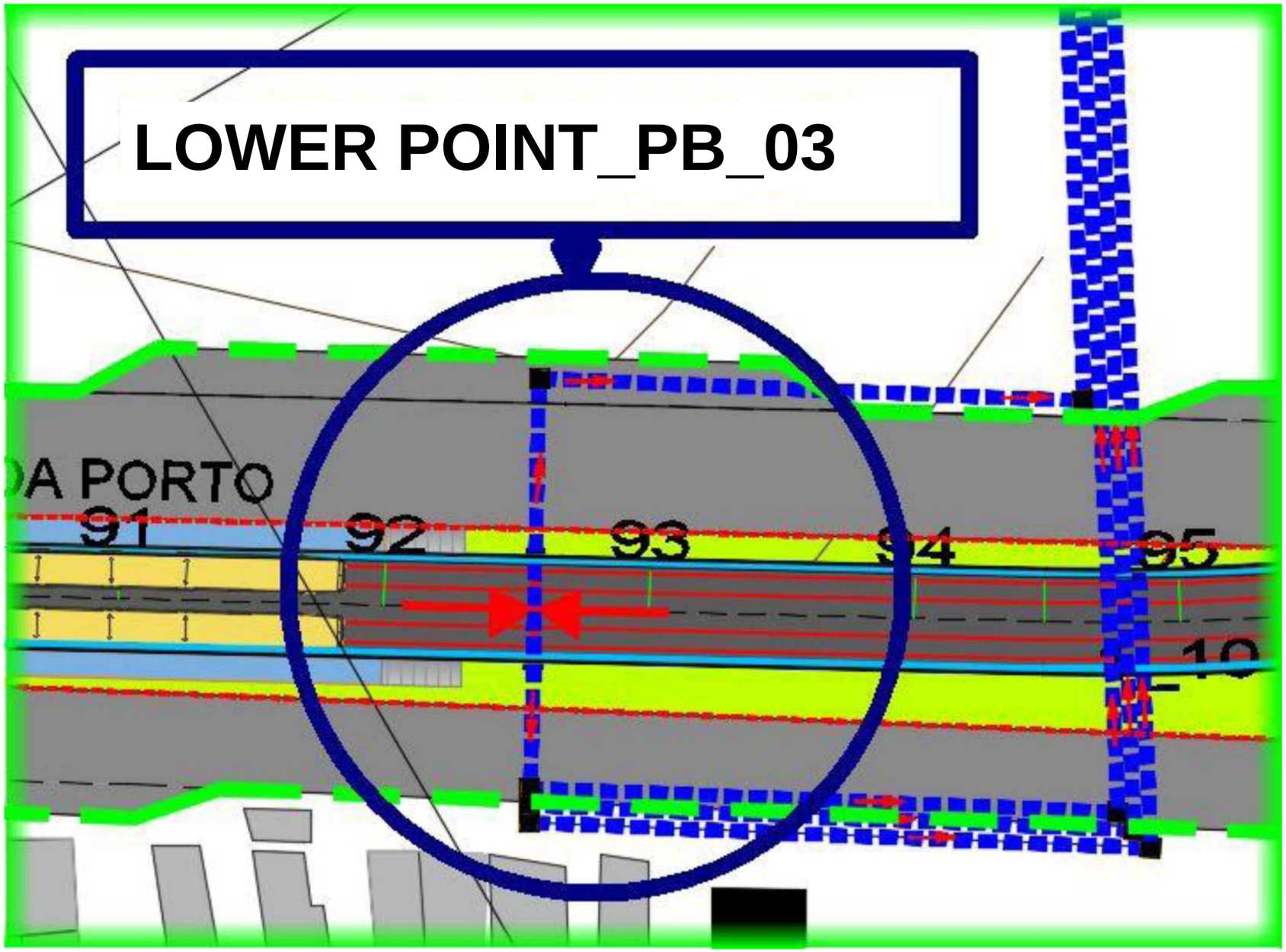
As a design principle, it was assumed the non interference nor use the Existing Draining System of the PMS, using a new system, additional, with capacity to meet the drainage needs of the permanent track and its interception consequences and further collect, as far as possible, the flood surplus of existing urban roads.

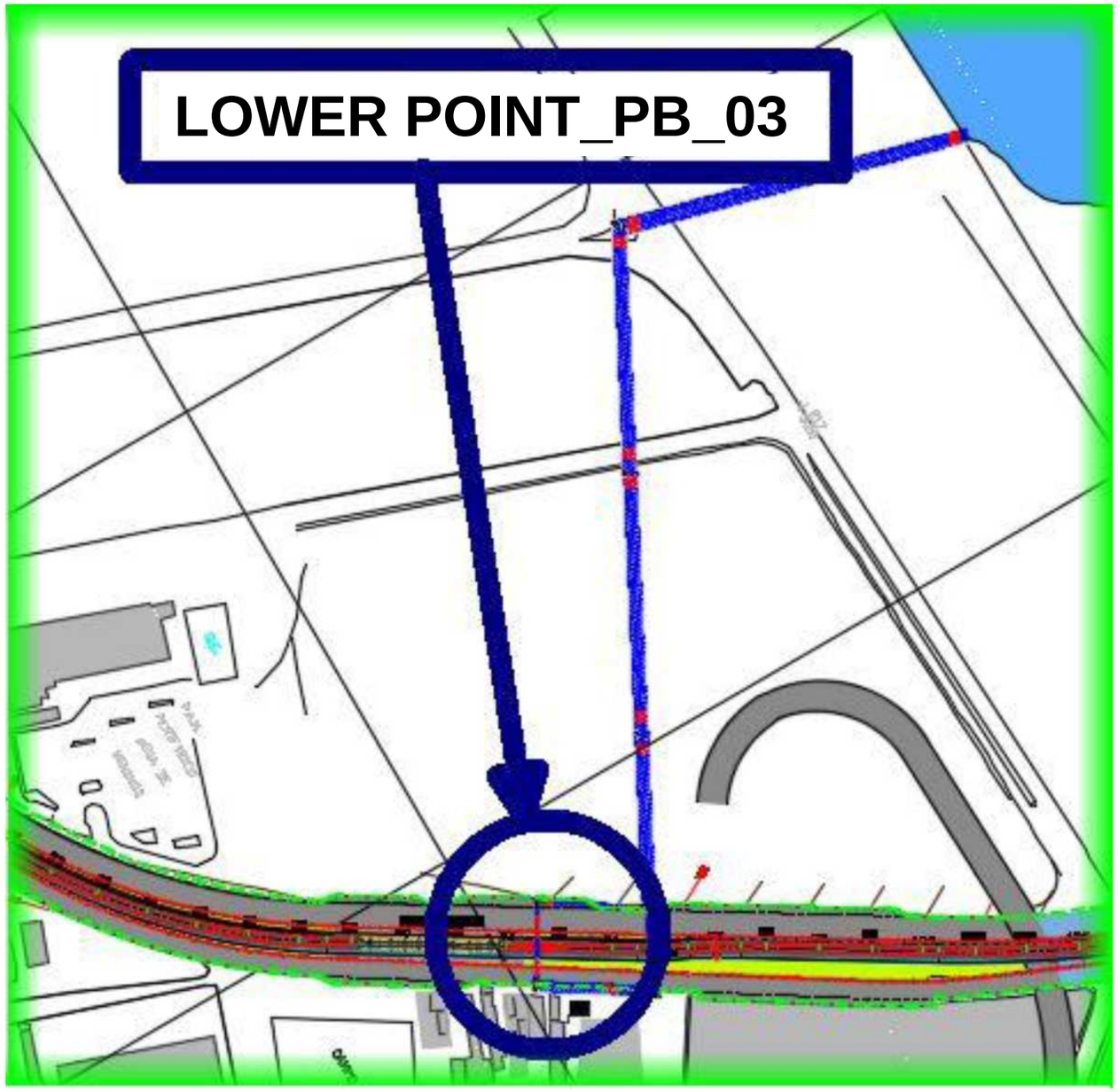
LOWER POINT_PB_01

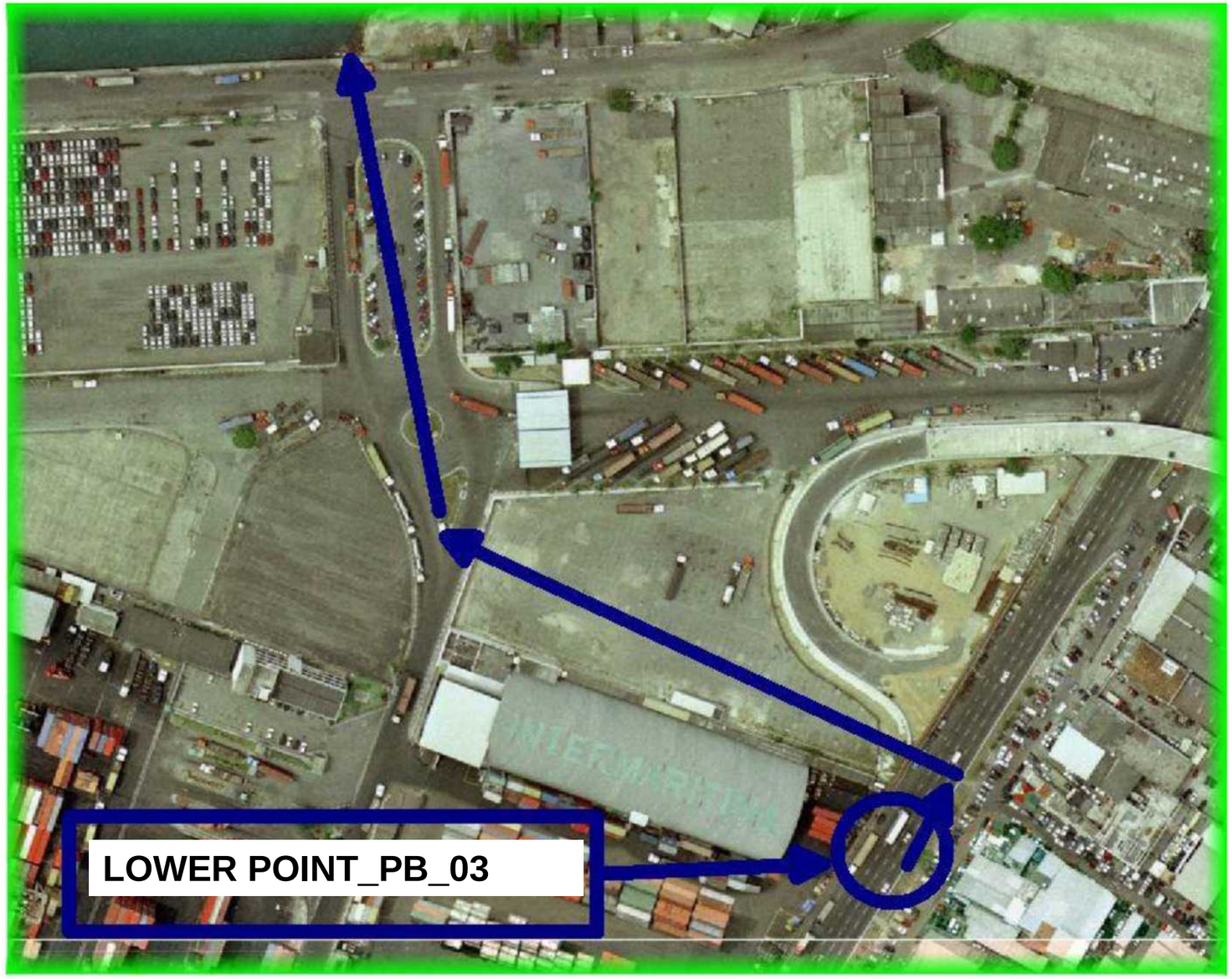

ALVADOR
29
30
31
32
33
34
LOWER POINT_PB_01

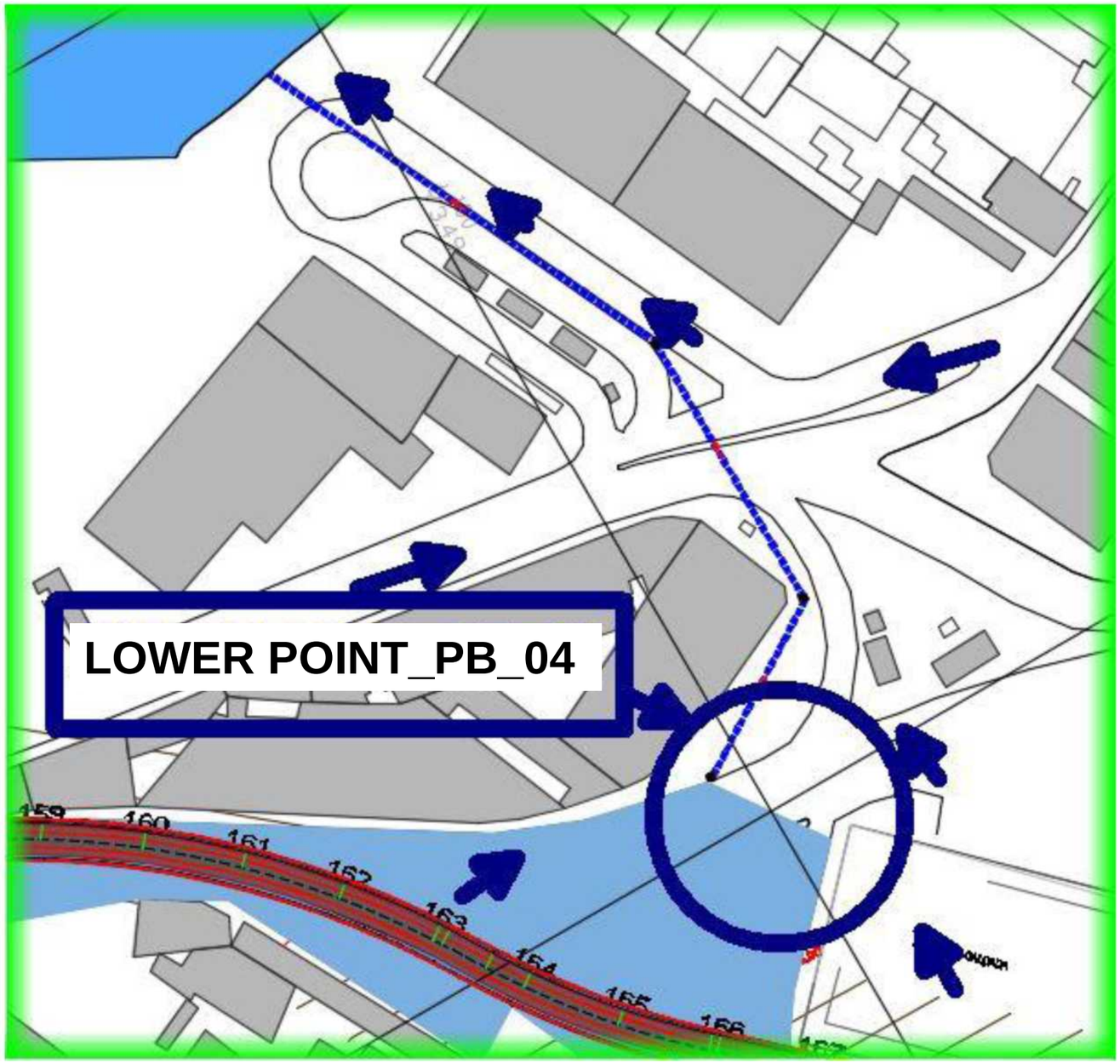

68
70
72
73
LOWER POINT_PB_02

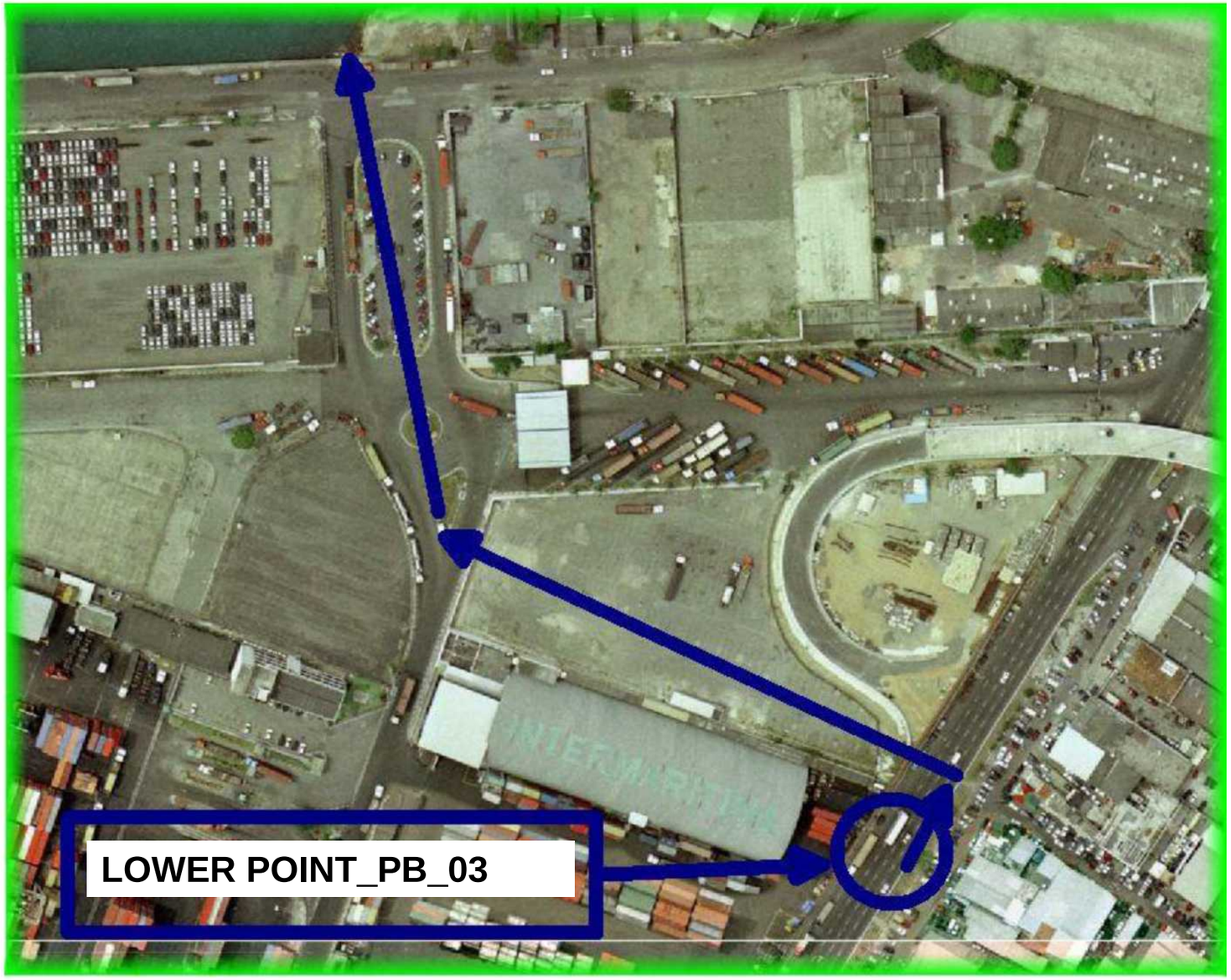

LOWER POINT_PB_02

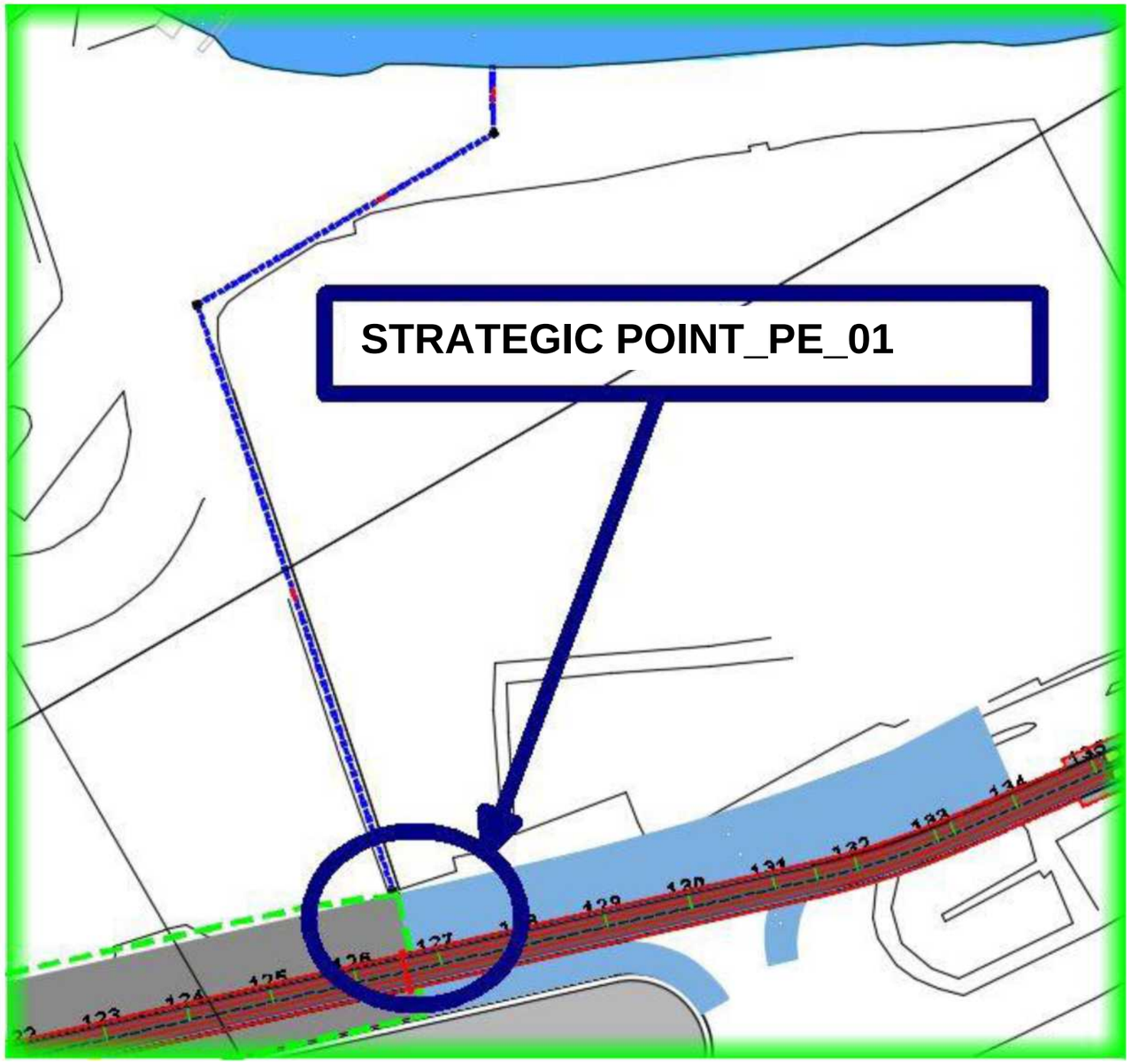

LOWER POINT_PB_03
A PORTO
91
92
93
94
95


LOWER POINT_PB_03

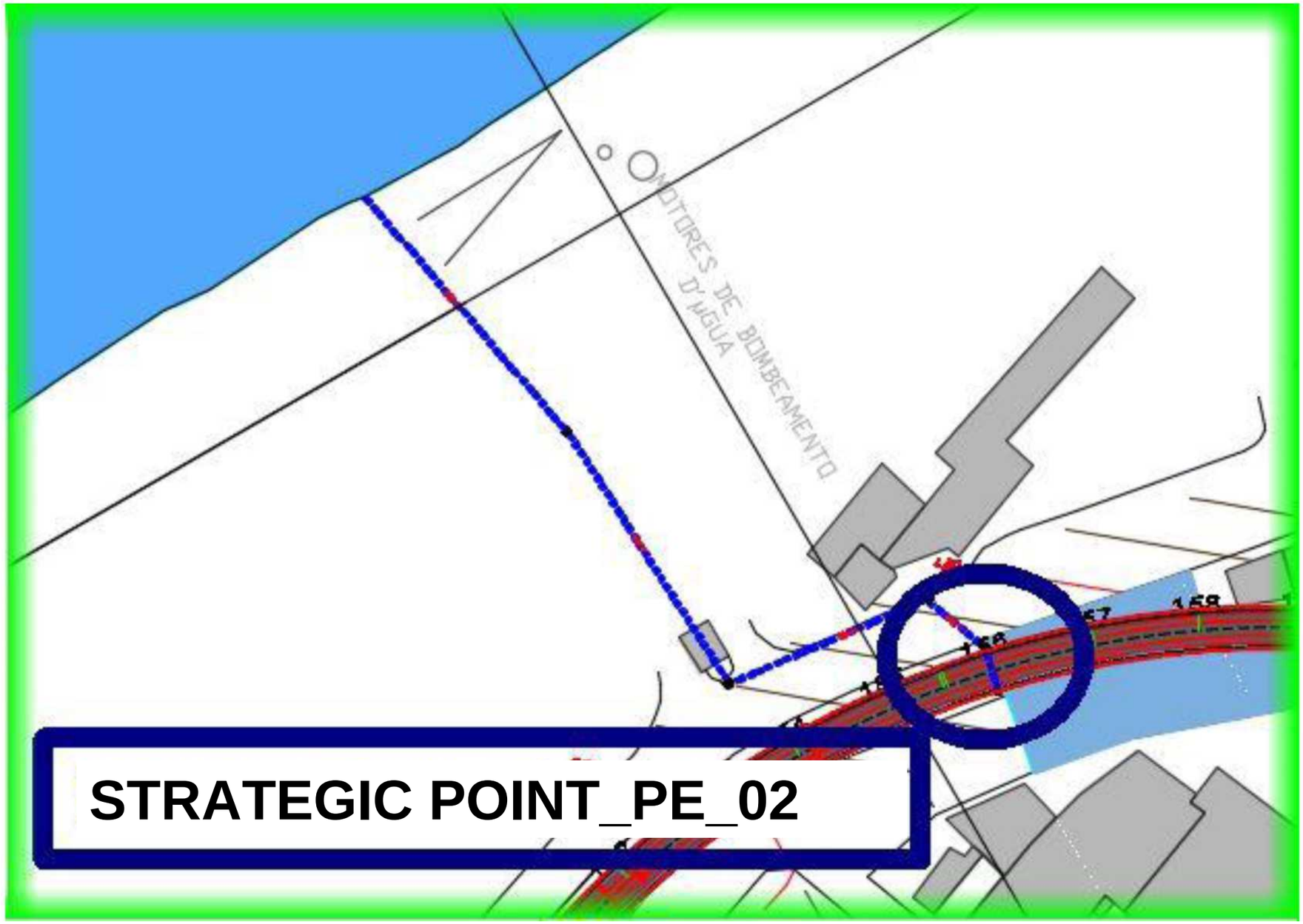

LOWER POINT_PB_03


LOWER POINT_PB_04
159
160
161
162
163
164
165
166

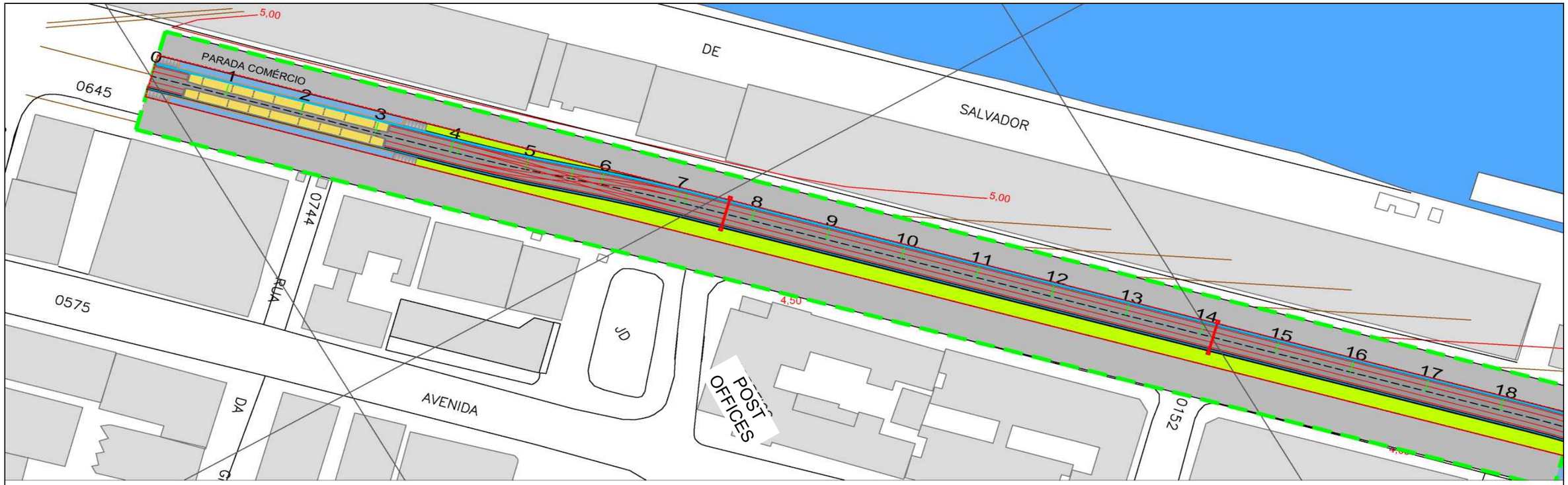

LOWER POINT_PB_03

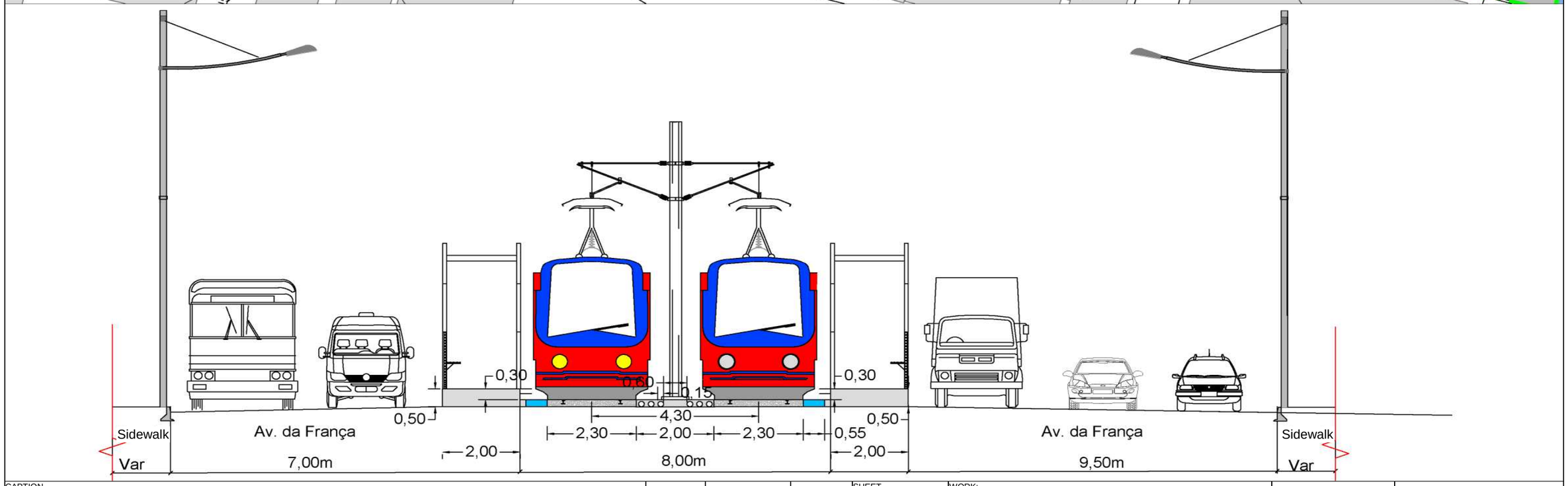

STRATEGIC POINT_PE_01

STRATEGIC POINT_PE_01


OPTORES DE BOMBEAMENTO D' µGUA
STRATEGIC POINT_PE_02

STRATEGIC POINT_PE_02





CAPTION

0 1 Axis Neck Rail Neck Rail Permanent Track

Construction sites

Higher Point

Lower Point

Limit of Urbanization

Limit of Intervention

Crossing for Public Services Networks - Ø = 0.60 m

Level Passages

Tubular gallery Ø = 0.40 m

Cell Gallery 1.00 x 1.00 m

Collecting or Passage Box

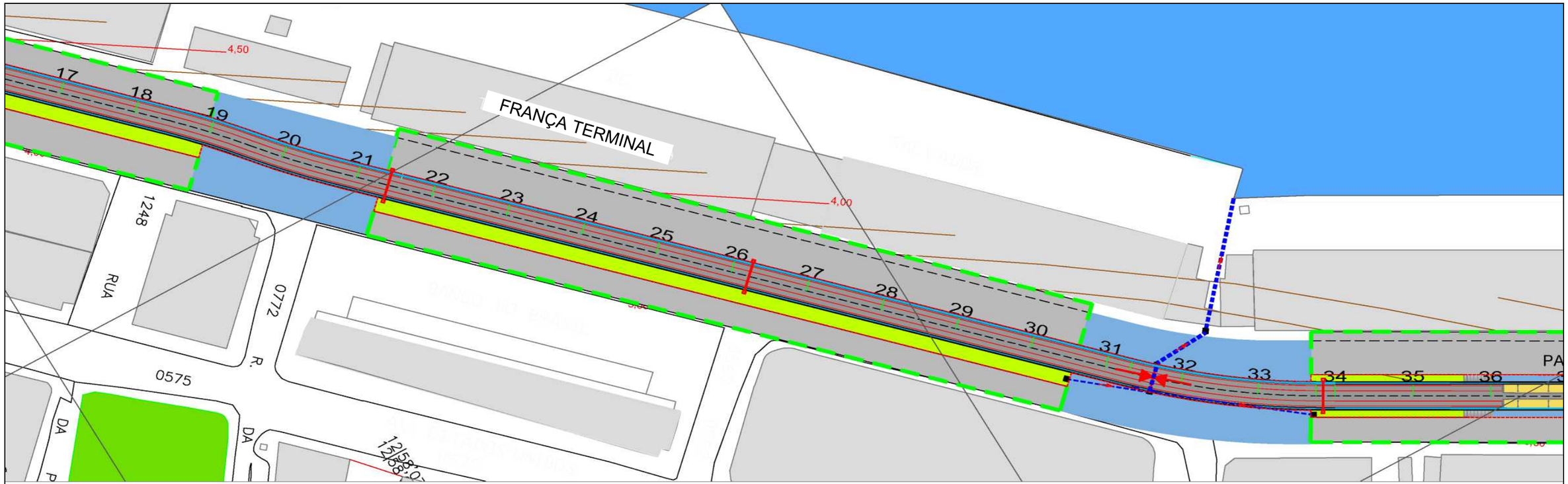
DRAWING		/ /	SHEET 01/10	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE PLANT AND CROSS SECTIONS
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

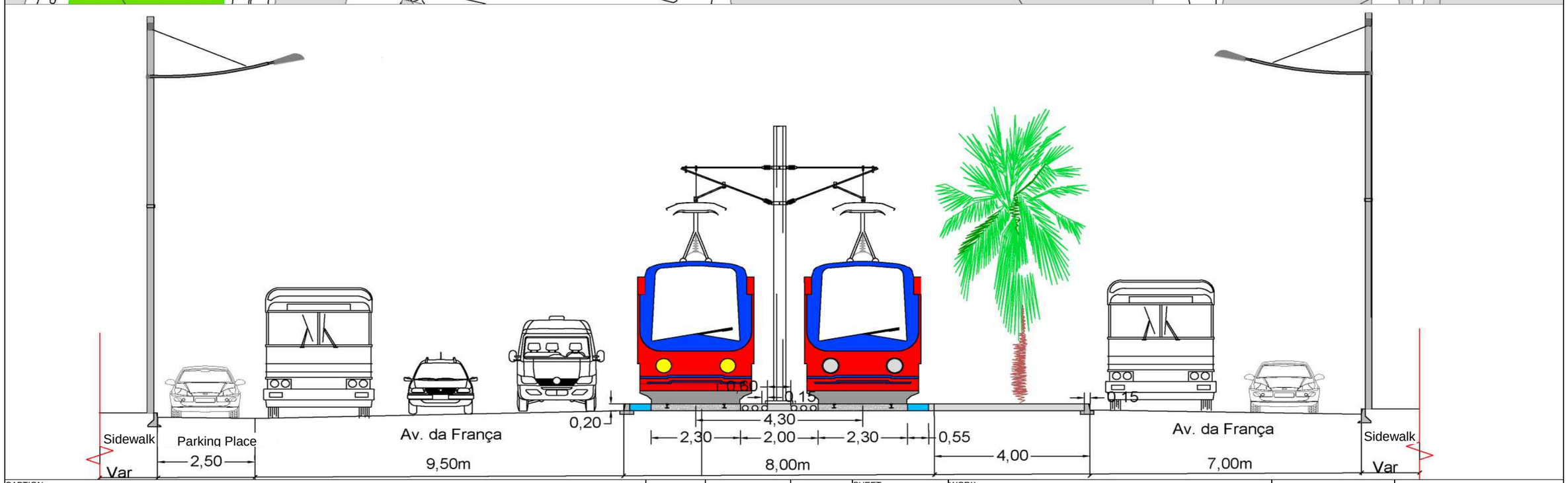
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

0 1

Axis

Neck Rail

Neck Rail

Permanent Track

Construction sites

Higher Point

Lower Point

Limit of Urbanization

Limit of Intervention

Crossing for Public Services Networks - Ø = 0.60 m

Level Passages

Tubular gallery Ø = 0.40 m

Cell Gallery 1.00 x 1.00 m

Collecting or Passage Box

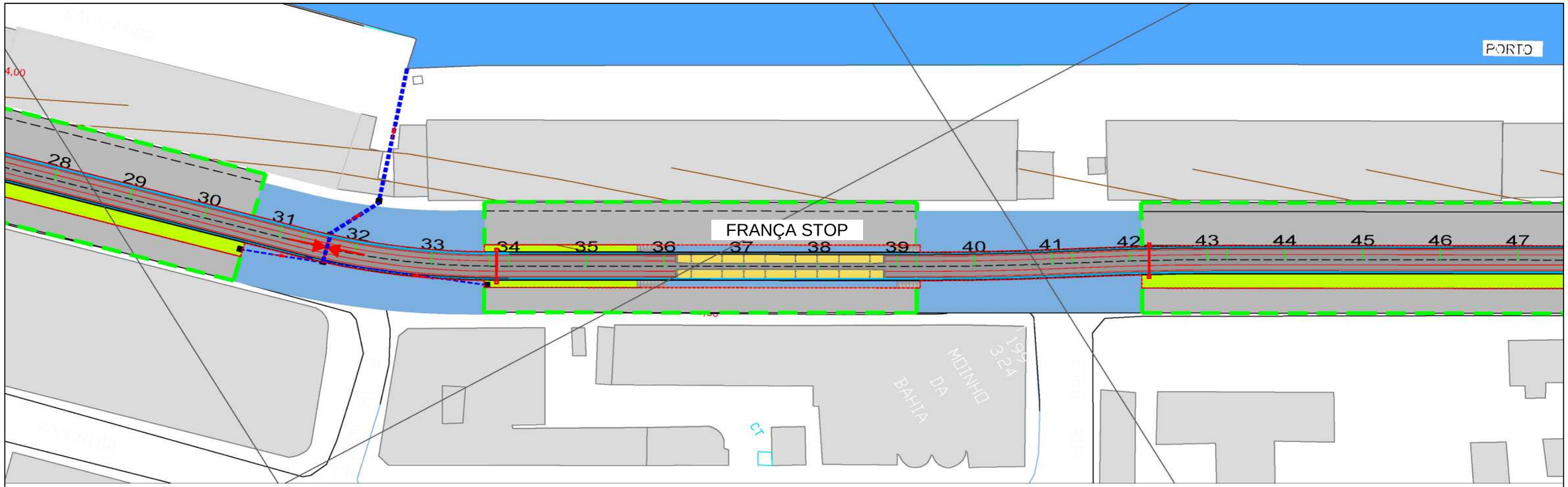
DRAWING		/ /	SHEET 02/10	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE PLANT AND CROSS SECTIONS
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

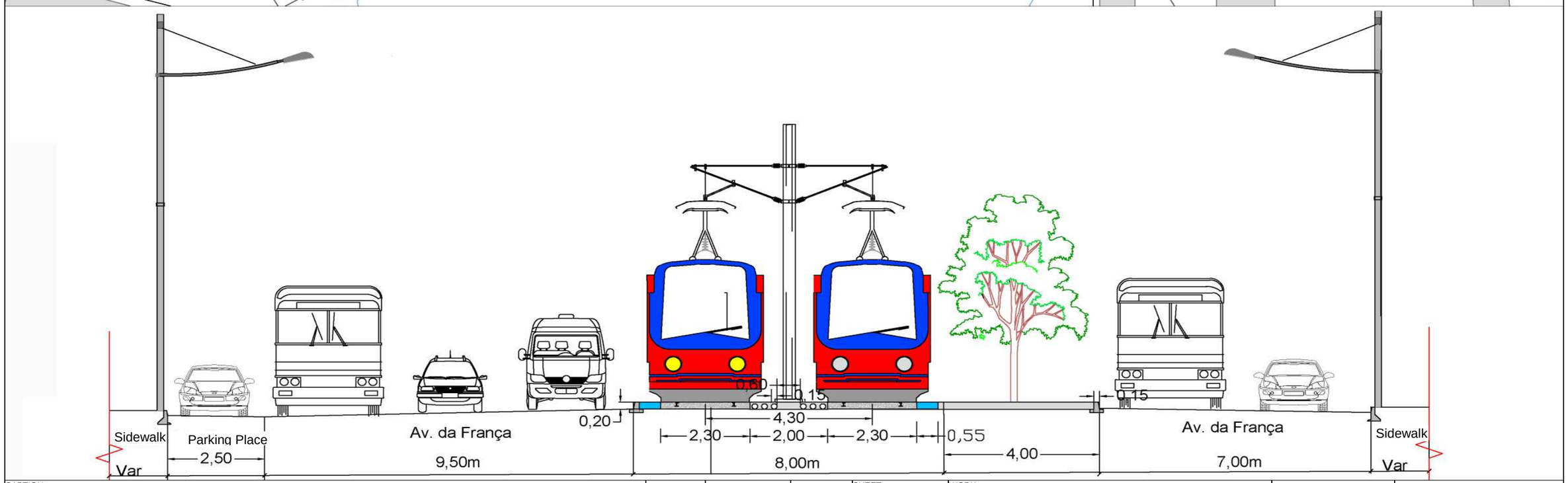
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

0 1
Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point

Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

Tubular gallery Ø = 0.40 m
Cell Gallery 1.00 x 1.00 m
Collecting or Passage Box

DRAWING		/ /	SHEET 03/10
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

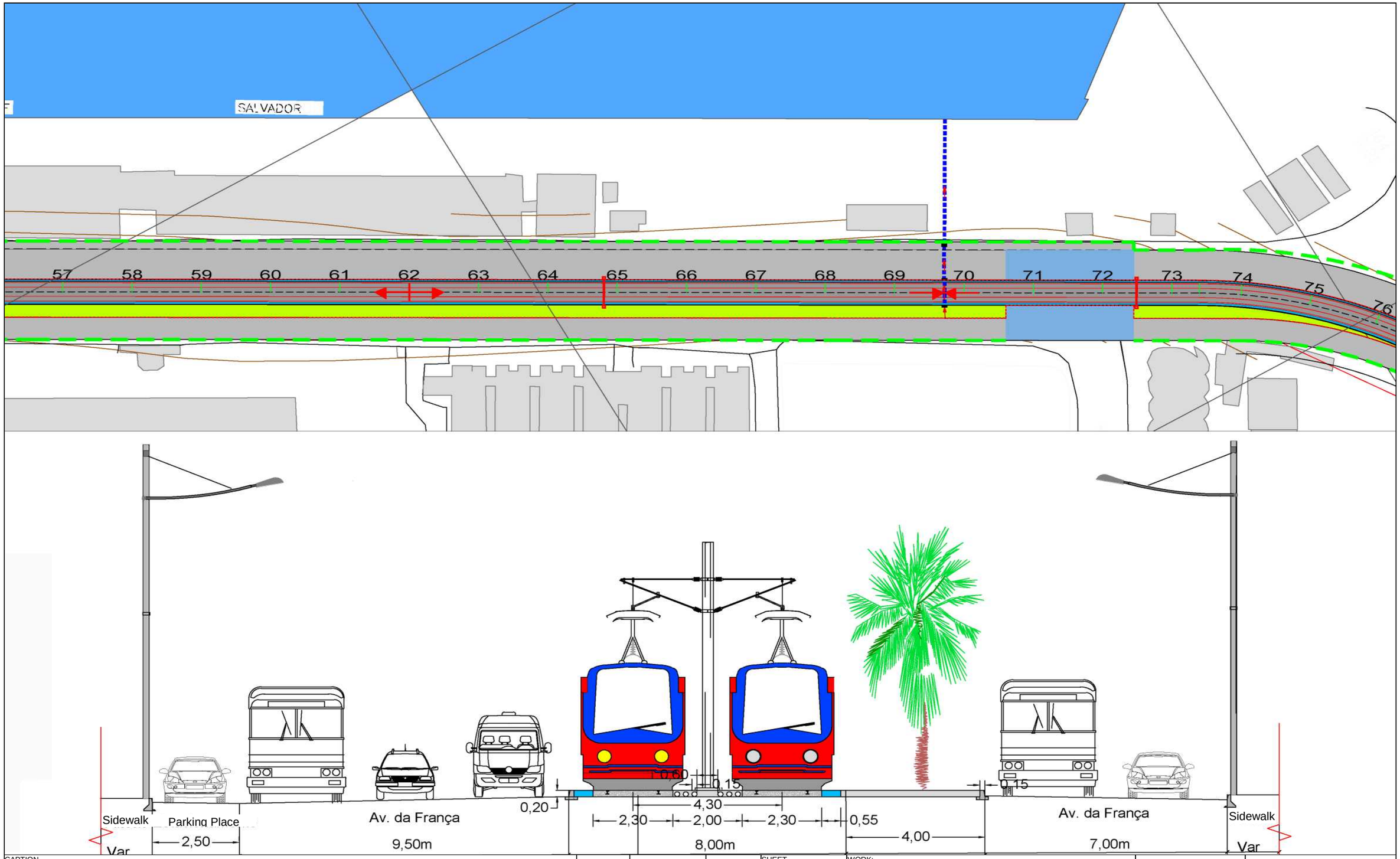
SUBJECT
DRAINAGE PLANT AND CROSS SECTIONS

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

0 1

Axis

Neck Rail

Neck Rail

Permanent Track

Construction sites

Higher Point

Lower Point

Limit of Urbanization

Limit of Intervention

Crossing for Public Services Networks - Ø = 0.60 m

Level Passages

Tubular gallery Ø = 0.40 m

Cell Gallery 1.00 x 1.00 m

Collecting or Passage Box

DRAWING		/ /	SHEET 04/10
CHECKING		/ /	SCALE
APPROVAL		/ /	Drainage - 1:1,000 Sections – 1:100
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

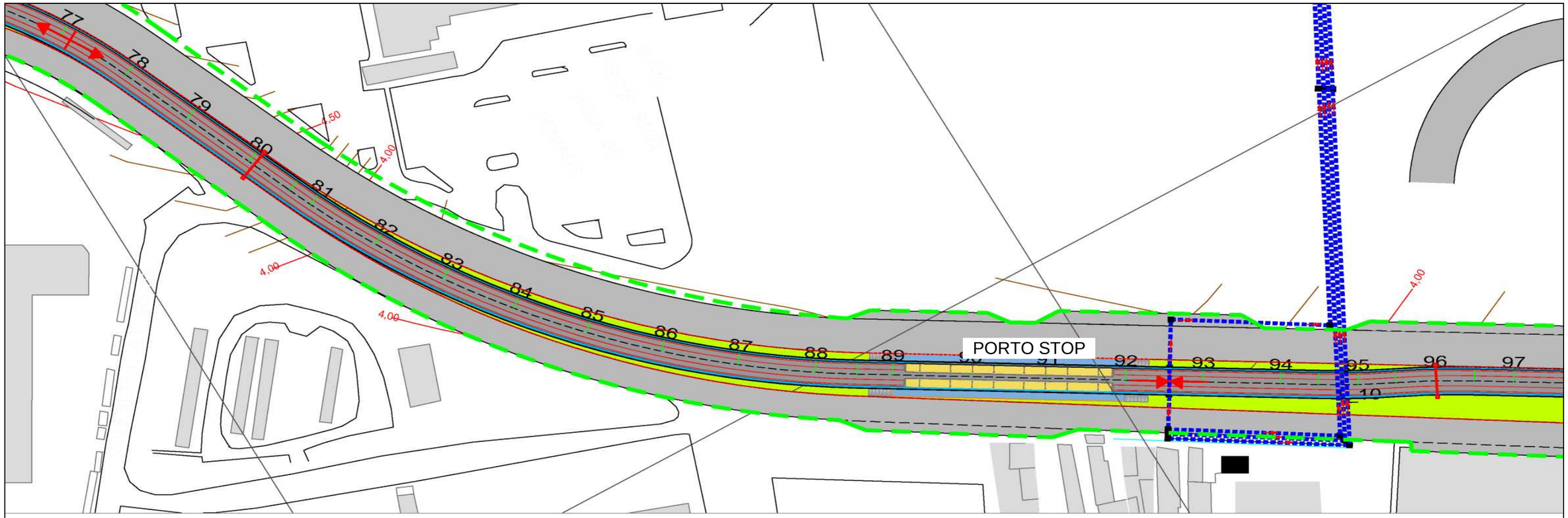
SUBJECT
DRAINAGE PLANT AND CROSS SECTIONS

DEPARTMENT OF URBAN DEVELOPMENT

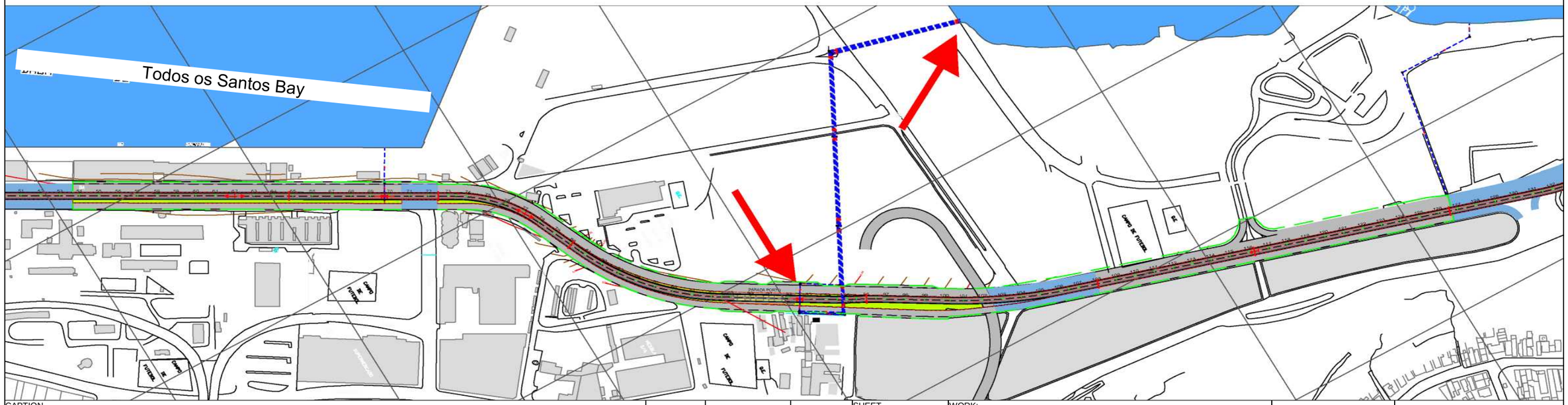
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



RELEASE OF LOWER POINT 03



CAPTION

0 1

Axis

Neck Rail

Neck Rail

Permanent Track

Construction sites

Higher Point

Lower Point

Limit of Urbanization

Limit of Intervention

Crossing for Public Services Networks - Ø = 0.60 m

Level Passages

Tubular gallery Ø = 0.40 m

Cell Gallery 1.00 x 1.00 m

Collecting or Passage Box

DRAWING		/ /	SHEET 05/10
CHECKING		/ /	SCALE
APPROVAL		/ /	Drainage - 1:1,000 Sections – 1:100
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

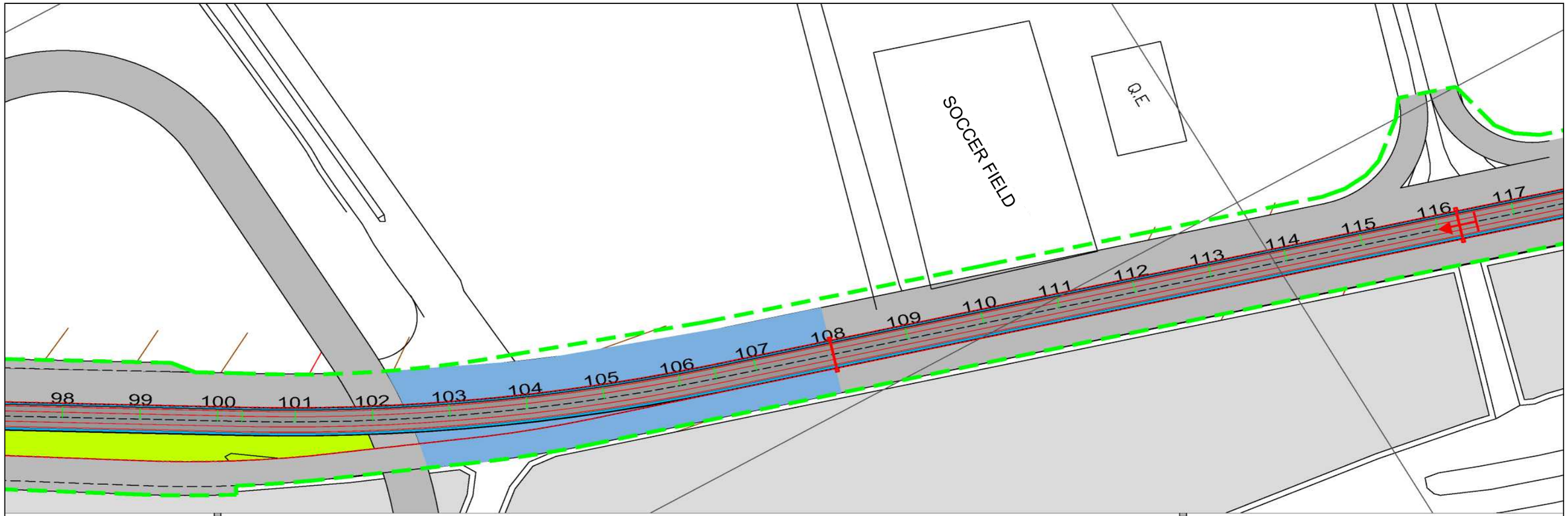
SUBJECT
DRAINAGE PLANT AND CROSS SECTIONS

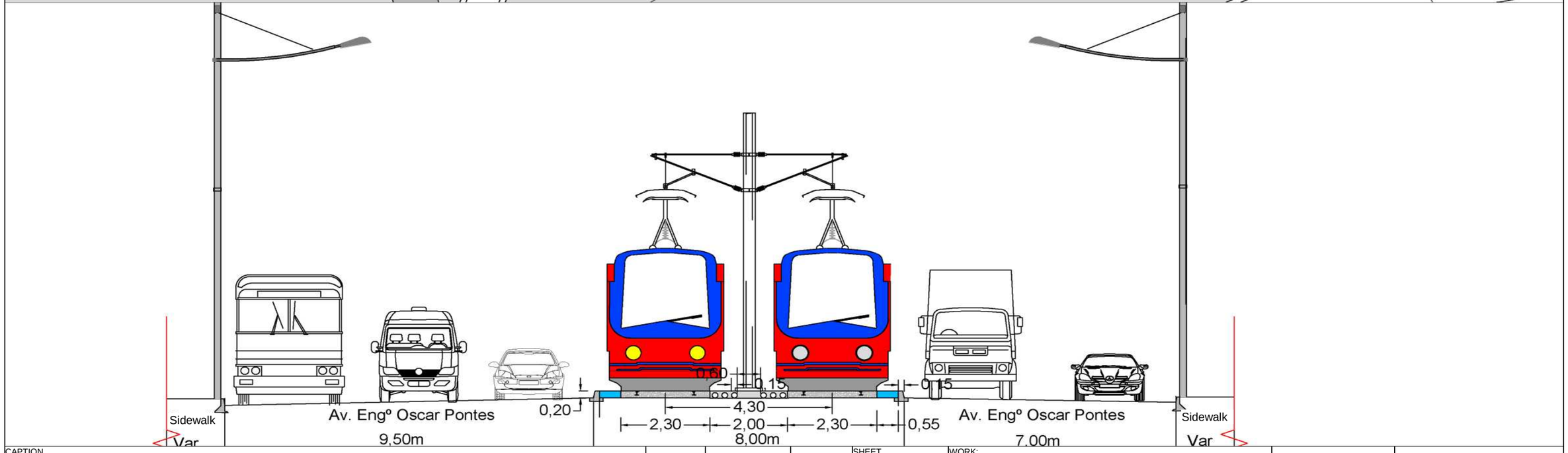
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

0 1
Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point

Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

Tubular gallery Ø = 0.40 m
Cell Gallery 1.00 x 1.00 m
Collecting or Passage Box

DRAWING		/ /	SHEET 06/10
CHECKING		/ /	SCALE
APPROVAL		/ /	Drainage - 1:1,000 Sections – 1:100
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

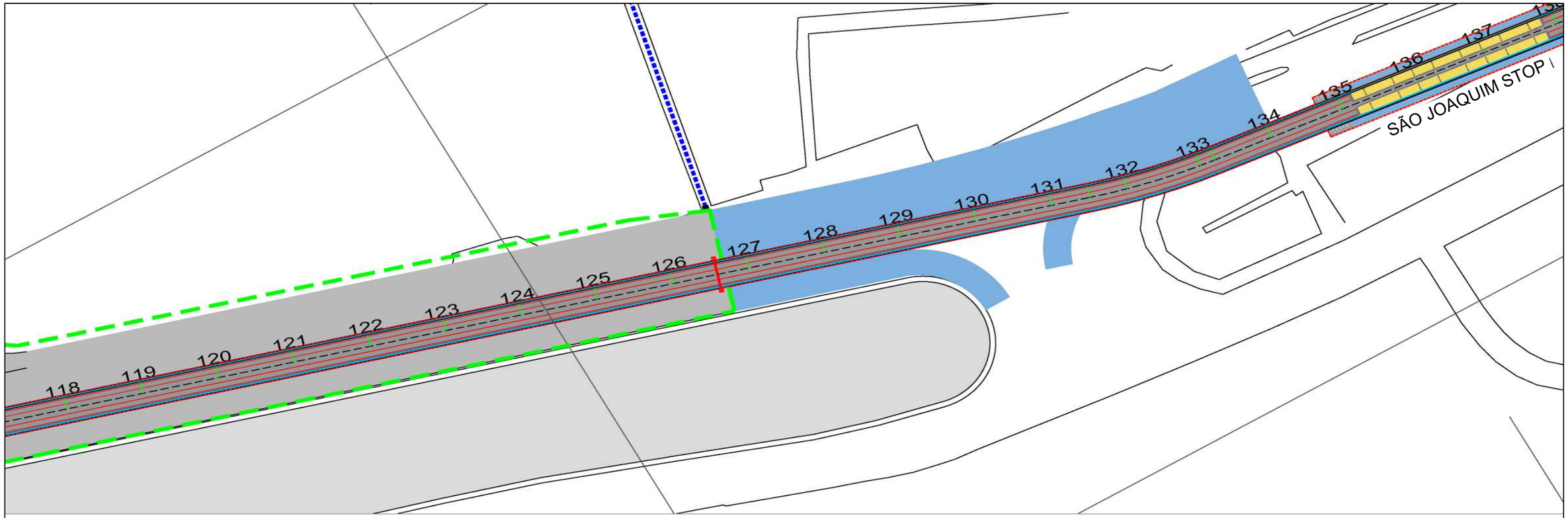
SUBJECT
DRAINAGE PLANT AND CROSS SECTIONS

DEPARTMENT OF URBAN DEVELOPMENT

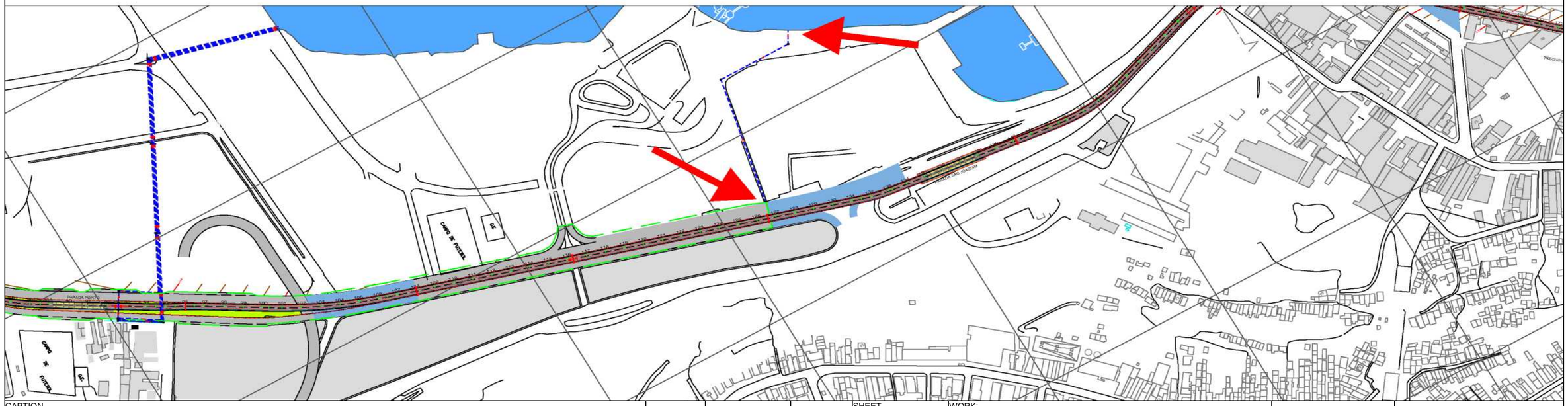
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



RELEASE OF STRATEGIC POINT _01



CAPTION

0 1

Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point

Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

Tubular gallery Ø = 0.40 m
Cell Gallery 1.00 x 1.00 m
Collecting or Passage Box

DRAWING		/ /	SHEET 07/10
CHECKING		/ /	SCALE
APPROVAL		/ /	Drainage - 1:1,000 Sections – 1:100
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

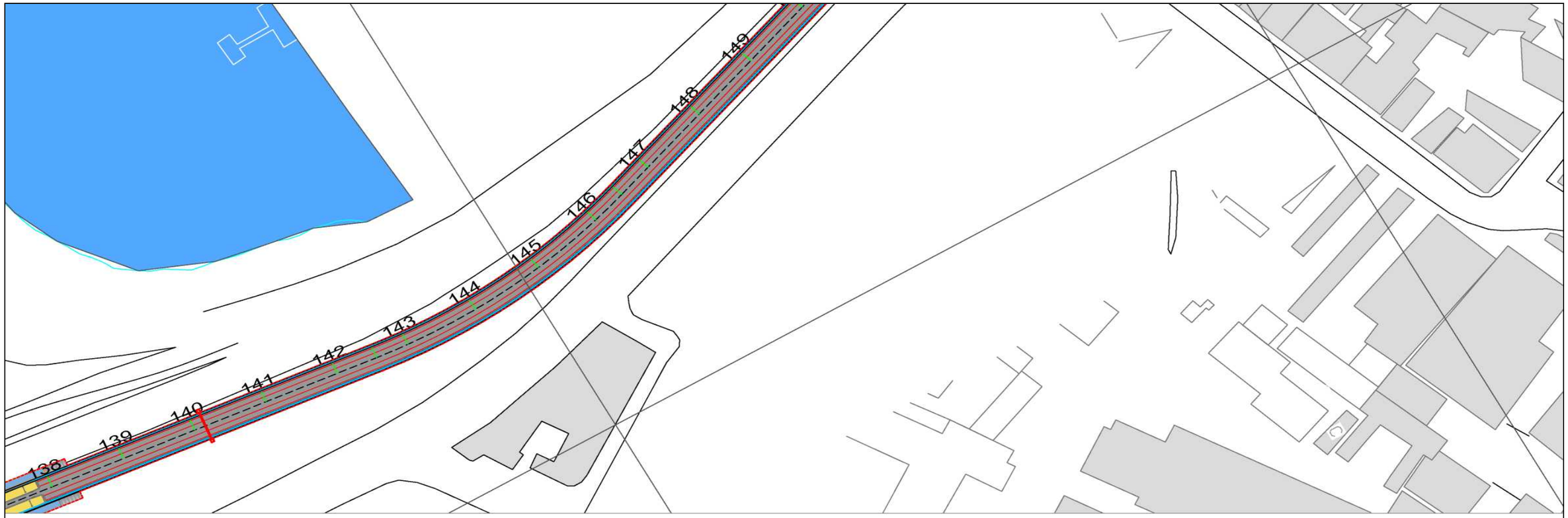
SUBJECT
DRAINAGE PLANT AND CROSS SECTIONS

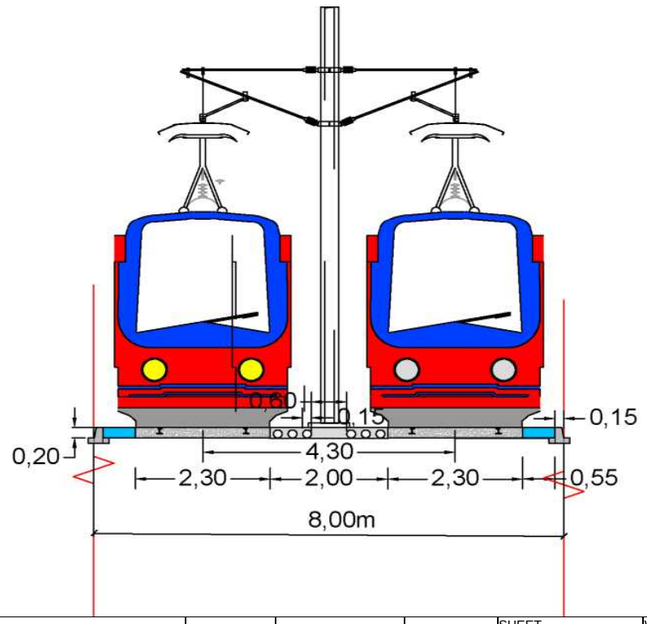
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

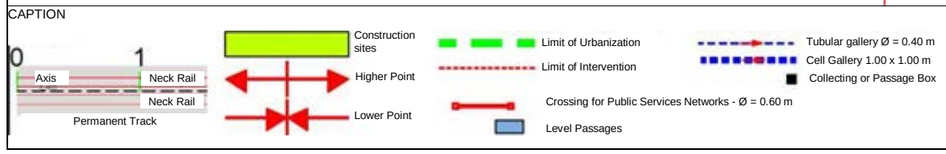
CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION



DRAWING		/ /	SHEET 08/10	
CHECKING		/ /	SCALE	
APPROVAL		/ /	Drainage - 1:1,000 Sections – 1:100	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

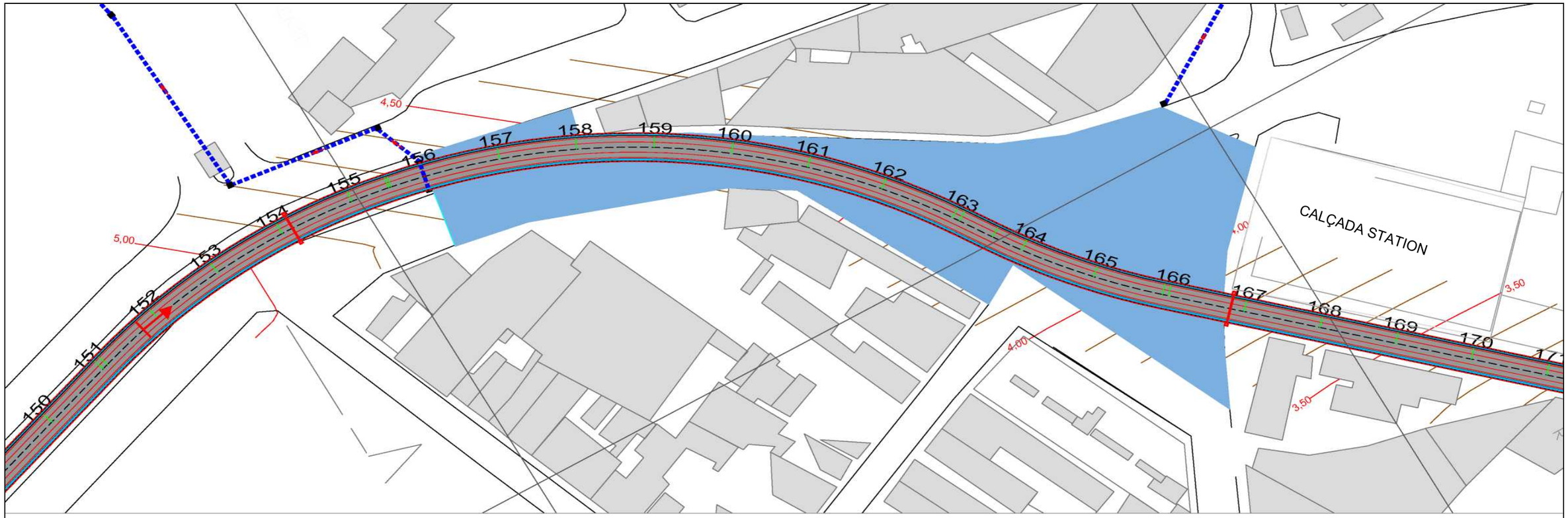
SUBJECT
DRAINAGE PLANT AND CROSS SECTIONS

DEPARTMENT OF URBAN DEVELOPMENT

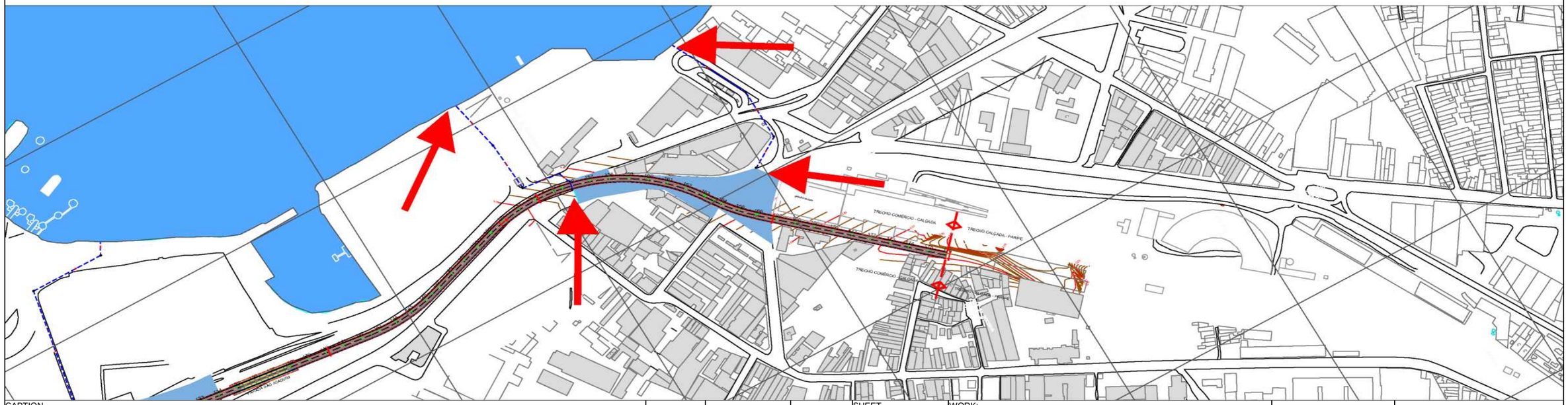
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



RELEASES OF STRATEGIC POINTS _02_AND LOWER POINT 04



CAPTION

0 1

Axis
Neck Rail
Neck Rail
Permanent Track

Construction sites
Higher Point
Lower Point

Limit of Urbanization
Limit of Intervention
Crossing for Public Services Networks - Ø = 0.60 m
Level Passages

Tubular gallery Ø = 0.40 m
Cell Gallery 1.00 x 1.00 m
Collecting or Passage Box

			SHEET 09/10
DRAWING		/ /	
CHECKING		/ /	SCALE Drainage - 1:1,000 Sections – 1:100
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		
NOTES			

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

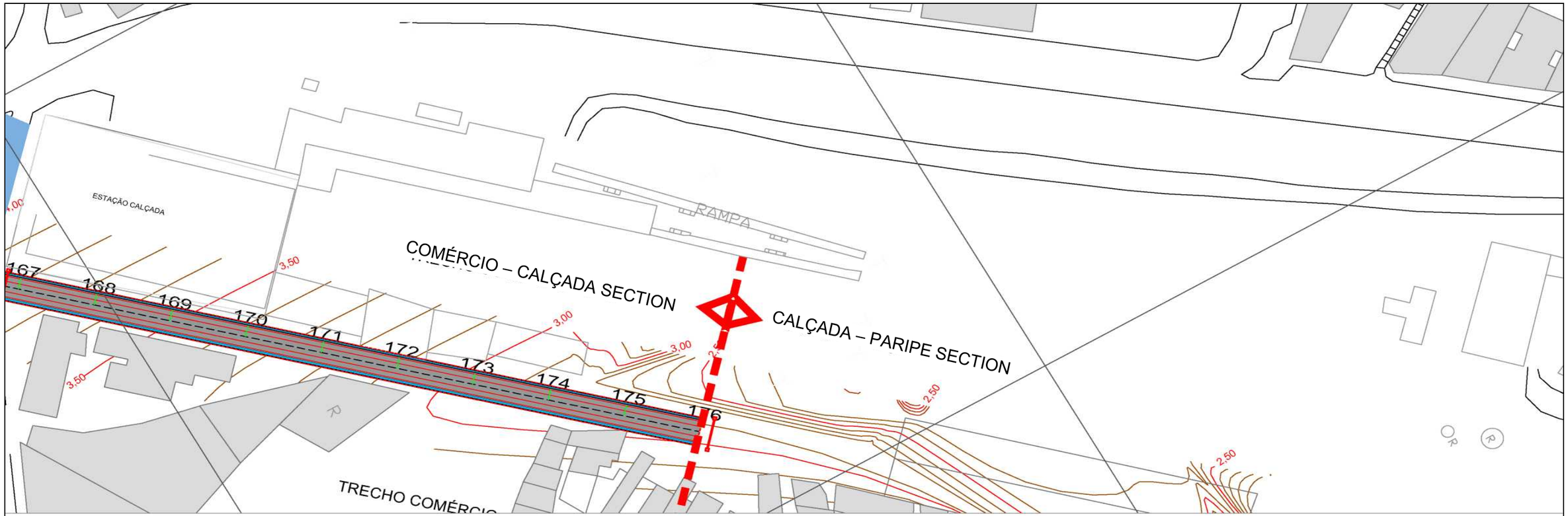
SUBJECT
DRAINAGE PLANT AND CROSS SECTIONS

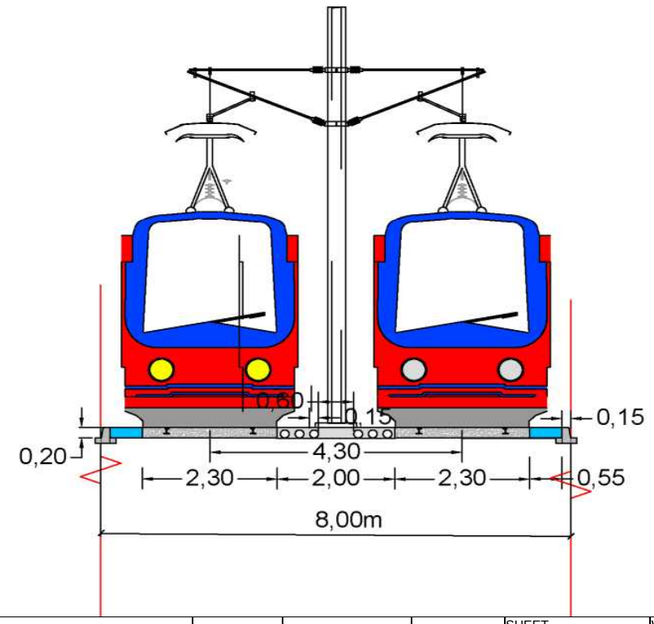
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

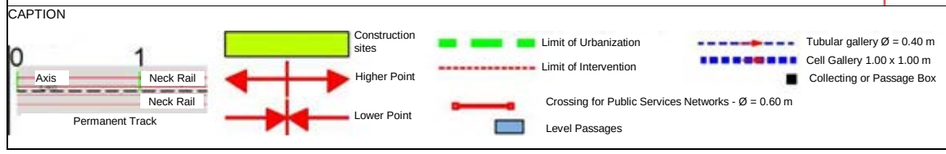
CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION



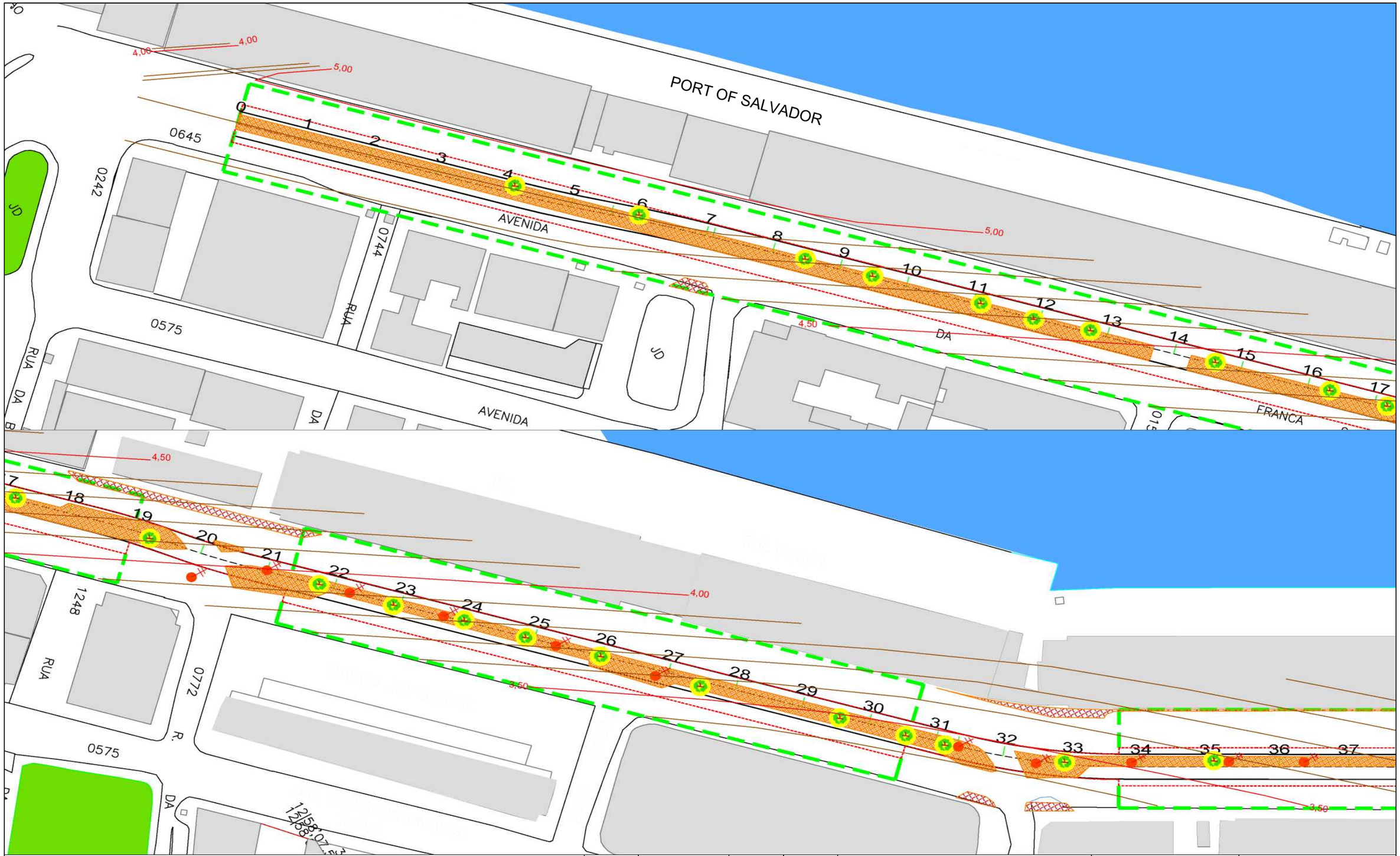
DRAWING		/ /	SHEET 10/10	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	Drainage - 1:1,000 Sections – 1:100	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE PLANT AND CROSS SECTIONS
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- Removal of construction site / existing pavement for replacement of the sidewalk
- Removal of existing construction site for sub-ballast
- Removal of construction site / sidewalk for replacement of asphalt paving
- Removal of Tree
- Removal of Utility Pole
- Limit of Urbanization
- Limit of Intervention

			SHEET	01/05
DRAWING		/ /		
CHECKING		/ /	SCALE	1:1,000
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

WORK:
SECTION – COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

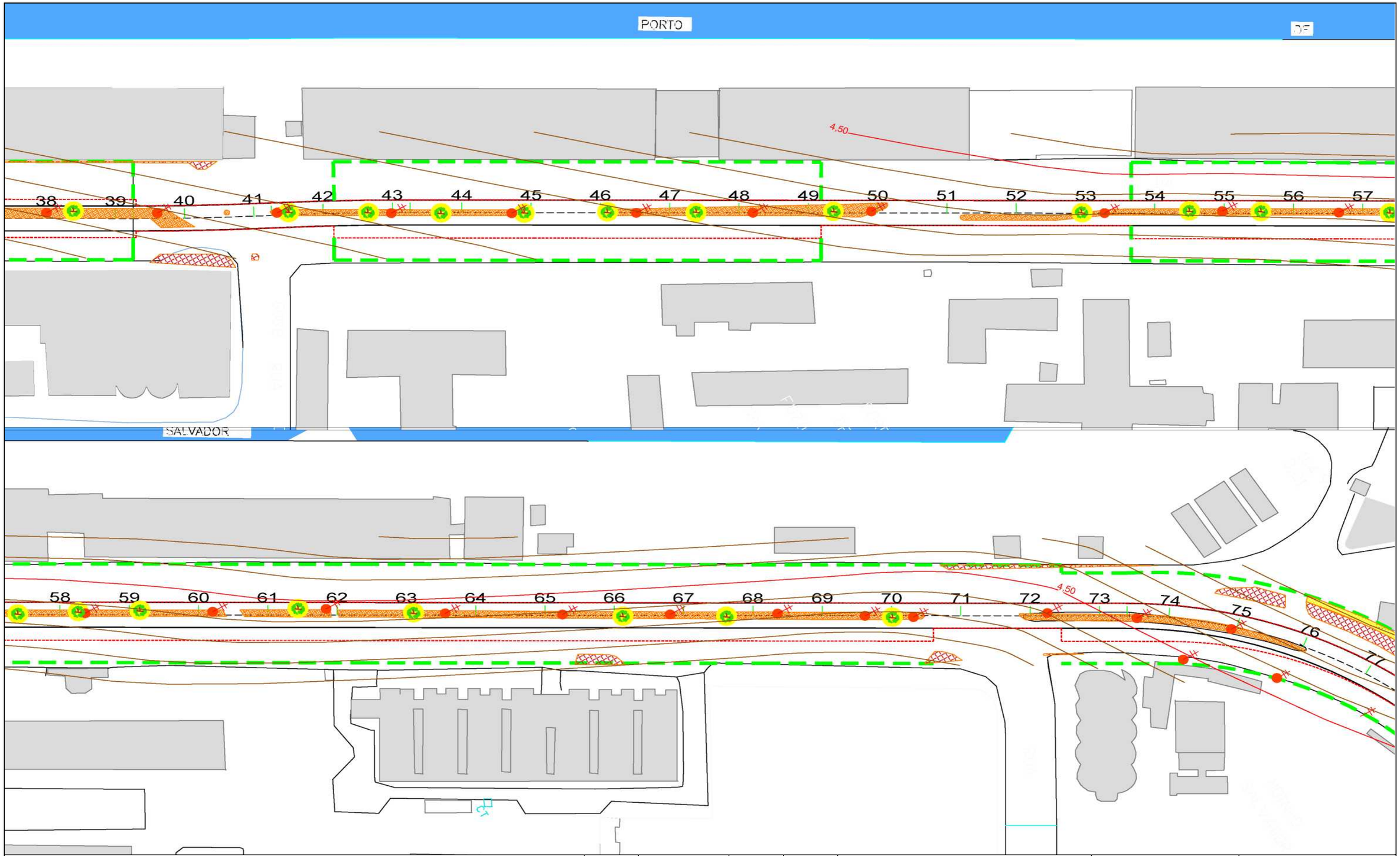
SUBJECT
REMOVAL OF INTERFERENCES

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- Removal of construction site / existing pavement for replacement of the sidewalk
- Removal of existing construction site for sub-ballast
- Removal of construction site / sidewalk for replacement of asphalt paving
- Removal of Tree
- Removal of Utility Pole
- Limit of Urbanization
- Limit of Intervention

			SHEET	02/05
DRAWING		/ /		
CHECKING		/ /	SCALE	1:1,000
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

WORK:
SECTION – COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

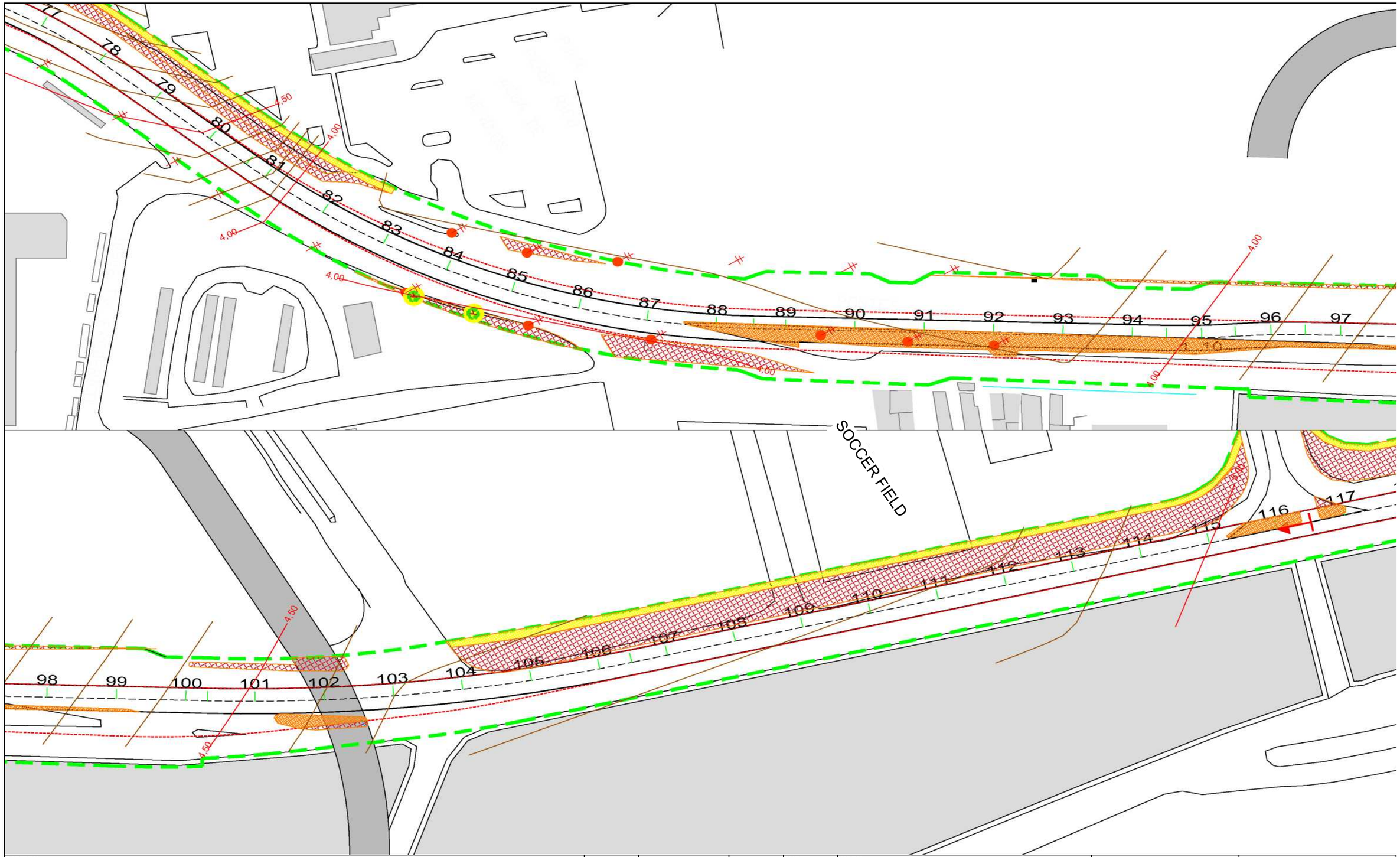
SUBJECT
REMOVAL OF INTERFERENCES

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- Removal of construction site / existing pavement for replacement of the sidewalk
- Removal of existing construction site for sub-ballast
- Removal of construction site / sidewalk for replacement of asphalt paving
- Removal of Tree
- Removal of Utility Pole
- Limit of Urbanization
- Limit of Intervention

			SHEET	03/05
DRAWING		/ /		
CHECKING		/ /	SCALE	1:1,000
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

WORK:
SECTION – COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

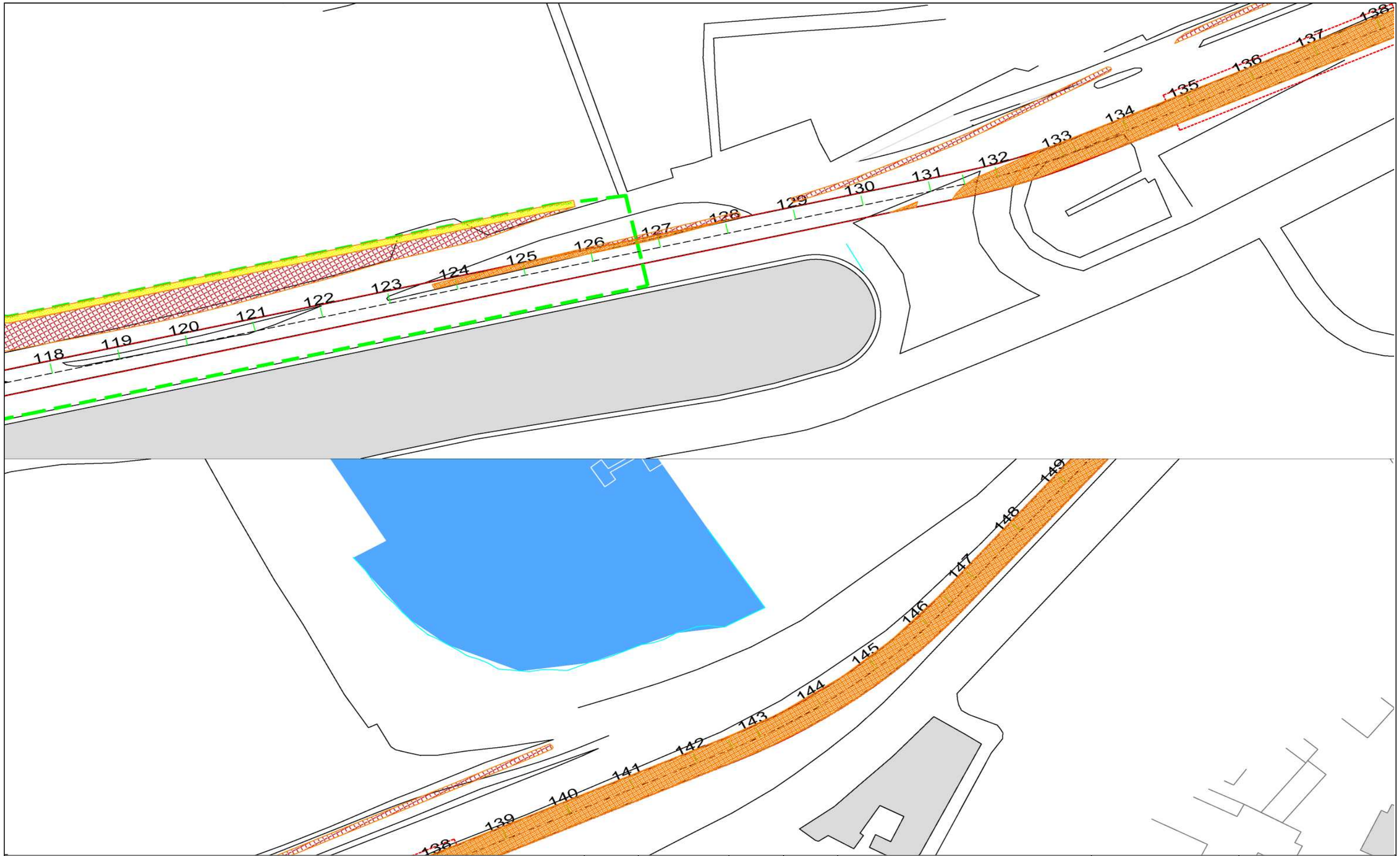
SUBJECT
REMOVAL OF INTERFERENCES

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- Removal of construction site / existing pavement for replacement of the sidewalk
- Removal of existing construction site for sub-ballast
- Removal of construction site / sidewalk for replacement of asphalt paving
- Removal of Tree
- Removal of Utility Pole
- Limit of Urbanization
- Limit of Intervention

			SHEET	04/05
DRAWING		/ /		
CHECKING		/ /	SCALE	1:1,000
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

WORK:
SECTION – COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

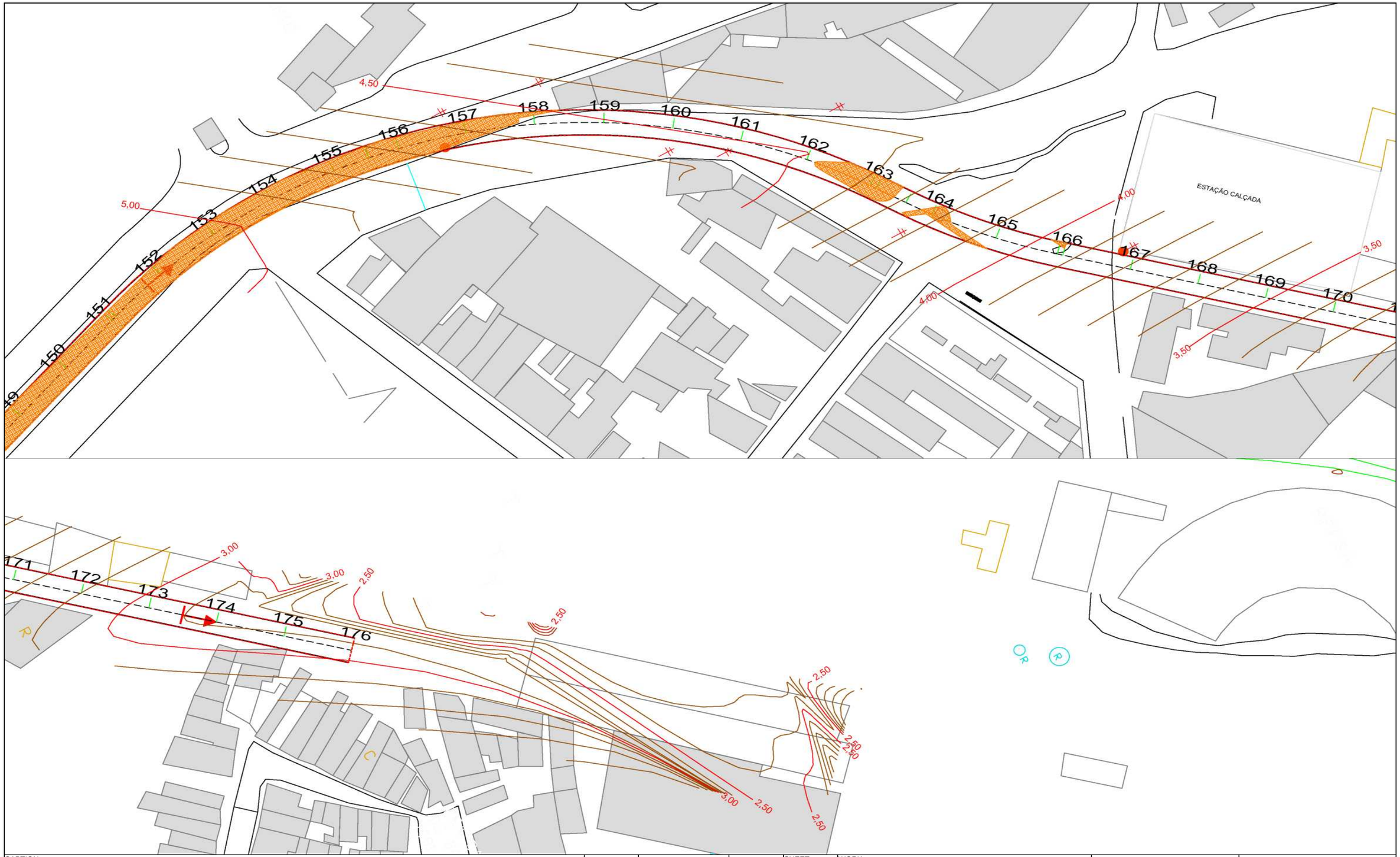
SUBJECT
REMOVAL OF INTERFERENCES

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

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			SHEET
DRAWING		/ /	05/05
CHECKING		/ /	SCALE
APPROVAL		/ /	1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
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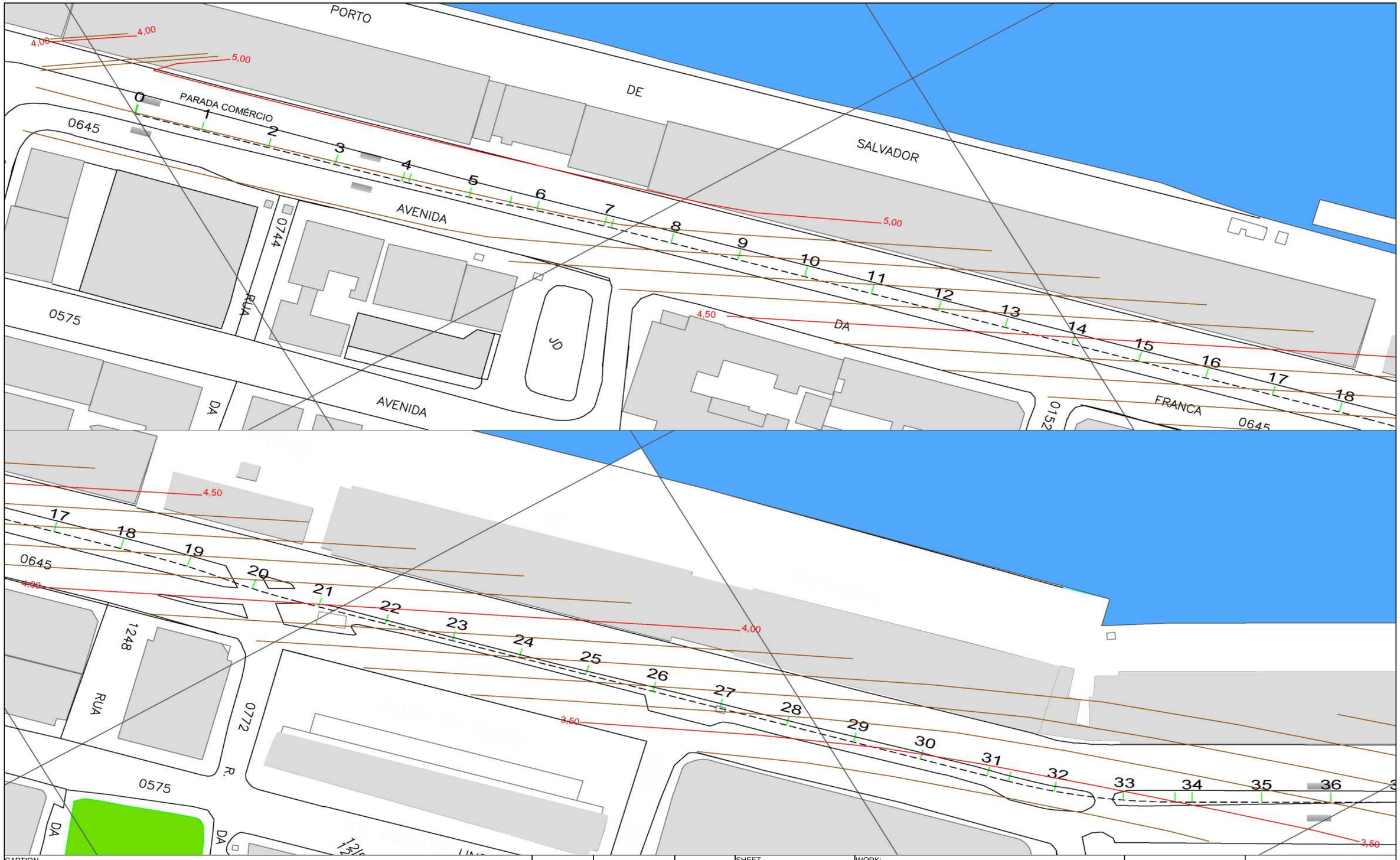


CAPTION

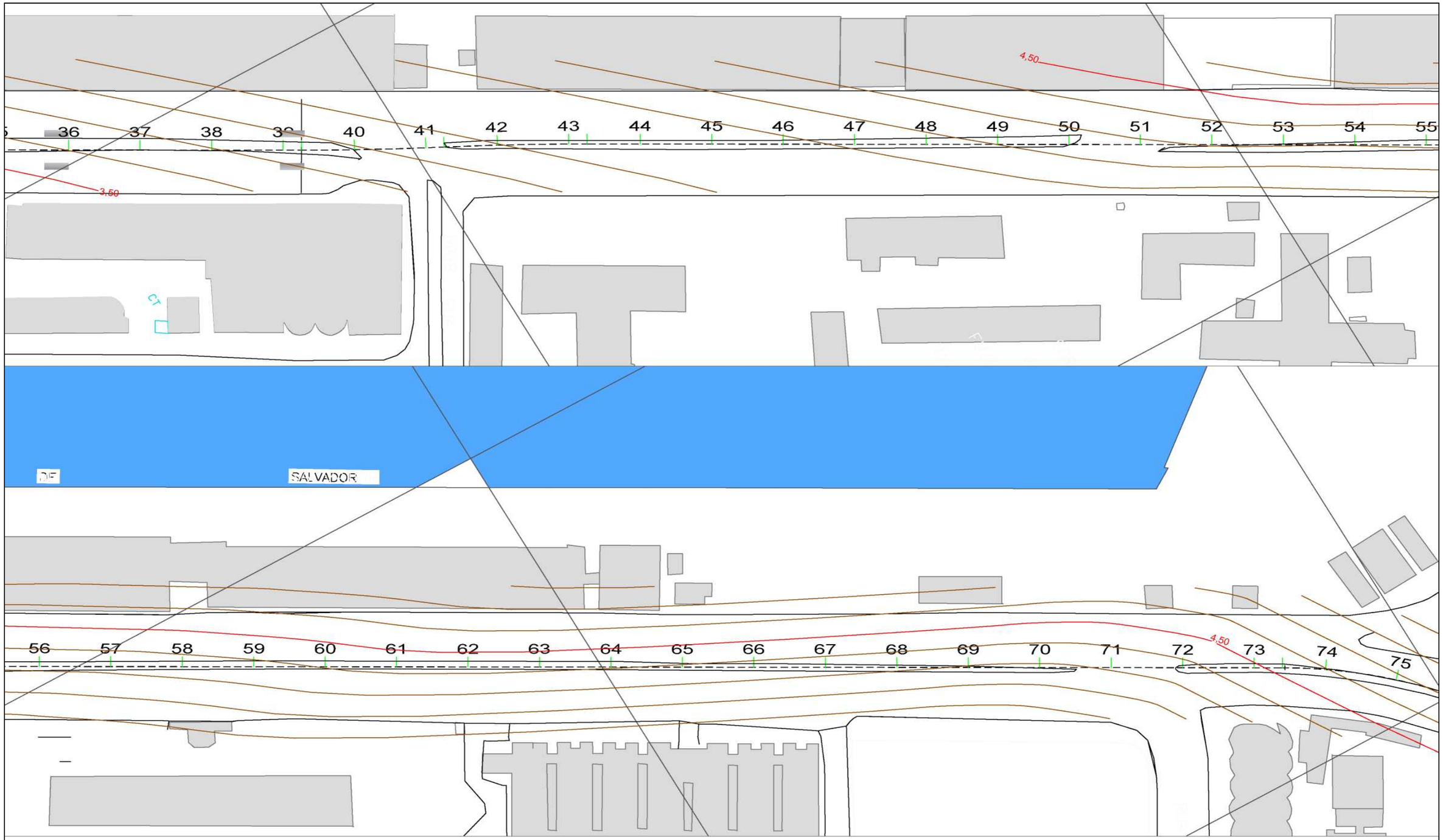
Axis 1

DRAWING		/ /	SHEET 01/05	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE 1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT TOPOGRAPHIC BASE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV



CAPTION

Axis 1

			SHEET	02/05
DRAWING		/ /		
CHECKING		/ /	SCALE	1:1,000
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

WORK:
SECTION - COMÉRCIO - CALÇADA

MUNICIPALITY
SALVADOR

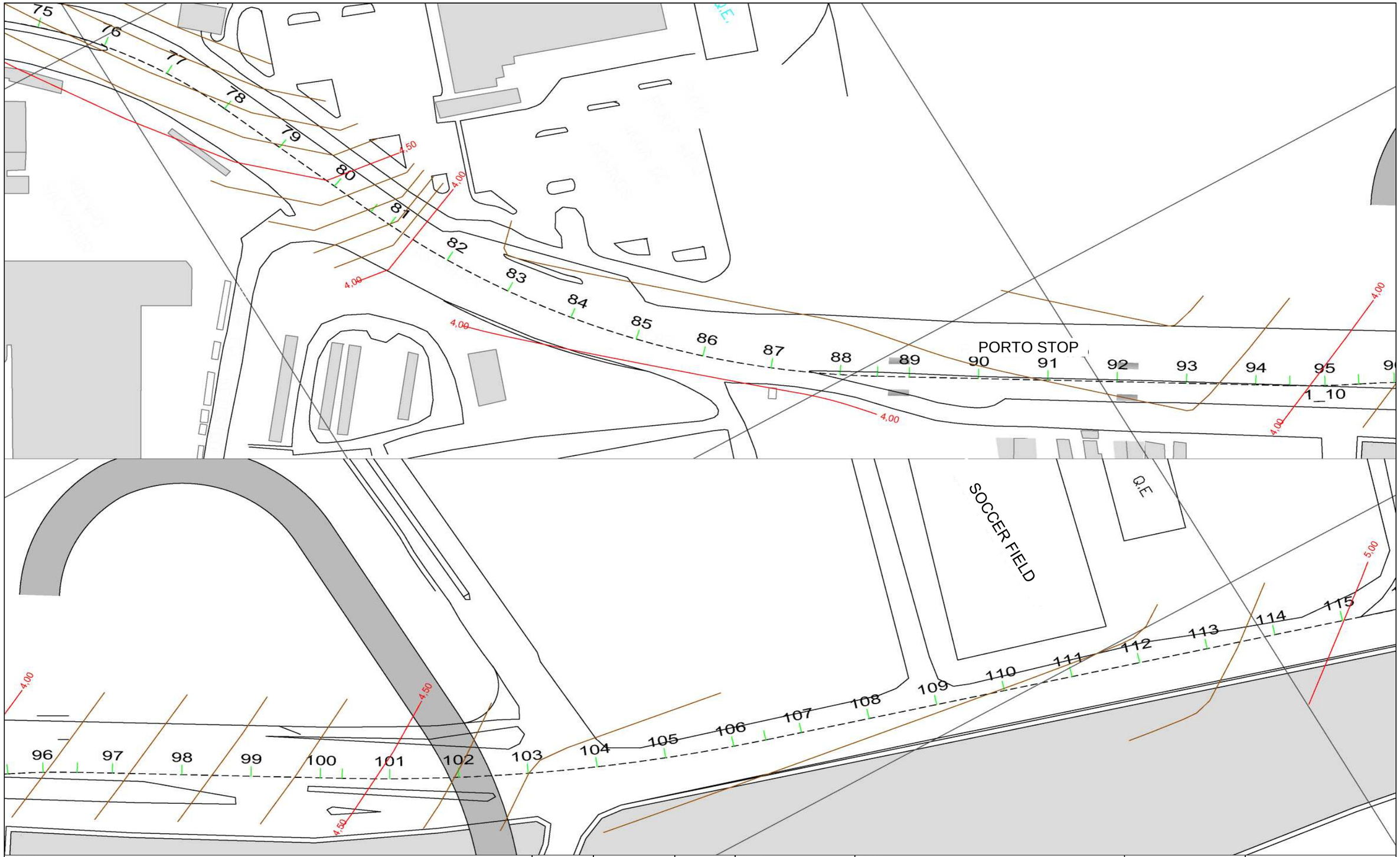
SUBJECT
TOPOGRAPHIC BASE

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

Axis 1

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CHECKING		/ /	SCALE 1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT TOPOGRAPHIC BASE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			
NOTES				

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

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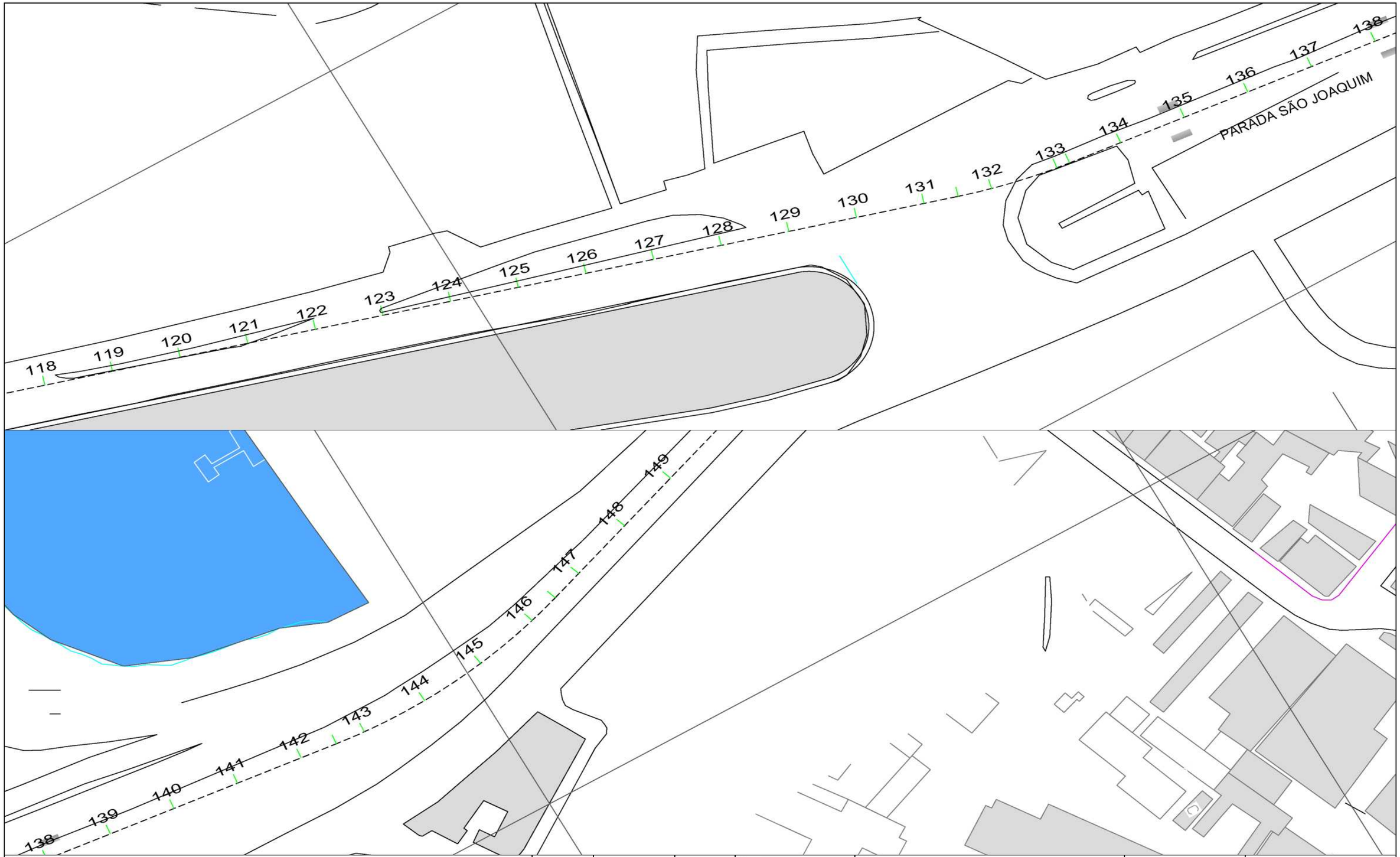
LIGHT-RAIL VEHICLE
LRV



CAPTION

Axis 1

DRAWING		/ /	SHEET 04/05	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT TOPOGRAPHIC BASE
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
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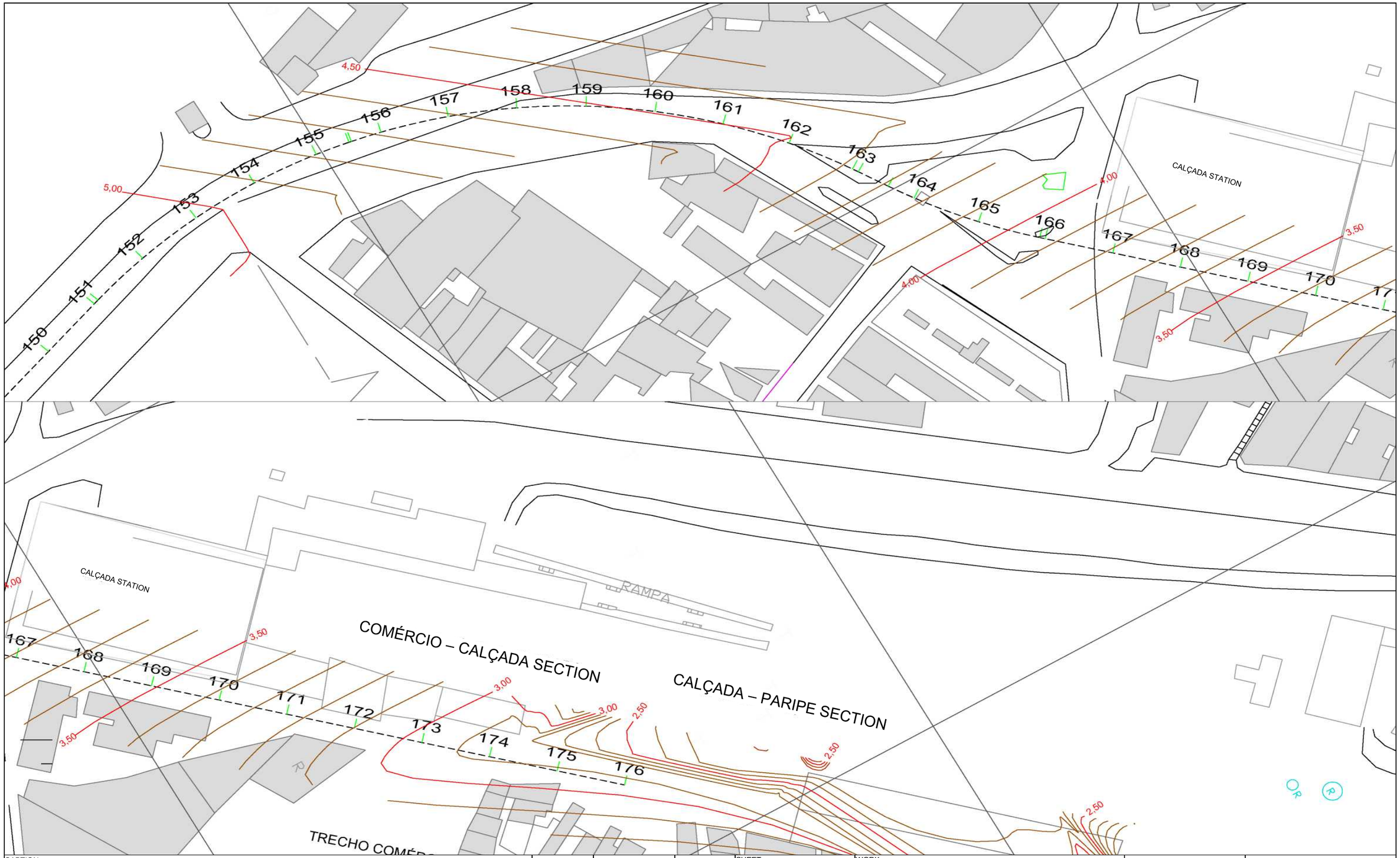
LRV



CAPTION

Axis 1

DRAWING		/ /	SHEET 05/05	WORK: SECTION - COMÉRCIO - CALÇADA
CHECKING		/ /	SCALE	MUNICIPALITY
APPROVAL		/ /	1:1,000	SALVADOR
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			TOPOGRAPHIC BASE
NOTES				

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV

Volume II - Railway Superstructure - Calçada - Paripe

Item	Content List
F_01	Desire line
F_02	Conditions for deployment
F_03	Deployment of the enterprise
F_04	Route geometrization
F_05	Rails
F_06	Sleepers
F_07	Ballast
F_08	Sub-ballast
F_09	Dimensioning of Railway Superstructure
F_10	Geometric conditioning of Boarding and Disembarkation Stops - PED
F_11	Geometrical and Structural Conditioning of the Level Passages - PN
F_12	Drainage
F_13	Special Works of Art - Tunnel and Containment

Desire Line

The desire line established in the Program of Needs for the Metropolitan Train Design is actually the current route in which currently runs the Suburban Railway trains. This line has been operated for 150 years, it is the desire to travel of those who are head to Suburban region, in Calçada - Paripe section or who travel looking for some location along this corridor.

This is therefore a Permanent Track in operation, which we want to requalify, with no need to change the route. This maintenance of the route is imposed by the topographic conditions defined by the existence of a steep slope, on the right side, near and along the entire coast. On the left side, the border and the coastline of the Suburb Railway.

Thereby, it is in fact a railroad requalification, by opting for maintaining the full route that already has a defined right of way of 15.00 m wide for each side of the axis of the outer head of the left and right tracks. The State Government of Bahia, by taking over the operation of the existing Railway System, is requesting to the Federal Government, equity transfer of this right of way, owned by the Federal Government.

The spaces available for requalification of this track, although it has been partially occupied over the years, is sufficient to maintain a railway corridor with railway bed of 8.00 m, in double track, and along the center of the existing track through which passes the existing railway and under operation of Calçada - Paripe connection.

The need to use the existing track as a reference for requalify the Permanent Track was fundamental, and conditioned the designers to establish route maintenance procedures, considering qualified and quantified weights, geared towards a fast deployment, causing the little disruption as possible to the local and passing population, and prices capable of fitting the budgetary limits available. In order to achieve these objectives, the following activities were listed:

- ✓ Assess locational conditions for maintenance of the route for the requalification of the Permanent Track, in dual line, for compliance with a conventional desire line connecting Calçada to the suburban town of Paripe, passing in its course by all existing stops along the section;
- ✓ Assess alternative conditions of use, in this section of the LRV - Light-Rail Vehicles, powered by electricity;
- ✓ Assess the locational conditions for deployment of mandatory stops, complementary for boarding and disembarkation at the locations indicated by demand studies and confirmed in the Program of Needs made by the State, also incorporating the indications made by the Municipal Government of Salvador;
- ✓ Assess the accessibility conditions for the users in each of the existing stops and its connection to the current road system;
- ✓ Assess the impact of the deployment of the track on the current users using vehicles and on foot
- ✓ Assess the conditions for decommissioning of some stops, due to unsuitability of their locational situations.

When assessing the existing route, we tried to reconcile it to maintain a path that could meet the requirements of a rail corridor capable of operating with a train every 10 minutes to meet a demand of 50,000 passengers. This alternative should reconcile the requirements of a corridor with some existing road crossings and clandestine passages already consolidated by use. The following were the main interference and conditions to be assessed and considered in the preparation of the Basic Design:

- ✓ Conditions for implementation and access to a new Calçada Stop - PED_01, at stake 177 + 10, in the Operational Yard of Calçada replacing the existing Boarding and Disembarkation Platform;
- ✓ Conditions for deployment and access to a new Boarding and Disembarkation Stop - PED_02, at stake 227 + 10, in Baixa do Fiscal;
- ✓ Conditions to access the facilities of the Stop and requalifying them with deployment of Santa Luzia Stop - PED_03, at stake 265 + 10;
- ✓ Conditions for deployment and access to a new Stop - PED_04, under Viaduto da Suburbana, at stake 328 + 10;
- ✓ Conditions to access the facilities of Lobato Stop and requalifying them with deployment of a new Stop - PED_05, at stake 345 + 10;
- ✓ Conditions for deployment and access to a new Stop - PED_06 in the town of União, at stake 396 + 10;
- ✓ Structural and geometric conditions of São João's Bridge - OAE_01, existing between the stakes 416 and 439, for passage of the LRV considering an operational speed of 70 km/h and an axle load of 10 t;

- ✓ Conditions for deployment and access to a new Stop - PED_07, in the town of São João, at stake 445 + 10;
- ✓ Decommissioning of Almeida Brandão Station, existing at stake 459 and assessment of their allocation for new operating or community uses;

- ✓ Conditions for deployment and access to a new Stop - PED_08, in Platform location shifted spatially to the new position, at stake 471 + 10;
- ✓ Conditions for deployment and access to a new Stop - PED_09, in the town of São Brás (Mocotó), at stake 519 + 10;
- ✓ Conditions to access the facilities of the Stop and requalifying them with deployment of Itacaranha Stop - PED_10, at stake 567 + 10;
- ✓ Conditions to access the facilities of the Stop and requalifying them with deployment of Escada Stop - PED_11, at stake 598 + 10;
- ✓ Conditions to access the facilities of the Stop and requalifying them with deployment of Praia Grande Stop - PED_12, at stake 665 + 10;
- ✓ Special treatment of the railway level intersection - PN_01, at stake 688 + 15, in front of the Araketu facilities, for vehicles passage under operational control;
- ✓ Special treatment of the railway level intersection - PN_02, at stake 695 + 7, in front of Largo de Periperi (Largo da Igreja), for pedestrian passage, eventually vehicles passage, under operational control;
- ✓ Access conditions to the facilities of the Stop and readjustment thereof with deployment of a Stop in Periperi - PED_13, at stake 704 + 10 and assessment of allocation of existing facilities to new operating or community uses;
- ✓ Special treatment of the railway level intersection - PN_03, at stake 718 + 10, in front of Av. Afrânio Peixoto, near the mini-traffic circle of Paraguarí River, for passage of vehicles under operational control;
- ✓ Structural and geometric conditions of the existing Small Bridge over Paraguarí River - OAC_01, existing at stake 735 + 10, for passage of the LRV, considering an operational speed of 70 km/h and an axle load of 10 t with International clearance;

- ✓ Structural and geometric conditions of existing tunnels - OAE_02 and OAE_03, existing, from stakes 738 to 743 to pass the LRV, considering an operational speed of 70 km/h and an axle load of 10 t with International clearance;

- ✓ Geometrical conditions of existing tunnels - OAE_02 and OAE_03 existing from the stakes 738 to 743 for possible evacuation in case of accidents or unintended stop;
- ✓ Conditions for deployment and access to a new Stop - PED_14, in the town of Setubal, at stake 750 + 10;
- ✓ Access conditions to the facilities of the Stop and readjustment thereof with deployment of a Stop in Coutos - PED_15, at stake 796 + 10 and assessment of allocation of existing facilities to new operating or community uses;
- ✓ Special treatment of the railway level intersection - PN_04, at stake 800, shortly after Coutos Stop for passage of vehicles under operational control;
- ✓ Special treatment of the railway level intersection - PN_05, at stake 831, before Paripe Stop for passage of pedestrian, eventually vehicles, under operational control;
- ✓ Access conditions to the facilities of the Stop and readjustment thereof with deployment of a Stop in Paripe - PED_16, at stake 842 and assessment of allocation of existing facilities to new operating or community uses;

Aiming to establish a confrontation of locational characteristics aimed at achieving the objective of the Enterprise, evidently associated with the time availability and financial resources, without forgetting the quantified and qualified evolution of demand, related to the operational structure of the traffic (train, road vehicles and pedestrians), present and future, we will comment on some conditions related to the desire line selected:

- ✓ Use of construction processes and procedures to prevent or minimize vibration and noise;
- ✓ Use of construction processes and procedures that fit within the right of way;
- ✓ Use construction processes and procedures to ensure linearized progressive development of the works, in the direction Calçada - Paripe, in order to allow the construction traffic of the works, on tracks from General Construction Site, in the area of Calçada Station or Periperi Yard;
- ✓ Use of construction processes and procedures for the implementation of temporary fences, in order to prevent or minimize vibration and noise and offer security guarantees;
- ✓ Use of construction processes and procedures to ensure safety conditions to the existing traffic;
- ✓ Use of processes and procedures that enable multiple construction fronts in order to minimize the construction time.

Below follows a chart with the list of ***"Desire Line"*** that matches the existing route.

Calçada
Baixa do Fiscal

Baixa do Fiscal
Santa Luzia

Viaduto
Suburbana
Santa Luzia

Viaduto
Suburbana
Lobato
União

São João
Plataforma
União

São Bras
plataforma

Brás
Itacaranha
Escada

Escada
Praia Grande

Setúbal
Periperi
ande

Setúbal
Coutos

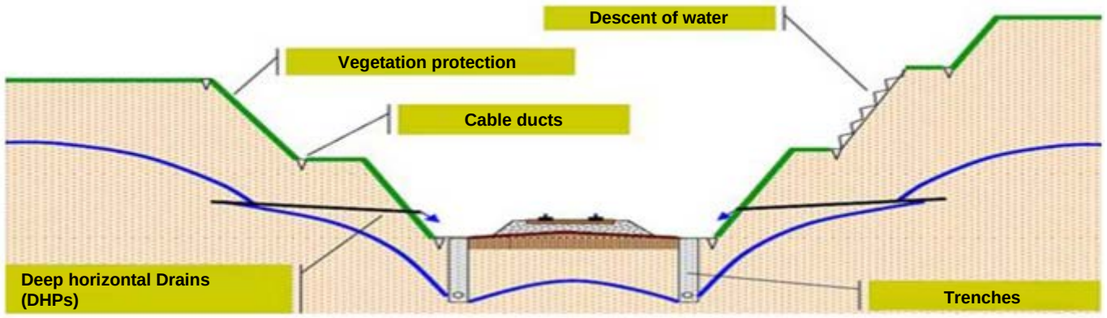
Coutos
Paripe

Conditions for Deployment of the Enterprise

Interventions due to the needs of the Program, as previously mentioned, were oriented to the establishment of an infrastructure capable of providing physical support and operational conditions for deployment of a double-track railway, with international clearance, electrified and ballasted with crushed stone ballast, prestressed monoblock concrete sleepers and TR_45 rails.

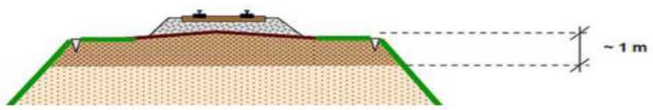
Permanent Track → the final surface of the prepared land for deployment of support infrastructure of a railroad is called ***platform,*** that can be structured with natural or treated soils.

On the railway, the platform is the support of the track structure that receives, through the ballast, the pressure due to the movement of trains, provides space for the facilities necessary for railway operation, such as overhead network poles for communication, power or for surface or underground network systems of conductor cables.



The platform has as main purpose providing support for the track superstructure that do not suffer deformations or can negatively influence the operation under traffic conditions conditioned by the line layout. In order to make it happen, the platform must have certain strength characteristics provided by the physical characteristics of residual soil or incorporated in the construction of embankments or identified on the surface of cuts prepared for this function.

The soil to be used in the construction of the railway infrastructure are considered suitable when selected from methods such as visual identification, granulometric structure, sedimentation, Atterberg limits (liquid limit, plastic limit, plasticity ratio), CBR, etc.



We can establish the natural terrain platform, grounded, settled or cut, since the resistance value required for this function is met. In any situation to the preparation of the platform is necessary cleaning the site of works along the entire section where they plan to deploy the superstructure of Permanent Track and construction in suitable geometric format of cuts and landfills with selected materials or having enough bearing capacity to receive loading resulting from traffic.

In some situations, when there are completed cuts in the lower bed, or on the basis of landfills, soils incompetent with low bearing capacity or expansive, it is required replacement of materials of the lower layers.

In cuts, after excavation, if the geomechanical characteristics do not meet the strength requirements and deformation capacity, should be necessary to replace the materials.

The allowable tension of lower bed support was established initially supported in limited experiments and techniques in 1.4 kgcm^2.

The Spanish Railways (RENFE) recommend the following expression:

$$\sigma_{adm} = \frac{0.006 \cdot E_d}{1 + 0.7 \cdot \log n}$$

wherein:

- σ_{adm}: maximum allowable tension of the lower bed;
- E_d: modulus of dynamic elasticity of the soil (Ed = 100.CBR);
- n: number of load passages;

Very rigid platforms are not suitable because they can lead to destruction of the ballast, by progressive crushing due to repetitive passage of loads.

Sub ballast → its functions is to increase of progressively, the bearing capacity of the platform, so as to bring the work rate in the land and as a consequence, enable a ballast layer with the lower height, and prevent penetration of the ballast on the platform. It also has the function of increasing the resistance of the bed to erosion and water penetration, assisting in the drainage process of the track, besides allowing relative elasticity to the ballast support, to decrease the stiffness of the permanent track.

The following are the main features of the sub-ballast material:

- ✓ IG → Group Index or bearing capacity equal to zero;
- ✓ LL → Liquidity limit or the lowest content of maximum moisture of 35%;
- ✓ IP → Maximum Plasticity Ratio of 6;
- ✓ maximum expansion of 1%;

When executed, the sub-ballast must be compressed in order to obtain apparent gravity corresponding to 100% of the value obtained in the Simple Proctor Test.

The material for sub-ballast must fall, preferably, in the A1 group of HRB (Highway Research Board) soil classification***:*** A1 - Soil well graduated consisting mainly of rubble and sand, but containing a small amount of fine materials.

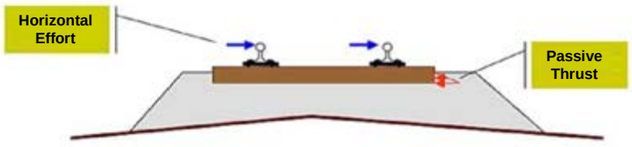
Clay soils (A4 to A7) should not be used since they are subject to large volume variation in resistance during drying and wetting cycles. It should also be avoided using poorly graded soil, such as fine sand (A3), because they are difficult to be compacted to achieve high densities in non-confined locations. The commonly used materials are crushed stone and gravel.

Thickness of the sub-ballast → the thickness of sub-ballast should be obtained by structural sizing, so that the distribution of pressure through it entails, on the platform, in a working rate compatible with the bearing capacity thereof. In most cases where the CBR of the lower bed good structural quality and in tracks with relatively low loads (LRV-passenger train), the sub-ballast with a thickness of 20 cm is sufficient.

Ballast → it has the function of increasing the bearing capacity of the platform, allowing to distribute on the sub-ballast the efforts resulting from the loads of the vehicle, producing a suitable pressure and its capacity.

The ballast must provide a cushion to some extent elastic, in order to mitigate the resulting vibrations due to passage of vehicles and form a smooth and continuous surface to the sleepers and rails, removing small irregularities in the platform or sub-ballast surface.

The ballast should prevent the displacement of the sleepers, either longitudinally or transversely and promote drainage of the superstructure and, in the case of wooden sleepers its aeration.



Qualities of ballast → it must have sufficient strength to the efforts transmitted by the sleepers and the elasticity needed to mitigate the shocks.

The materials used must be large enough to allow its interposition between and under the sleepers, filling the platform or sub-ballast depressions and allowing the perfect leveling of the rails, as well as having resistance to atmospheric agents. They must have permeability to make the drainage of rainwater, and not be subject to wear producing dust, besides allowing an efficient ***tamping*** by mechanical means (punchers, vibrators).

Materials used → granulated slag, steel slag, quarry gravel, river gravel, pebbles, crushed slag, and the crashed is the most used material.

Specifications - according to AREMA ***(American Railway Engineering and Maintenance-of-Way Association)***

- ✓ minimum specific weight of 2.7;
- ✓ tensile strength of 700 kg/cm^2;
- ✓ solubility: the stone cannot become discolored subjected to a solubility test;
- ✓ absorption: weight increase due to water absorption of a sample of 230 g, it should not exceed 1% when immersed in water for some time;
- ✓ the amount of harmful substances and clay clods should not exceed 1%;
- ✓ granulometry: ballast stones must have dimensions between 2 and 6 cm.

Sizing	Cumulative percentages in the sieves					
	63,5 mm	50 mm	38 mm	25 mm	19 mm	12,7 mm
50 mm to 25 mm	0	0 - 5	35 - 65	85 - 100	90 - 100	95 - 100

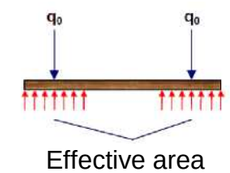
Methodology for dimensioning of the ballast layer → the first step is to define the basic parameters of the Permanent Track, such as clearance, size, spacing between sleepers, maximum total load per vehicle, separation between two consecutive wheels and operational speed. From these elements, using appropriate mathematical formulation:

- ✓ Determine the dynamic load (Pv);
- ✓ Determine the pressure on the lower part of the sleeper (Pm);
- ✓ Determine the allowable pressure (Pap) for the material to be used in the sub-ballast or platform;
- ✓ Determine the height of the ballast layer.

Dimensional elements - Limits for sizing the section → the ballast does not cover the sleepers, and is crowned with 5 cm from the top face. In the case of concrete sleeper with blocks connected by metal tie rod, the ballast must be 2 cm below the tie rod, maintaining the crowning of 5 cm.

The tamping coverage geometry must be at least 30 cm for the metric clearance, from each side of the axis of the rails under the sleepers.

$$p_m = \frac{2 \cdot q_0}{A_{ef}}$$

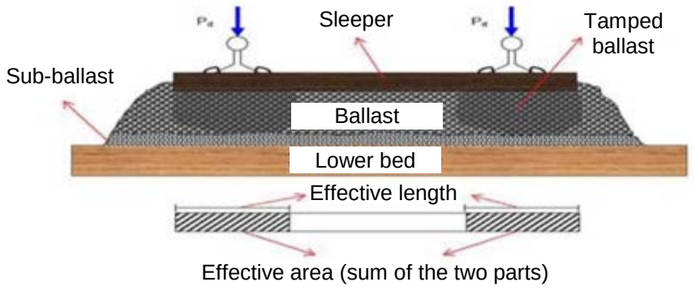


Effective area

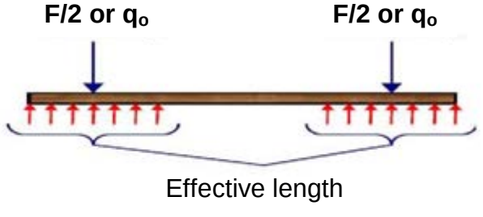
where:

- p_m: pressure in the contact between sleeper-ballast;
- q_0: load applied by the rail in the sleeper;
- A_{ef}: effective contact area (sum of the two areas where the ballast is tamped);

The central range not affected by tamping will have at least 30 to 40 cm wide.



The platform bearing capacity should not be exceeded by the pressure transmitted by the ballast, which will have sufficient thickness to standardize it.



The abutment will have adequate width with respect to the track stability, being recommended 30 cm for tracks with long welded rails (TLS), 20 cm for tracks with high density without TLS traffic and 15 cm for the other.

The geometry of the ballast embankments will not have slope greater than 1 (V): 1.5 (H);

The height of the ballast layer under the sleepers is dimensioned and can vary from 30 cm to 15 cm in the metric clearance lines. The calculation of transfer of tension is done by applying the theory of elasticity or employing the simplified Talbot expression.

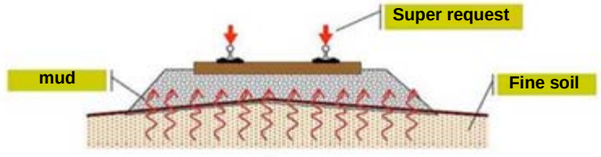
$$p_h = \frac{16.8}{h^{1.25}} \cdot p_m \qquad \text{(Talbot)}$$

where:

- h: height of the ballast in inches;
- p_h: strength of the lower bed;
- p_m: pressure in the contact between sleeper-ballast;

In large requesting lines, either due the load or the speed, the thickness may be increased until reaching the value of the face-to-face clearance of the sleepers, then using a layer of graded crushed stone (ballast) and a sub-ballast with smaller particle size materials.

When the height of the sized ballast layer exceeds the recommended height for line class can be used, for economic measure, lower category material as ***sub-ballast*** since it offers good drainage condition and has bearing capacity for the pressure to be transmitted.



Constructive aspects → the choice of material for ballast must comply with the economic criteria, subject to the provisions of technical standards;

The ballast or sub-ballast should only be released on the platform properly regulated, leveled, compacted, bulged and have adequate drainage condition;

The tamping of the ballast should be carried out preferably by mechanical process and be made in any case in layers of about 15 cm, being recommended to reduce this value to 10 cm in lines of great responsibility.

Utilization conditions → the grid, in this section does not present utilization conditions and should be completely removed.

There are no evident route alternatives, since the existing one features excellent geometric characteristics, with respect to the curves and their corresponding minimum radii or even maximum ramps.

The geometric realignment of the track with the necessary corrections in the horizontal and vertical routes will be made by incorporation of new radii and super elevation required for every radius amplitude related to the design speed and operation speed.

In the section where the existing ballast layer is spread to configure and strengthen the old sub-ballast should be an equalization of horizontal and vertical geometric positioning. The designed ramps and radii fall completely under current legislation, mainly considering the characteristics required by LRV - Light-rail Vehicle, which will be used and have milder geometric requirements.

Deployment

The strategy to be followed for the construction of works, offers, in this situation, several possibilities and different alternatives. However, given the existence of different situations of foundation conditions, it was considered relevant describes them separately and sequentially order the installation process, used for the superstructure, incorporating removal of the current grid in metric clearance (rails and sleepers), the existing ballast regularization turning it into sub-ballast and construction of a new ballast of crushed stone and then installing a new grid with International clearance.

We need to properly sequence the constructive guidance to ensure the continuity and process linearity and establish that construction starts obligatorily on the Calçada Station and has continued and uninterrupted advance toward to Subúrbio Station. If you opt for a secondary Construction Site in Periperi Yard, or even in Paripe Yard, other fronts can be opened, evidently keeping the construction condition with directional linearity.

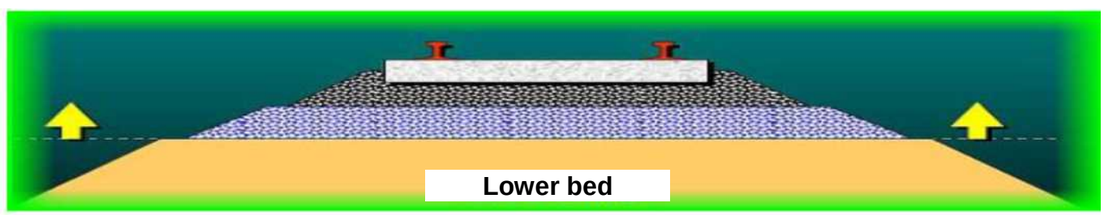
The sequential construction continues from Calçada, it was conditioned by the location of the Highway Median Strip in the inner area of this Station, where deposits of materials purchased for the execution of the works will be deposited, favoring the mobilization of construction, minimizing the movement of load vehicles on the surrounding road system.

Another reason for this directional orientation, also of great importance, is the ability to use the sections of built tracks for transportation of materials toward the fronts of services on the new seated rails. The relationship between mobility and transportation between the Construction Site - Work Fronts would always be made through railway, already built, minimizing the disruption to local traffic along the section under construction.

This strategic procedure would ensure that the construction sequence would only interfere with the road system in the evolution of the process, always leaving free the subsequent section, and with no changes to the development and movement of traffic.

If you choose, at the time of construction, for multiple work fronts, these should always be for contiguous sequential segments, thus avoiding works fragments randomly spread, creating difficulties to traffic and inconvenience to users.

Treatment and preparation of sub-ballast → the sequence of the installation of the Permanent Track, considering the use of ballast as sub-ballast, implies in complete regularization of the existing ballast material, properly compressed, forming a new geometric conformation of sub-ballast, considering the extension requested by the clearance change. Anyway, it should be added to regularized the surface of the sub-ballast, one layer of crushed stone for the purpose of sealing the separation between ballast and sub-ballast due to the existence of this thin layer.



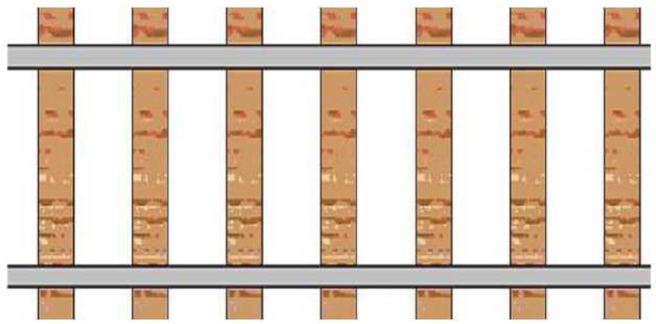
Installation Process of the Permanent Track → the installation process of the track, to compose the Permanent Track, can be done by starting up the operations of geometric markings for georeferencing the project axis.

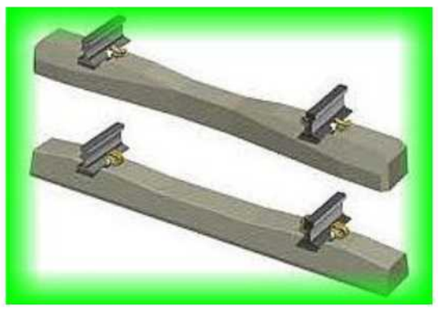
Then, it follows with the location of the reference vector of the Permanent Track, using total topographic stations from the analytical graph axes established in the design. At this moment, it will be located only the axes in its horizontal development in order to enable the positioning and mounting of alignment jigs and anchoring the rails.

Geometric marking operations for precision and conference of heights and alignment → After completed the preliminary mounting phase of the jigs, it will be made new topographical markings to enable the adjustments using the alignment reference frames of horizontal and vertical dimensional elements, arranged in the service notes to establish the radii of curvature, super elevation, super width, if necessary, and sequence of ramp points with the respective distributions of the super elevation. These adjustments marked in the reference frames are transmitted with the use of devices to establish the heights and distances of each rail in relation to the horizontal and vertical axis of the design.

Construction operations of the crushed stone ballast → After the regularization of the sub-ballast resulting from the use of the existing ballast, it is made the markings, adjusted to the final axis established on the occasion of preparation of the executive design for the implementation of ballast ensuring the geometric and structural requirements.

Grid positioning operations (sleepers and rails) → After concluded the markings, adjusted to the final axis established on the occasion of preparation of the executive design, it is made the conference of the ballast for installation of the grid involving sleepers spaced at set sleepering rate, considered in the sizing of the superstructure, ensuring the geometric conformation required, including super elevation, super width and dimensional requirements of the clearance. Mounting devices must ensure elasticity conditions.

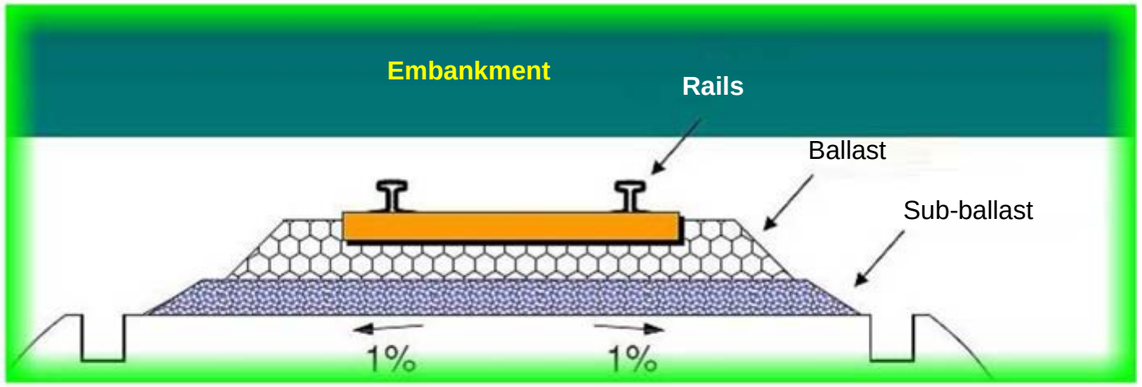


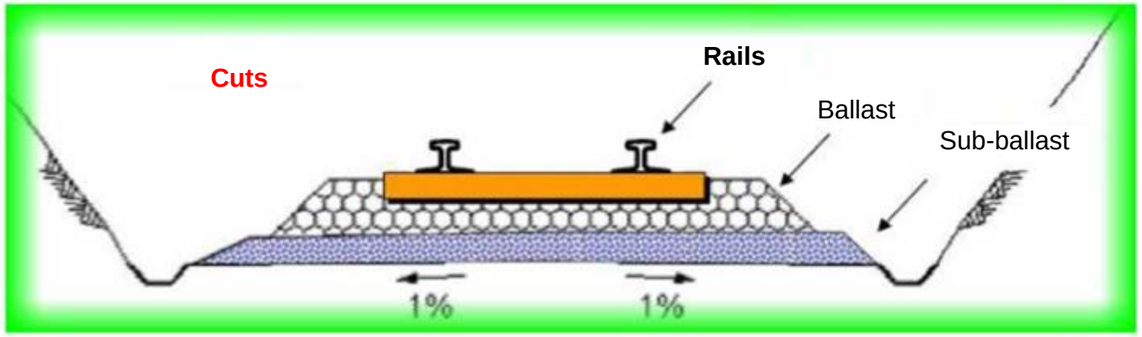


In the sections of straight segments, the welding of the rails will be made. The operation for rail cutting and welding, can be made at the construction site or even on the work site.

In curved sections, you need to bend the rails with the curvatures defined in geometric design. The bending of the rails, when necessary, will be made at the Central Workshop or in the Construction Site. In spaces of the tracks or at the sides, they put up all complementary elements such as ducts, grids, etc.

In the spaces between the rails or on the sides, all complementary elements such as ducts, grilles etc. are placed.

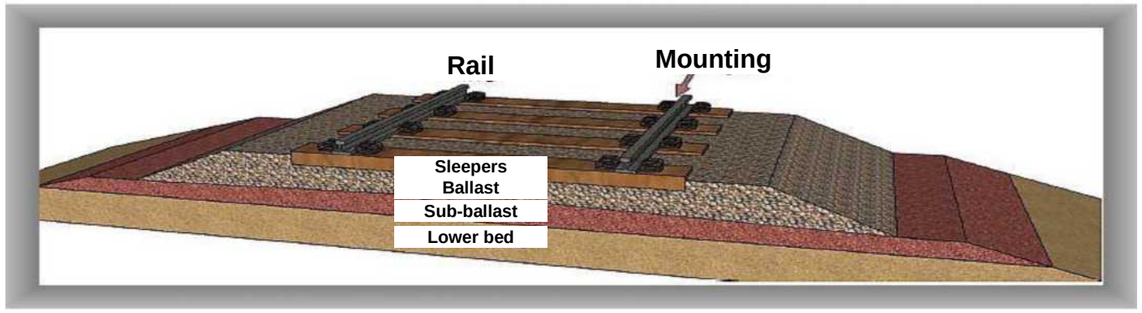


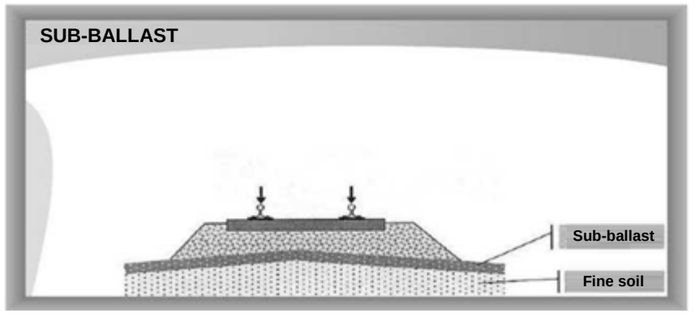


The section in question was and has being used for over 150 years. For implementation of the works, some assumptions have been established;

- ✓ The entire grid (rails and sleepers) will be removed due to the aging by long time use;
- ✓ The rails and sleepers on acceptable conditions will be used in by-passes, and parking lines of wagons;
- ✓ The existing ballast due to its high rate of contamination will be scarified and spread, forming a new platform of sub-ballast;
- ✓ Where there is a shortage of material for composing the minimum thickness established for the sub-ballast, it will be added additional volumes of crushed stone to complete the layer thickness;

Permanent Track → The Permanent Track, in this case will consist of the following elements: the existing sub-ballast to be geometrically and structurally regularized, graded crushed stone ballast, prestressed concrete sleepers and TR_45 rails.





Alignment and leveling marks –

Location and deployment of alignment and leveling marks

- **before you begin laying the railway superstructure, it must be made <u>location of the axis</u> of the track, called *location for rails*;**
- **After location of the axis, in which are implanted the <u>pickets</u>, it is made new leveling in the axis and designed the final grade of the rails;**
- **this study of final grade of the tracks will suppress any platform irregularity through small variation in the heights of ballast.**

- **the location of the axis is <u>transferred to the edge of the platform,</u> placing small pieces of rails with a lateral notch, which indicates the position of the bearing surface of the rails, thereby Including the height of the ballast, of the tie rod and rail;**
- **In the curves will be included, at the time indicated by the alignment and leveling reference marks, also the value of *super elevation* to be given to the outer rail.**

Regularization of Sub-ballast → The existing ballast is almost entirely contaminated, reason why it will be scarified and complemented with incorporation of crushed stone, if necessary the geometric conformation of the layer, forming a new platform needed to accommodate the dimensional elements of sub-ballast for international clearance.

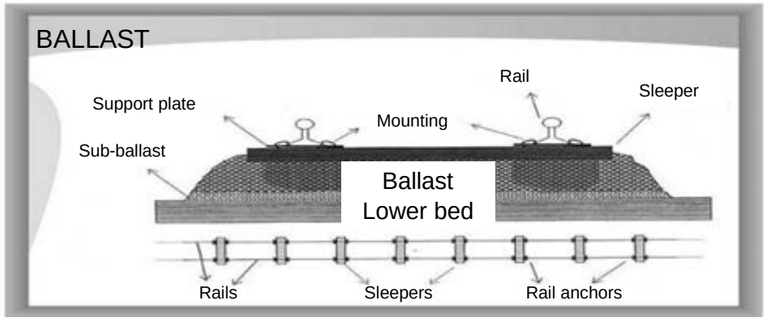
The material thus formed, geometrically in accordance with the alignment and leveling indications, will be compressed 100% of the Intermediate Proctor, noting the need for ensuring a CBR of at least 30%.

Implementation of Graded Crushed Stone Ballast → After settlement and compaction of sub-ballast structured in accordance with the geometric dimensional elements of the design, and after conference and acceptance of the final heights of the grade, the ballast construction operations will begin, during which the following instructions should be followed:

WORK IMPLEMENTATION

Modern process

- In this case, all material is transported using trucks along the railroad platform, including crushed stone for ballast;
- then the ballast is spread on a first layer that allows the leveling of the line, making it a primary compression thereof;
- following the sleepers and rails are laid on the same ballast layer, by performing the operations described in the previous process;
- after the beginning of the railway traffic, the ballast be can compacted, reaching the height specified in the design, and making the leveling, pulling and final finishing.



Grid Preparation - Settlement of Sleepers and Rails mounting → The final preparation operations of the grid, i.e. the settlement of sleepers and mounting the rails must follow a careful geometric control, including spacing of the sleepers obeying the minimum sleepering rate established in the design, mounting the rails in accordance with the geometry of the grade including super width and super elevation, the implementation of the clearance and incorporation of rails mounting devices including joints:

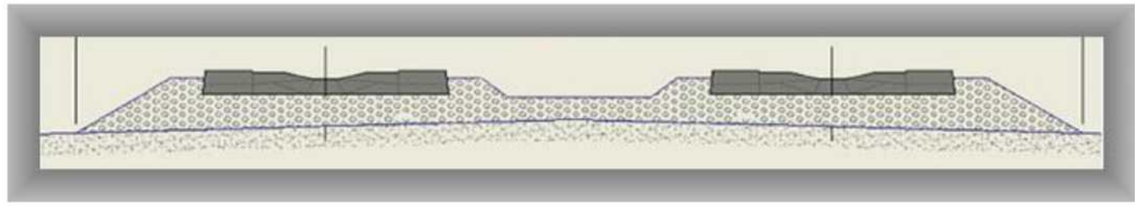
Settlement of Sleepers → The sleepers will be seated in accordance with the spacing established in design and obeying the following indications:

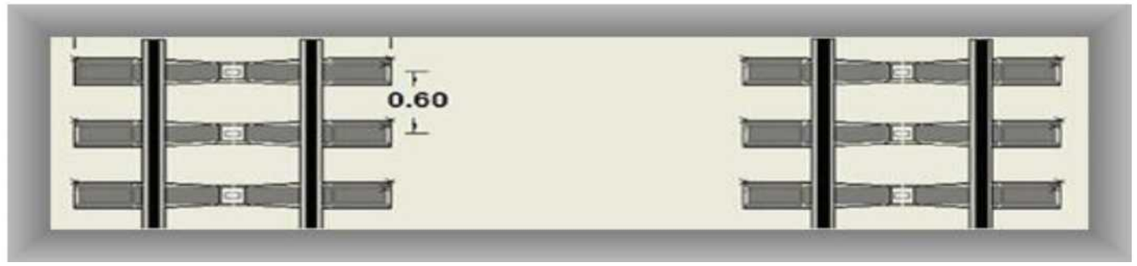
WORK IMPLEMENTATION

Distribution of the sleepers

- **the sleepers are placed perpendicularly to the rails, both in tangents and curves;**
- **the spacing between the sleepers depends on several factors, such as <u>loads of vehicles,</u> the <u>speed of the trains</u>, <u>traffic density,</u> <u>nature of the track platform</u> and <u>radius of curvature</u>:**
- **in Brazil, the sleepering rate varies from 1,400 to 1,800 sleepers/km and may reach 1,900 sleepers/km:**
- **In the joints of the rails, it is common put the sleepers closer to better support the joint. The neighboring sleepers of the joint should be gradually closer.**

The typical section of the Permanent Track will be →





The sleepers are placed perpendicularly to the rails, both in tangents and curves. The spacing between the sleepers depends on several factors, such as loads of vehicles, the speed of the trains, traffic density, nature of the track platform and radius of curvature. It is called sleepering density, the amount of sleepers placed per kilometer of the line.

American railroads and also in Brazil, where the trend is the formation of heavier trains, we use from 1,600 to 1,850 sleepers per kilometer. In the project was established sleepering rate of 1,667 sleepers/km, thus, a spacing of 60 cm between the axes thereof.

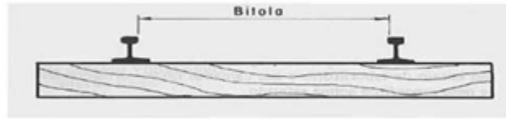
Settlement of the rails and clearance deployment → After settlement of the rails on sleepers, using elastic mounting accessories and appropriate joints, it is made a fine adjustment for deployment of the correct clearance.

Clearance

distance between the rails heads

The most used clearances

- Metric: 1.00 m (narrow)
- Large: 1.60 m (standard clearance)
- International: 1,435 m



The clearance defines the train-track geometric ratio

The implementation of the clearance resulting from settlement of the rails passes through the following indications, necessary to guarantee a geometrically grid according to the project settings, evidently subject to the standard tolerances. In the Project was used the International clearance:

- **The rails are seated with a small <u>slope to the vertical</u>, in order to monitor the rim slope of the vehicle wheels;**
- **In Brazil, this slope is generally 1:20 (5%);**
  This slope can be given directly in the sleeper or mounting plate.

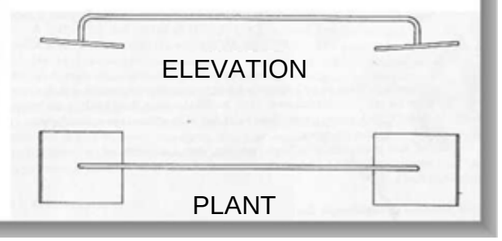
- **In straight alignment, it should be strictly used the clearance specified for the iron road;**
- **In curves, the clearance is slightly increased - *super width.***

TOLERANCE IN THE CLEARANCE

- **The passage of vehicles makes the track to develop defects that change the clearance that are *enlargements* and narrowing;**
- **The *enlargement* occurs due to loosening of the rail mounting or wear thereof;**
- **The *narrowing* occurs if the rail slope is increased for any reason;**
- **The tolerances allowed in the clearance range from -3 to +6 mm in straight alignments and +10 mm in the curves.**

WORK IMPLEMENTATION

Notching clearance (manual)



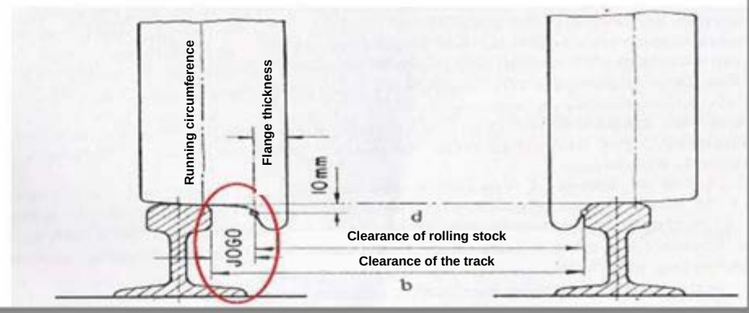
TRACK LOOSENESS

- **It is the difference between the track clearance (straight) and the distance between the outer faces of wheel flanges, measured 10 mm below the running plan:**

$$J = b - d$$

- **The track looseness, in straight alignment, is set between 9 and 15 mm;**
- **In curves, the total looseness is the sum of track looseness in straight alignment plus the *super width* used.**

TRACK LOOSENESS

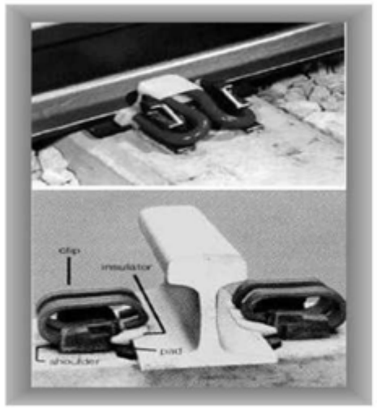


Tolerances in the clearance → With the passage of vehicles, it is noted that the track develops defects that change the clearance, giving rise to enlargements or narrowing of the clearance, especially the first.

The enlargement may be due to loosening of rail mounting or wear thereof. The narrowing of the track occurs, particularly, when the rail slope is increased for any reason.

The tolerances generally accepted in the clearance range from - 3 to + 6 mm in straight alignments (Tangents), reaching + 10 mm on curves

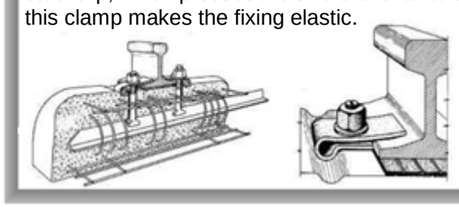
Equipment and mounting accessories → The mounting equipment must be elastic:

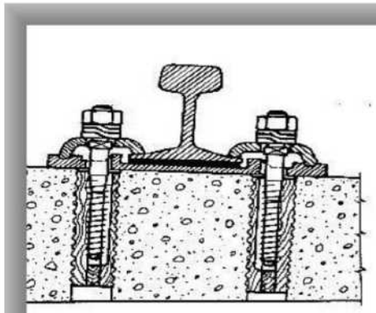


CONCRETE SLEEPERS

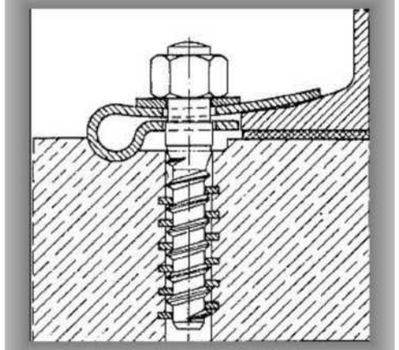
Construction details for fixing the rail

The fixing of the rail, since it not allowed to use screw fastened to the concrete is made by an anchored screw on the steel beam, inserted into holes left in the concrete block, and mild steel clip, which presses the skid of the rail and this clamp makes the fixing elastic.





Fixing using screw in concrete sleepers



Deployment of joints →

The relative position of joints, of each side of the two rows of the rail, can vary regardless they are located along the same normal to the rails or not.

When the joints on both sides, are about the same normal to the line, they are called concordant or parallel joints. Otherwise, they are called alternating joints.

In the case of adopting this provision, one should try to put the joints on one side, closest to the center of the rail on the opposite side.

Joints can also be classified as supported and cantilevered. In the first case, the ends of the rails are put on a sleeper, while, at the cantilevered joint are put two closer sleepers (joint sleepers), leaving, however, the ends of the rails cantilevered.

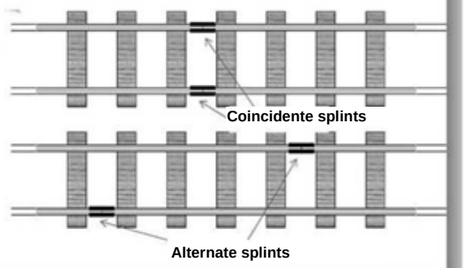
WORK IMPLEMENTATION

Joints

- the relative position of joints, of each side of the two rows of the rail, can vary regardless they are located along the same normal to the rails or not.
- when the joints on both sides, are about the same normal to the line, they are called concordant or parallel joints. Otherwise, they are called alternate joints*;*
- in the case of adopting ***alternate***, one should try to put the joints on one side, closest to the center of the rail on the opposite side;
- The parallel joints favor the so-called *galloping movement,* while alternate joints favor the *rocking motion.*
  For medium standard lines or lower, the practice indicated galloping movement as the most damaging **(+** *accidents)*

WORK IMPLEMENTATION

Joint



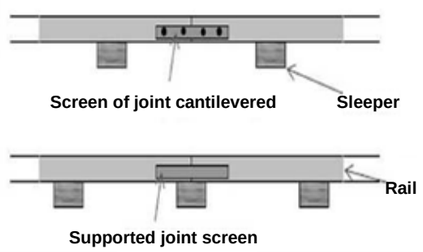
WORK IMPLEMENTATION

Joints

- **the joints can also be classified as *supported* and *cantilevered*;**
- **In the case of *supported* joints, the ends of the rails are on the same sleeper;**
- **in the joints *cantilevered*, we put two closest sleepers (joint sleepers), leaving the ends of the rails cantilevered.**

WORK IMPLEMENTATION

Joints



WORK IMPLEMENTATION

Joints

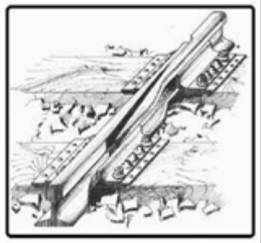
- in the ***supported* joints,** rails suffer a quick **kneading from the tips** due to the shocks of the wheels at the ends of the rails;
- when the wheel reaches the end of the track before the joint, in case it is supported, the deformation of this track is different from that which occurs at the end of the other rail, since there is a tendency of the sleeper under the joint undergo a rotation, increasing the settlement on one side. Therefore, it is formed a shoulder in the passage from one track to the next and so there is hammering in the latter;
- this phenomenon is cumulative and due to the *tipping* of the sleeper the situation worsens and the joint does not remain leveled;
- in the case of joint cantilevered, the deformation at both ends is almost the same, resulting in reduction of shock.

Execution of connections between rails →

CONNECTIONS

EXPANSION JOINTS

- Joint between two rails where one is a needle and the other a counter needle
- Supported on the same sleepers
- Forged in Z
- Higher cost



CONNECTIONS

WELDS

The use of long rails offers advantages of technical and economic order. The joints, as we know, are the weak points of the track, starting points of the most serious defects of the line and cause more accidents in traffic. Thus, the use of this type of rail brings economy of these materials together and reduces the track conservation costs.

Aluminothermy weld directly in the line

This is a process that involves a reaction of aluminum with the metal oxide, resulting in the metal involved and aluminum oxide, with release of heat. The process produces coalescence of metals by heating them.

For applications in welding, the filler metal is taken from the liquid metal formed in the chemical reaction.

Calçada - Santa Luzia

Section showing the current conditions of the permanent track.

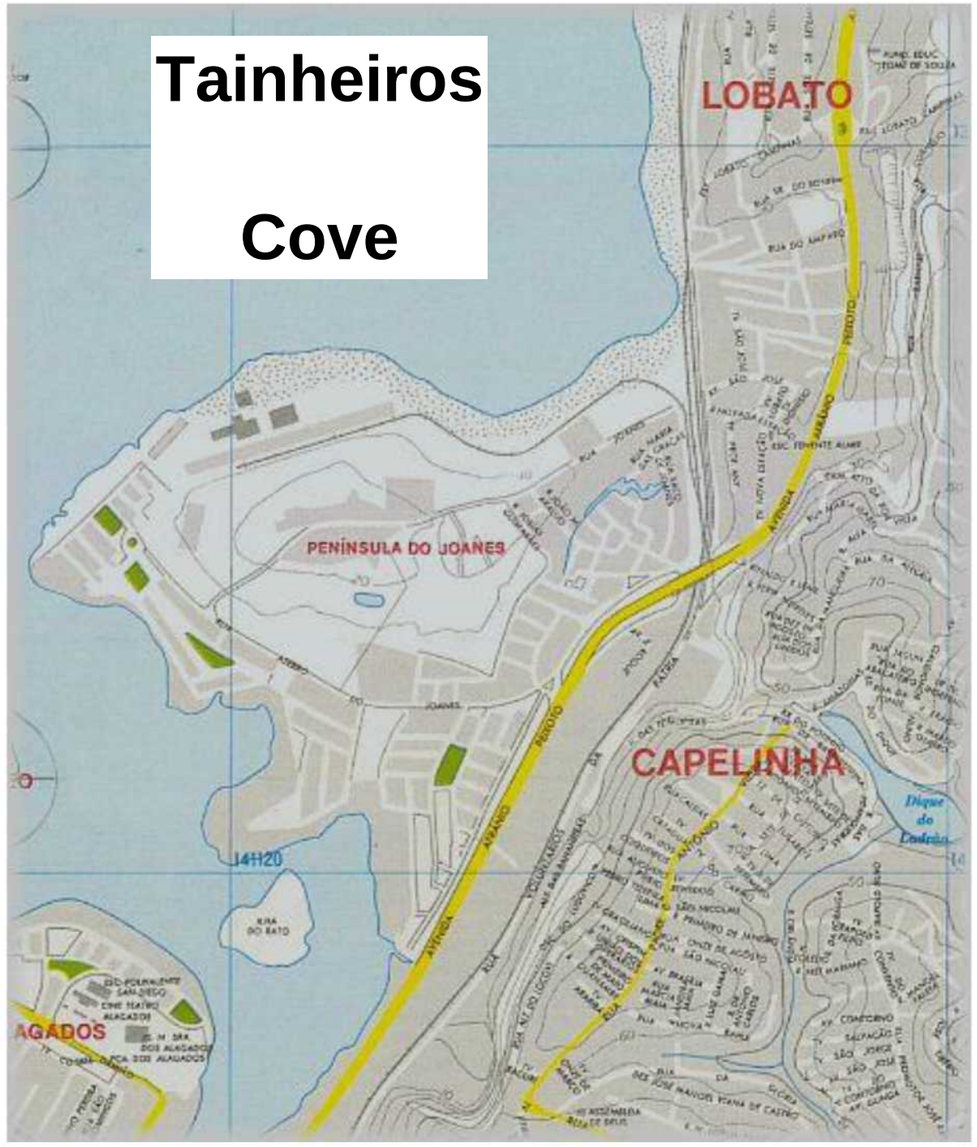
Section showing the current conditions of the permanent track.

Viaduct of the drivers over the railroad in the city of Baixa do Fiscal

Along Rua Voluntários da Pátria, the drainage ditches side are crumbling, completely silted and covered with vegetation.

In Santa Lucia there are only two lateral platforms bounded by segregation walls, one on each side.

Santa Luzia – Lobato



This Section begins just after Santa Luzia Stop showing the conditions of the permanent track, with dual-block concrete sleepers, side ditches blocked and covered by vegetation that need cleaning and structural recovery. Segregation walls are complemented by low fences already destroyed.

A clandestine level passage appears in the background, which needs assessment for decision on removal or maintenance duly signed and structured.

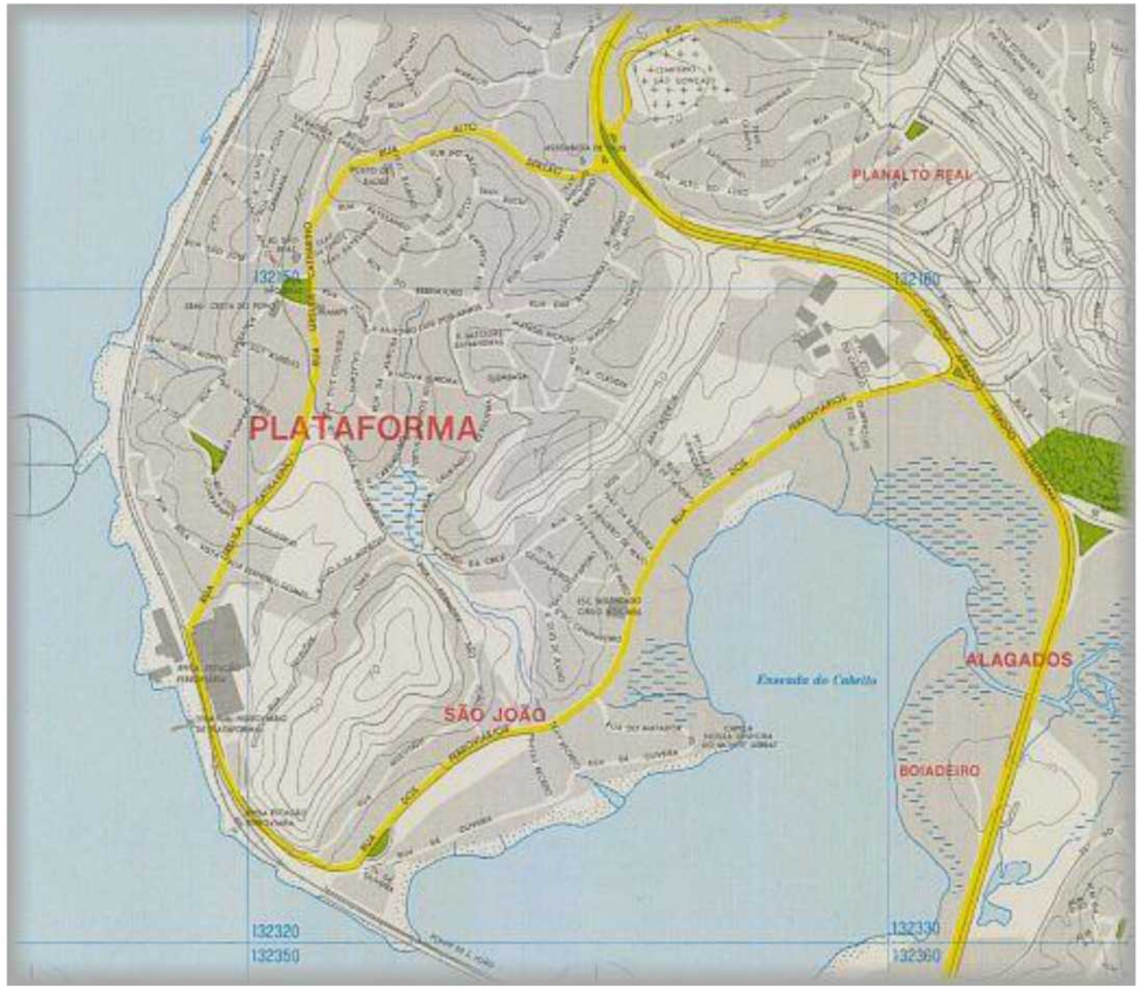
Near the city of São Brás, we can see the trenches conservation condition and a large amount of debris and garbage thrown on the drainage ditches.

The Project is providing for the implementation of a new stop because of demand growth under the Viaduct of Av. Suburbana.

The existing Lobato station will be re-qualified and suitable to the standard model of Stops

.

São João - Mocotó



In the city of São João, shortly after meeting North of São João's Bridge there is Almeida Brandão Station, which is intended to be decommissioned due to the proximity with the Nautical Integration Stop in Platform.

Even with decommissioning of Almeida Brandão Station, the existing catwalk should be maintained and conditioned to ensure accessibility standards established in the legislation. This catwalk will be used as crossing to the communities that inhabit the hill on the right side circling toward the sea. The state intends to allocate these facilities according to the local community facilities.

In the previous photos, one can see the Pier of the Nautical Platform Terminal, which should be integrated with a new stop to be located nearby, in front of the ancient ruins of the textile factory.

Facilities of the Nautical Integration Point

It is recommended in addition to the solution for the slip problem, the implementation of a deep drain all along the slope, and the total cleaning of channels and sewers, recovering those damaged and building new complementary draining devices

Note that the ditches at the foot of the retaining wall are completely damaged and clogged. Because of drainage problems, the ballast is quite contaminated with fine and partially damaged material.

These photos in the section between Plataforma Stop and São Braz Stop, there is a retaining wall along the entire section, which serves as contention for the original embankment of the Permanent Track platform. This slope with large and pronounced height, saturated in the rainy season, and then causes a hydraulic gradient due to water percolation in the embankment towards the sea.

Due to the expansive nature of the local soils in the presence of water (montmorillonites-black clay) occasionally occur landslides with significant proportions. There was a landslide slightly ahead, which led to the ban of one of the lines, reason why the designers indicated in this section the implementation of deep drains

São Brás - Itacaranha

In this section, the slope on the right disappears and even with the poor drainage conditions the ballast is more preserved. The ditches require cleaning and coating.

Escada Station will also be reconfigured as Standard Stop, and the existing facilities will be evaluated for operational use.

Escada station that appears in the picture, presents platforms with curved path, with some shelters on both sides and must be reconfigured to operate as Standard Stop.

The managing and billing facilities are at the end of the platform because of the space depletion. This situation will be reviewed to function as Standard Stop.

Due to the expansive nature of the local soils in the presence of water (montmorillonites-black clay) occasionally occur landslides with significant proportions. There was a landslide slightly ahead, which led to the ban of one of the lines, reason why the designers indicated in this section the implementation of deep drains.

Itacaranha – Escada

In this section, once again there is a steep slope on the right side, with the same problems mentioned above.

Escada station has two platforms one on each side, with simplified shelters, benches and a catwalk that needs to be adapted to the accessibility conditions required by the standards. The station needs to be requalified in order to fit the standard model presented.

Escada - Praia Grande

Once again there is the presence of pronounced slope, this time the retaining walls are tied-ups, which means they may prevent slipping of the black clay (montmorillonite in a state of decomposition due to the presence of water).

We insist once again on the cleaning of drains and ditches and the need to implement deep drains.

With the construction of Av. Suburbana, there was a staggering of the slope that favored the stability conditions of the permanent track platform with lower retainers and lower risks of slipping. However, it is necessary to clean and extend existing grade channels and ditches.

In this section the number of clandestine level passages is very large and with small intervals between them. It will be necessary to assess the situation, regularizing some of them, with proper signage and suppressing others.

Ballast contamination is very high throughout this section due to the existence of a marginal track and the proximity of the houses. Attempts for segregation with walls have had no effect, hey were demolished by human action. The ditches in these flat sections require special care.

Praia Grande - Periperi

In this land, next to Periperi Station, being standardized as Stop, it is intended to implement the accessibility devices required by the situation, such as parking lots, bike racks, etc.

In order to solve the pedestrian passage, catwalk was built, however, it has not been used.

In this section, where there are streets on both sides of the segregation, walls were completely destroyed, and the ballast contamination is absolute, and there are no more traces of crushed stone

There is level crossing used by vehicles without any protection of the rails. This situation is aggravated due to the proximity of the AMV devices.

Periperi Station is one of the most crowed in the Suburb, which implies in a deeper requalification. A complete Urbanization Design of this area is being studied.

Administrative facilities are in good condition requiring evaluation for use in Urbanization Design that is being developed in the area.

Periperi - Coutos

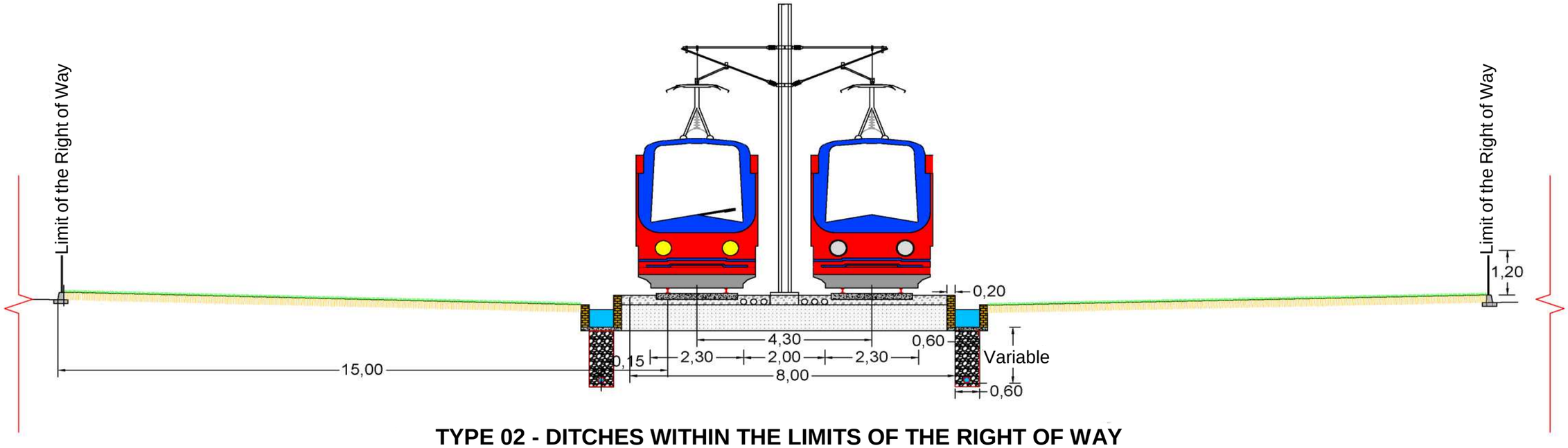
Exit of Periperi Station

View of the Tunnel - Periperi - Paripe.

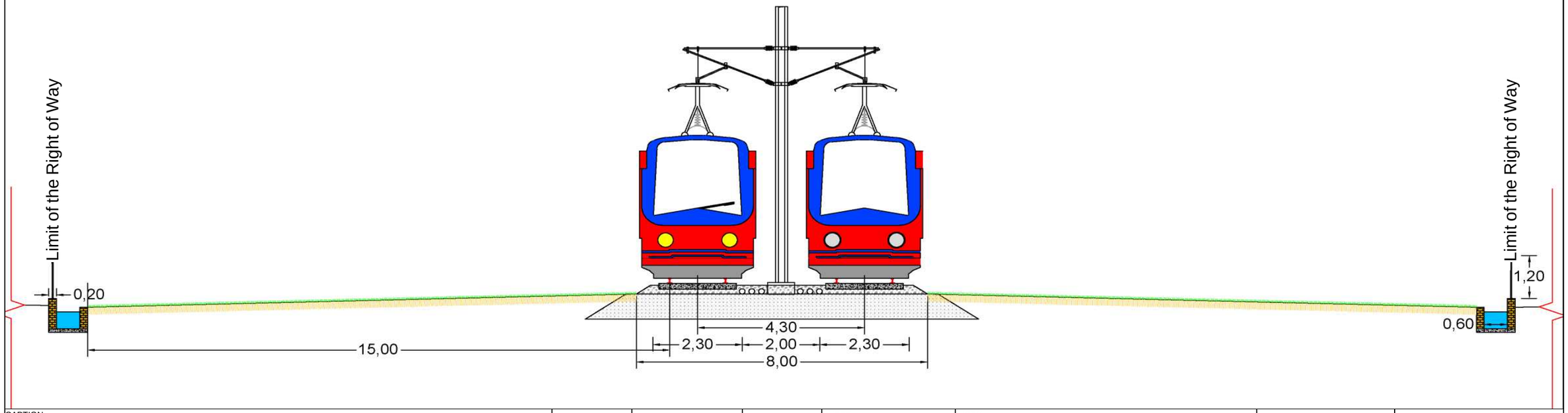
This will be the location of the future Setubal Stop. You can see the location of the existing Coutos station.

Coutos Station is in good condition but will require some adjustments and reconfiguration to work as Stop, especially in the accessibility item.

TYPE 01 - DITCHES WITHIN THE LIMITS OF THE PERMANENT TRACK

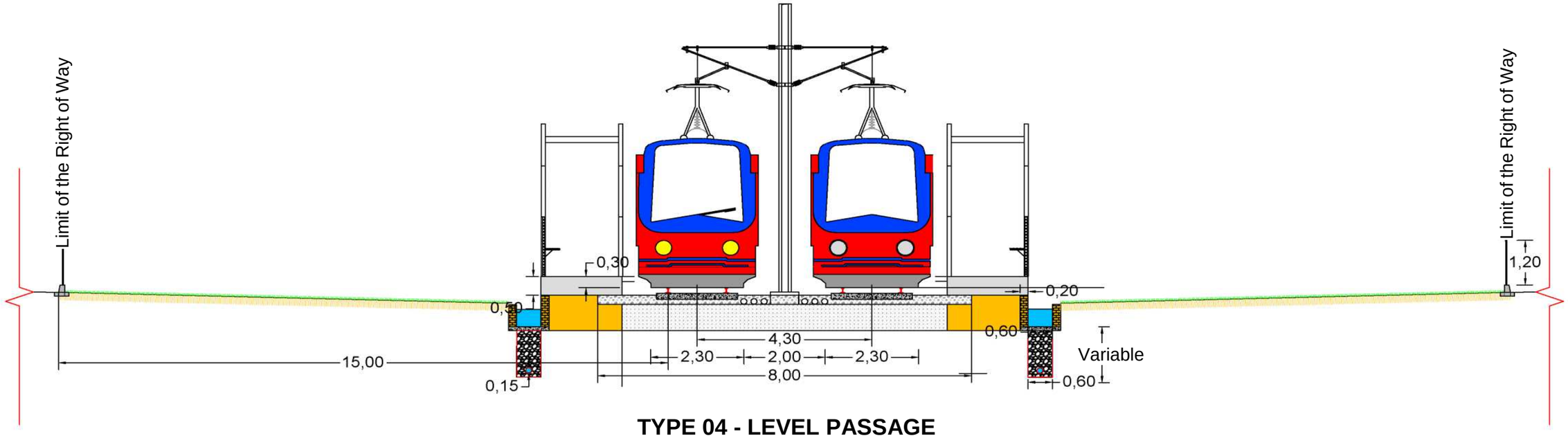


TYPE 02 - DITCHES WITHIN THE LIMITS OF THE RIGHT OF WAY

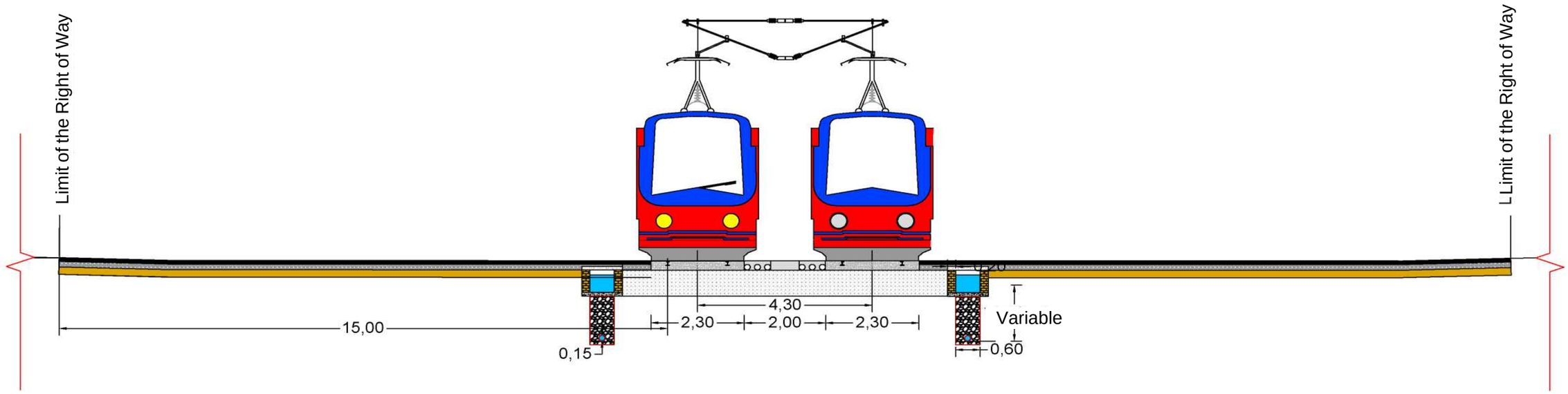


CAPTION				SHEET 01/02	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /			
	CHECKING		/ /	SCALE 1:100	MUNICIPALITY SALVADOR	
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT TRANSVERSAL SECTIONS TYPE	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				

TYPE 03 - STOP



TYPE 04 - LEVEL PASSAGE



CAPTION				SHEET 02/02	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT	BAHIA GOVERNO DO ESTADO / CJB
	DRAWING		/ /				
	CHECKING		/ /	SCALE 1:100	MUNICIPALITY SALVADOR		
	APPROVAL		/ /				
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT TRANSVERSAL SECTIONS TYPE	LIGHT-RAIL VEHICLE LRV	
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA					
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA					

Route geometrization

The geometrization presented below was performed only for reference to the design elements, since there is a track and is in operation.

Axis 02	Horizontal Agreement - LRV - Comércio São Luís - Section Calçada - Paripe																07/30/2015
Elements of Polygon					Elements of the Circular Curve												Distance
code	X(m)	Y(m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	Frac.	PT	PC/PT
2_0	554,371,5032	8,568,913,6761			2_0	176	0.00									
2_1	554,525,7208	8,569.079,8272	226.69	42°, 52' 00"	PCe	186	1.97	0º, 33' 59"	24.72	5,000.0000	49.44	0º, 00' 21"	188	11.41	PT	201.97
2_2	554,728,2703	8,569,302,4245	300.96	42°, 18' 01"	PCd	198	16.45	13º, 32'09"	71.20	600.0000	141.75	0º, 02' 52"	205	18.19	PT	205.04
2_3	554,991,8432	8,569,481,3068	318.54	55°, 50' 09"	PCe	211	5.04	26º, 21'24"	140.49	600.0000	276.01	0º, 02' 52"	225	1.05	PT	106.85
2_4	555,202,2654	8,569,853,5426	427.59	29°, 28' 45"	PCd	235	7.45	11º, 31'17"	80.71	800.0000	160.87	0º, 02' 09"	243	8.31	PT	206.40
2_5	555,451,7627	8,570,140,5507	380.29	41°, 00' 02"	PCe	250	3.55	15º, 35'50"	164.35	1,200.0000	326.66	0º, 01' 26"	266	10.22	PT	135.24
2_6	555,631,4595	8,570,518,9324	418.88	25°, 24' 12"	PCd	274	18.95	16º, 16' 35"	85.80	600.0000	170.45	0º, 02' 52"	283	9.40	PT	168.73
2_7	555,839,4136	8,570,752,5013	312.73	41°, 40' 47"	PCe	288	11.68	16º, 41'04"	124.64	850.0000	247.52	0º, 02' 01"	300	19.20	PT	102.29
2_8	555,986,0477	8.571,067,0264	347.03	24°, 59' 43"	PCd	308	3.15	14º, 53'42"	78.43	600.0000	155.98	0º, 02' 52"	315	19.14	PT	143.95
2_9	556,129,4604	8,571,238,6044	223.62	39°, 53' 25"	PCe	320	1.55	27º, 08' 56"	62.78	260.0000	123.20	0º, 06' 37"	326	4.74	PT	82.41
2_10	556,170,9215	8,571,421,9639	187.99	12°, 44' 29"	PCe	330	15.93	16º, 49'45"	34.02	230.0000	67.56	0º, 07' 28"	334	3.49	PT	91.19
2_11	556,145,2397	8,571.781,3139	360.27	355°, 54’ 44"	PCe	347	13.87	0º, 38' 24"	55.86	10,000.0000	111.72	0º, 00' 10"	353	5.59	PT	270.38
2_12	556,122,0025	8,572,062,2783	281.92	355°, 16' 20"	PCd	359	12.15	8º, 45' 14"	99.50	1,300.0000	198.62	0º, 00' 21"	369	10.77	PT	126.56
2_13	556,141,2073	8,572,335,1358	273.53	4°, 01'34"	PCd	371	5.46	36º, 42' 30"	139.34	420.0000	269.09	0º, 00' 21"	384	14.54	PT	34.69
2_14	556,500,3134	8,572,752,1277	550.31	40°, 44' 04"	PCe	387	10.35	101º, 32'05"	355.16	290.0000	513.91	0º, 00' 21"	413	4.26	PT	55.80
2_15	555,480,1939	8,573.322,2442	1,168.62	299°, 11' 59"	PCd	451	1.28	25º, 26' 38"	56.44	250.0000	111.02	0º, 00' 21"	456	12.30	PT	757.02
2_16	555,387,4566	8,573,452,9478	160.26	324°, 38' 36"	PCd	459	10.74	20º, 34' 33"	45.38	250.0000	89.78	0º, 00' 21"	464	0.52	PT	58.44
2_17	555,299,1601	8,573,787,5888	346.09	345°, 13' 09"	PCe	476	5.06	11º, 27' 21"	56.17	560.0000	111.97	0º, 00’ 21“	481	17.03	PT	244.54
2_18	555,158,3723	8,574.073,2452	318.47	333°, 45' 48",	PCd	485	10.21	49º, 31'24"	189.11	410.0000	354.38	0º, 00' 21"	503	4.59	PT	73.18

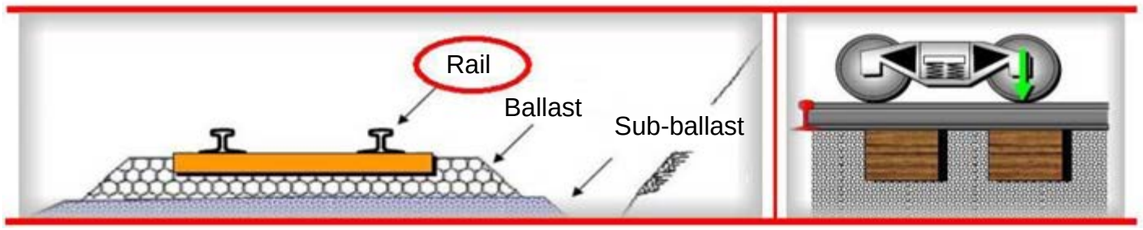
Axis 02		Horizontal Agreement - LRV - Comércio São Luís - Section Calçada - Paripe														07/30/2015
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y(m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC/PT
2_19	555,492,3840	8,574,849,3139	844.89	23°, 17' 12"	PCe	534	2,66	10º, 46' 27"	37.72	400.0000	75.22	0º, 00' 21"	537	17.87	PT	618.06
2_20	555,518,2111	8,574,965,6946	119.21	12°, 30' 44"	PCd	538	4,28	21º, 15' 43"	75.08	400.0000	148.44	0º, 00‘ 21"	545	12.72	PT	6.41
2_21	555,564,6043	8,575,035,0635	83.45	33º, 46' 27"	PCd	545	13.03	2º, 12’ 02"	8.07	420.0000	16.13	0º, 00' 21"	546	9.16	PT	0.30
2_22	555,662,2474	8,575,169,5824	166.22	35°, 58' 29"	PCe	553	18.64	3º, 00' 39"	8.67	330.0000	17.34	0º, 00' 21"	554	15.98	PT	149.48
2_23	555,750,0638	8,575,304,9939	161.39	32º, 57' 50"	PCe	557	2.52	29º, 02' 14"	106.18	410.0000	207.79	0º, 00' 21"	567	10.31	PT	46.55
2_24	555,761,7449	8,575.475,1677	170.57	3º, 55' 36"	PCe	568	18.81	1º, 22' 17"	35.90	3,000.0000	71.80	0º, 00' 21"	572	10.61	PT	28.50
2_25	555,770,0840	8,575.662,0160	187.03	2º, 33' 20"	PCd	572	11.58	48º, 56' 05"	150.16	330.0000	281.84	0º, 00‘ 21"	586	13.42	PT	0.97
2_26	556.014,9827	8,575,856,8858	312.97	51º, 29' 25"	PCe	592	6.90	19º, 18' 21"	49.33	290.0000	97.71	0º, 00' 21"	597	4.62	PT	113.48
2_27	556,144,3500	8,576.062,4412	242.88	32º, 11' 04"	PCd	600	6.43	44º, 45' 13"	131.74	320.0000	249.95	0º, 00' 21"	612	16.38	PT	61.81
2_28	556,574,9811	8,576,162,3496	442.07	76º, 56' 18"	PCe	614	13.67	69º, 59' 28"	273.04	390.0000	476.41	0º, 00' 21"	638	10.08	PT	37.29
2_29	556,715,4563	8,577.315,2070	1,161.38	6º, 56' 50"	PCe	681	16.79	6º, 07' 07"	21.65	405,0000	43.25	0º, 00' 21"	684	0.04	PT	866.70
2_30	556,719,5748	8,577,600,0023	284.83	0º, 00' 00"	PCe	694	9.44	13º, 37'48"	53.78	450.0000	107.05	0º, 00' 21"	699	16.49	PT	209.40
2_31	556.656,7926	8,577,876,3081	283.35	347º, 11' 55"	PCe	709	16.01	5º, 43' 59"	30.04	600.0000	60.04	0º, 00' 21"	712	16.05	PT	199.53
2_32	556,493,9853	8,578,361,9174	512.17	341º, 27' 56"	PCd	723	13.74	63º, 46' 50"	264.44	425,0000	473.10	0º, 00' 21”	747	6.84	PT	217.69
2_33	556,802,9844	8,578,668,2741	435.13	45º, 14' 46"	PCe	752	6.02	20º, 16' 18"	71.51	400.0000	141.52	0º, 00' 21"	759	7.54	PT	99.18
2_34	556.963,0191	8,579.011,8700	379.04	24º, 58' 28"	PCe	769	1.87	23º, 15' 37"	113.20	550.0000	223.28	0º, 00' 21"	780	5.15	PT	194.33
2_35	556,972,2510	8,579,320,3503	308.62	1º, 42' 51"	PCd	784	11.09	29º, 54' 03"	109.48	410.0000	213.97	0º, 00' 21"	795	5.06	PT	85.94
2_36	557,147,9520	8,579,605,7795	335.17	31º, 36' 54"	PCe	804	16.53	4º, 53' 58"	34.23	800.0000	68.41	0º, 00' 21"	808	4.94	PT	191.47
2_37	557.297,1618	8,579,902,2487	331.90	26º, 42' 56"	PCd	819	1.93	16º, 41' 29"	80.68	550.0000	160.23	0º, 00' 21"	827	2.15	PT	216.99
2_38	557,584,7669	8,580,206,3081	418.53	43º, 24' 25"	2_38	844	0.00									337.85

Grade Parameters of Axis _ 2

Axis		Operating Speed				Design Speed	Visibility distance		Vertical Radius Convex		Vertical Radius Concave		
2		62				70	110		2,910		2,375		
P	C	V	**slope**	**distance**	**Y**	**PIV**			**E**	**Rv**	P	T	V
stake	**fraction**	**height**	**%**	**PCV/PTV**	**m**	**stake**	**fraction**	**height**	**m**	**m**	**stake**	**fraction**	**height**
						176	00.00	3,309					
192	10.00	3.309	0.00	330.00	180.00	197	00.00	3,309	0.018	223,389	201	10.00	3,382
244	10.00	4.074	0.08	860.00	180.00	249	00.00	4,147	-0.029	-139,842	253	10.00	4,104
267	00.00	3.974	-0.05	270.00	1,000.00	292	00.00	3,733	0.168	744,002	317	00.00	4,164
321	00.00	4.233	0.09	80.00	180.00	325	10.00	4,311	-0.085	-47,728	330	00.00	4,049
330	00.00	4.049	-0.29	0.00	280.00	337	00.00	3,642	0.098	100,314	344	00.00	3,626
407	00.00	3.478	-0.01	1,260.00	180.00	411	10.00	3,467	0.003	1,532,571	416	00.00	3,467
440	00.00	3.467	0.00	480.00	180.00	444	10.00	3,467	0.004	980,769	449	00.00	3,484
482	10.00	3.606	0.02	670.00	180.00	487	00.00	3,623	0.172	23,566	491	10.00	4,327
508	00.00	6.908	0.78	330.00	180.00	512	10.00	7,612	-0.169	-23,946	517	00.00	7,639
529	00.00	7.713	0.03	240.00	180.00	533	10.00	7,740	-0.119	-33,962	538	00.00	7,290
550	00.00	6.092	-0.50	240.00	180.00	554	10.00	5,642	0.107	37,718	559	00.00	5,622
617	10.00	5.361	-0.02	1,170.00	180.00	622	00.00	5,341	-0.080	-50,675	626	10.00	5,001
645	10.00	3.567	-0.38	380.00	180.00	650	00.00	3,227	0.080	50,487	654	10.00	3,208
748	00.00	2.816	-0.02	1,870.00	180.00	752	10.00	2,797	0.071	57,205	757	00.00	3,061
786	00.00	4.765	0.29	580.00	180.00	790	10.00	5,029	-0.071	-57,155	795	00.00	5,010
802	00.00	4.980	-0.02	140.00	180.00	806	10.00	4,961	-0.045	-89,426	811	00.00	4,761
			-0.22			844		3,292					

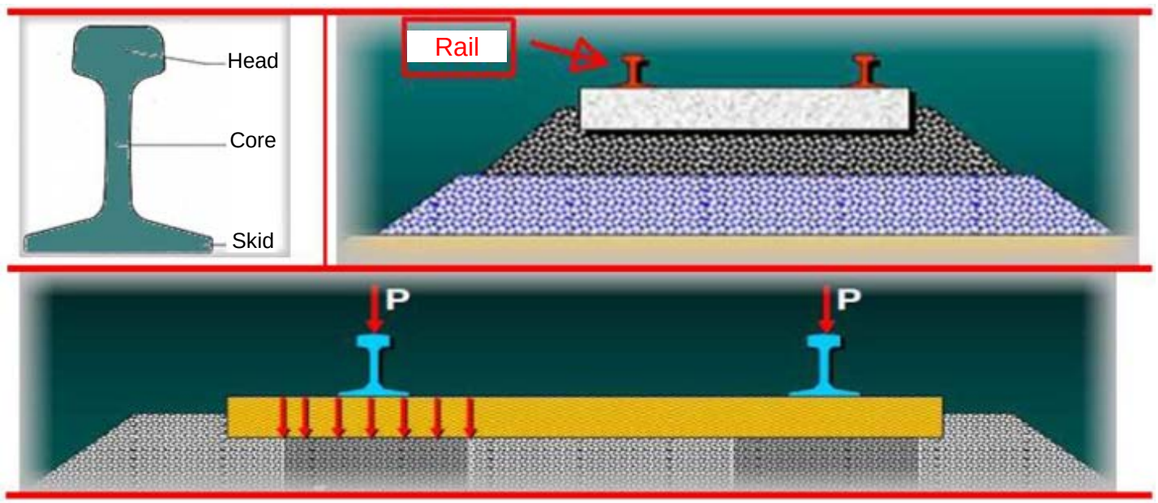
Rails

The Rail is the element of the superstructure that forms the bearing surface for the wheels of railway vehicles, at the same time, working as support and guide. They are settled beams on deformable supports receiving loads of trains and transmit it to the ballast and are the elements that determine the trajectory of the vehicles in their displacement.



The rails have undergone great evolution throughout the history of rail transport, in view of the development of steel technology. The shape and length of the pieces have evolved, gradually, until they reach the modern sections and weights per meter, supporting large loads through shafts, of modern trains.

The evolutionary process with respect to geometry related to the structural components of resistance to efforts and wear, in addition to difficulties in fixing this profile led to the current profile, designed by the English engineer Vignole (1836), which basically consisted of three parts: head, core and skid. This type, which features a profile in I, containing on top a head intended for contact with the wheels and receipt the cargo, a resistant structural element - the Core and the Skid for the support, fixation and final distribution surface of the load to the sleepers.

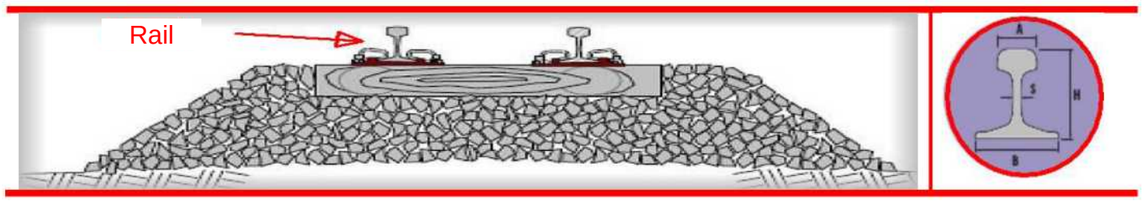


Selecting the rails

Among the various market alternatives, we tried to select the rail that could produce weight per meter compatible with loads distributed by the design vehicle, in this case, the LRV.

The existing rails in the railway section in operation are the TR_45 type, fact that conditioned in part the choice.

	Weight		Head "A"		Height "H"		Skid "B"		Core "S"	
	kg/m	lb/yda	mm	in/pulg.	mm	in/pulg.	mm	in/pulg.	mm	in/pulg.
141RE (TR70)	69.79	140.70	77.79	3 1/16	188.91	7 7/16	152.40	6	17.46	11/16
136RE (TR68)	67.41	135.88	74.61	2 15/16	185.74	7 5/16	152.40	6	17.46	11/16
133RE	66.10	133.25	76.20	3	179.39	7 1/16	152.40	6	17.46	11/16
132RE	65.31	131.66	76.20	3	180.98	7 1/8	152.40	6	16.67	21/32
CB122	60.77	122.50	74.61	2 15/16	177.74	6 25/32	152.40	6	16.67	21/32
119RE	58.87	118.67	67.47	2 21/32	173.04	6 13/16	139.70	51/2	15.88	5/8
115RE (TR57)	56.90	114.69	69.06	2 73/32	168.28	6 5/8	139.70	5 1/2	15.88	5/8
100RE (TR50)	50.35	101.50	69.26	2 11/16	152.40	6	136.53	5 3/8	14.29	9/16
100ARA-B	49.88	100.56	67.47	2 71/32	143.27	5 41/64	130.57	5 9/64	1429	9/16
100ARA-A	49.80	100.39	69.85	2 3/4	152.40	6	139.70	5 1/2	14.29	9/16
90ARA-A (TR45)	44.65	90 00	65.09	2 9/16	142.88	5 5/8	130.18	5 1/8	14.29	9/16



Rail Weight Calculation

If we use the Zimmermann Formula for preliminary sizing of the rail weight to be used, from the following values, we would have:

- ✓ $P_{max} \rightarrow$ 5 tons per wheel - LRV;
- ✓ D $\rightarrow$ spacing between sleepers - 60 cm considering a sleepering rate of 1,667 sleepers/km;
- ✓ $K_v \rightarrow$ coefficient due to speed - 15
- ✓ $p_t \rightarrow 2 * 5 * 60 / 15 \rightarrow 40$ kg/m

The TR_45 Rail according to the table before presented a weight per meter of 44.65 kg/m

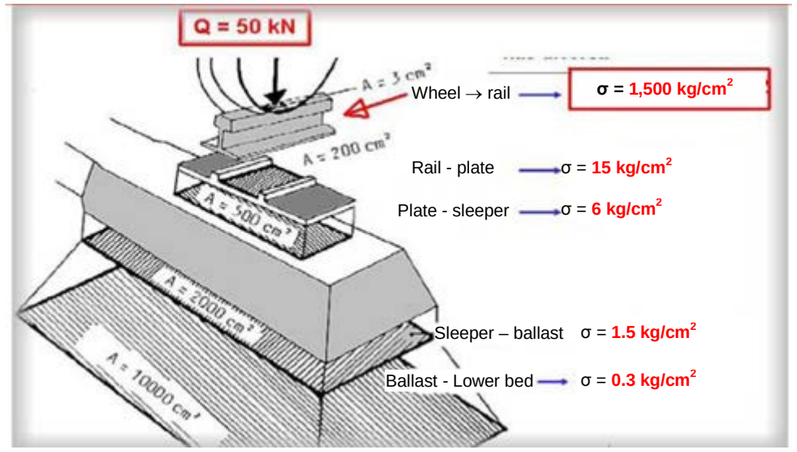
- Zimmermann Formula:

$$p_t = \frac{2 P_{max}\, d}{K_v}$$

Where:

P_{max} = maximum shear effort on the rail (in tf)
d = spacing between the sleepers (in cm)
K_v = coefficient due to speed:
K_v = 13 to 15 for high speeds
K_v = 15 to 17 for low speeds

Distribution of Tensions → Wheel → Rail



The cargo distribution, considering the structural segmentation of the railway superstructure, follows the order Wheel → Rail → Plate → Sleeper → Ballast → Sub-Ballast → Lower Bed, resulting in each level, tensions arising from the following order of magnitude:

Geometric and structural characteristics of the rails

Characteristics			Types of rails						
			TR-25	TR-32	TR-37	TR-45	TR-50	TR-57	TR-68
Calculated area of the section (cm^2)	Head	Area	13.23	17.16	19.87	20.58	24.51	25.51	31.35
		% of total	42.0	42.0	42.0	36.2	38.2	34.8	36.4
	Core	Area	6.58	8.58	9.94	13.68	14.52	19.68	23.35
		% of total	21.0	21.0	21.0	24.0	22.6	27.1	27.1
	Skid	Area	11.61	15.10	17.48	22.64	25.16	27.68	31.42
		% of total	37.0	37.0	37.0	39.8	39.2	38.1	36.5
	Total area		31 42	40.84	47.29	56.90	64.19	72.58	86.12
Momentum (cm^4)			413.7	703.4	951.5	1,610.8	2,039.5	2,730.5	3,950.0
Resistance module (cm^3)		Head	81.6	120.8	149.1	205.6	247.4	295.0	391.6
		Skid	86.7	129.5	162.9	249.7	291.7	360.7	463.8
Pivot radius (cm)			3.63	4.15	4.49	5.32	5.63	6.13	7.11
Resistance module ratio to the area of the rail (cm)			2.60	2.95	3.15	3.63	3.86	4.06	4.55

Sleepers

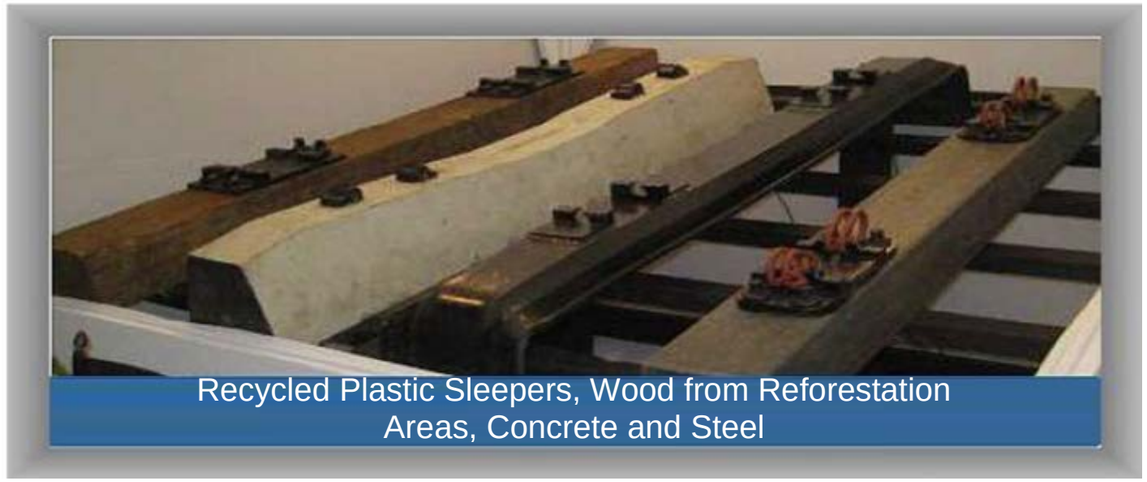
Sleeper is the element of the railway superstructure, which should receive and transmit to the ballast efforts produced by the loads of the vehicles, working as rails support, allowing its fixing and maintaining unchanged the distance between them (clearance). In order to accomplish these purposes, it is necessary:

- ✓ Their dimensions, length and width, providing sufficient support surface for the work rate in the ballast does not exceed a certain limit;
- ✓ Their thickness gives to it the necessary rigidity, however, allowing some elasticity;
- ✓ They have sufficient resistance to efforts;
- ✓ They are durable;
- ✓ They allow with relative ease, leveling the ballast (tamping) at its base;
- ✓ Effectively counters the longitudinal and transverse displacements of the track;
- ✓ They allow good attachment of the rail, i.e., a firm hold without being excessively rigid.

FUNCTIONS

Sleeper is the element of the railway superstructure, which should receive and transmit to the ballast efforts produced by the loads of the vehicles, working as rails support, allowing its fixing and maintaining unchanged the distance between them (clearance).

Types of sleeper - They are made of wood, steel, concrete and plastic.



Wood Sleepers - They gather almost all the qualities required for the sleeper and remains, to date, the main type of sleeper and can last more than 30 years on the line. However, their scarcity and poor reforestation have been resulting in their increasing appreciation.

The railways establish specifications to be followed in sleepers' acquisitions, fixing qualities, dimensions, tolerance, etc.

For a clearance of 1,435 m, the dimensions of the sleepers are → 2.20 m x 0.25 m x 0.15 m

There are also sleepers with special dimensions, for use on bridges and turnout - AMV.

Some factors influence the sleeper durability, such as climate; track drainage; weight and speed of trains; fixing type used for the rail; ballast type; mounting plate type of the rail in the sleeper; etc.

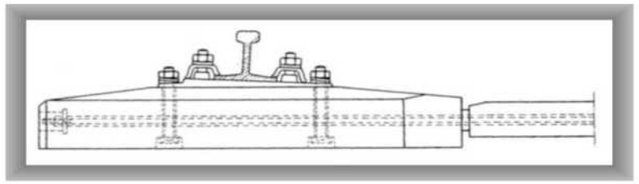
The choice of the sleeper is also subject to the following factors:

- ✓ Resistance to mechanical destruction caused by the movement of the trains;
- ✓ More or less ease to obtain it;
- ✓ Economical reasons.

Concrete Sleepers → They arose from the lack of good timber for sleepers and disadvantages of the steel sleepers pointed out.

Sleepers of Prestressed Concrete → The are capable of withstanding strong impacts, as they have in their design, the lower face elevated at the central part and a reinforced prestressing.

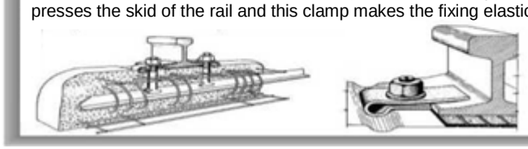
Fixation of rails on concrete sleepers → One of the key factors for the success of a concrete sleeper is fixing the rail to it. This fixation may not be rigid in order not to destroy the concrete at their contact points. In modern fixing types, one uses a plate, fixed to the sleeper through screws or tirefonds. In the latter case, the concrete is allowed to a metal frame, in which the tirefond is screwed. The fixing of the rail on the plate is made through clamp and nut, interposing a washer between these two latter elements.

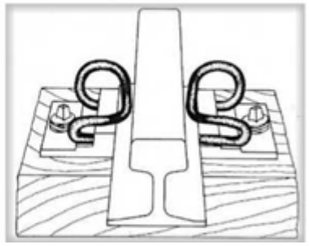


CONCRETE SLEEPERS

Construction details for fixing the rail

The fixing of the rail, since it is not allowed to use screw fastened to the concrete is made by an anchored screw on the steel beam, inserted into holes left in the concrete block, and mild steel clip, which presses the skid of the rail and this clamp makes the fixing elastic.





The following are the main advantages of the concrete sleeper: greater stability, it provides to the track, ballast economy, poor sensitivity to weathering and greater durability.

With respect to the weight, however, it is a favorable factor, since it increases the transversal resistance of the track, which is highly desirable to line with long welded rails. It can only be used in high standard lines, which rarely provides a derailment, as it disables the sleeper due to the impact of the wheels, especially in the case of mixed sleeper.

CONCRETE SLEEPERS

Types:

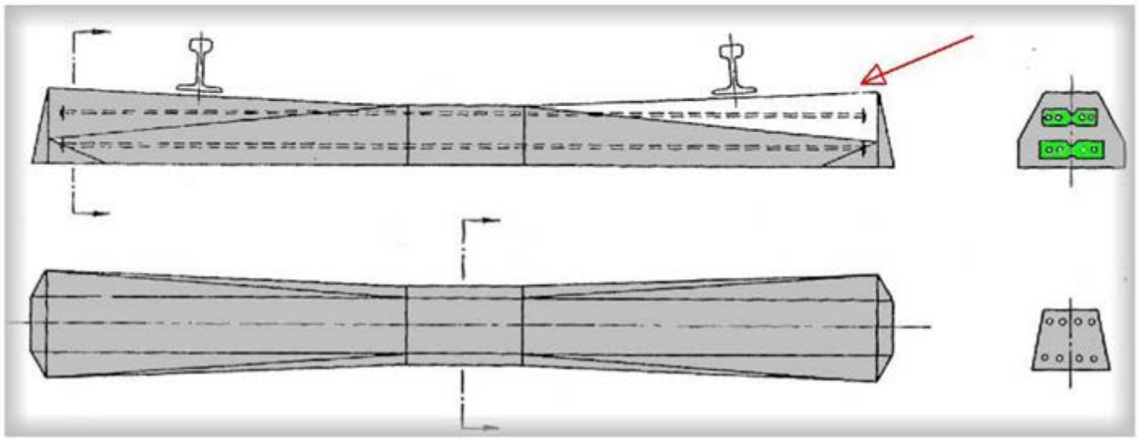
- prestressed;
- mixed;
- poly-block.

The concrete and steel used meet the current specifications for these materials and manufacturing, curing and handling of the parts are the same as concrete artifacts in general.

NBR 11.709 - This standard establishes the conditions required for concrete sleepers for railways

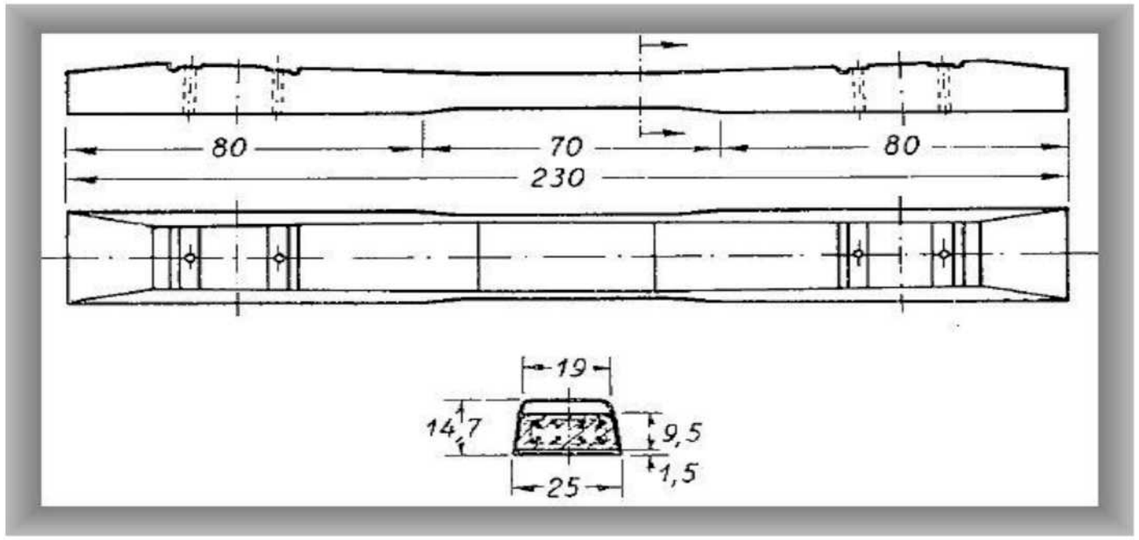
Advantages of the concrete sleepers

- they provide to the line greater weight, favorable factor in its resistance and stability;
- they offer greater resistance to warpage (buckling) of the track;
- they may effectively maintain the line clearance;
- they are poor conductors of electricity and can be easily isolated from the rails;
- they are not flammable and are not subject to destruction by fungi, insects, and corrosion;
- they have long useful life;
- they do not deteriorate when stored and require less area;
- in countries using local resources, they can be manufactured in large quantities.

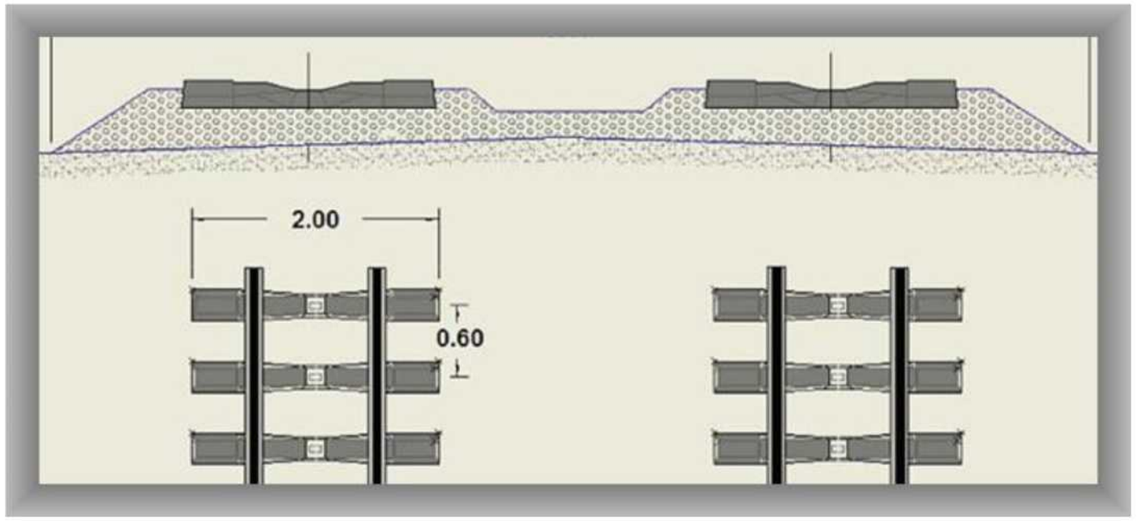


CHARACTERISTICS

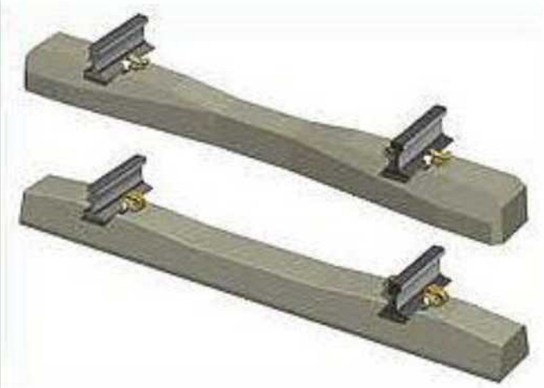
- **their dimensions, length and width, providing sufficient support surface for the work rate in the ballast does not exceed a certain limit;**
- **their thickness gives to it the necessary rigidity, however, allowing some elasticity;**
- **it has sufficient resistance to efforts;**
- **it has durability;**
- **they allow with relative ease, leveling the ballast (tamping) at its base;**
- **effectively counters the longitudinal and transversal displacements of the track;**
- **it allows a firm attachment of the rail without being overly rigid.**



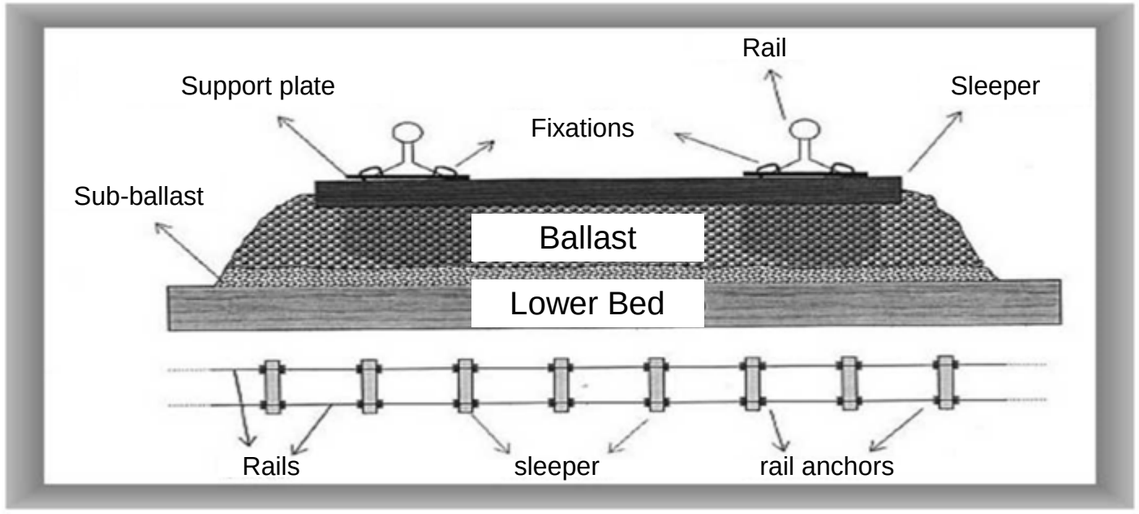
The width of the sleeper, mentioned above as 2.30 m can vary this value up to 2.20 m due to the used clearance.

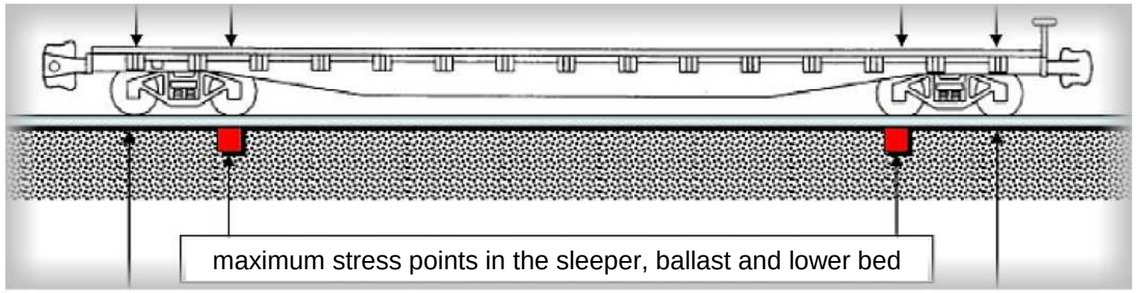


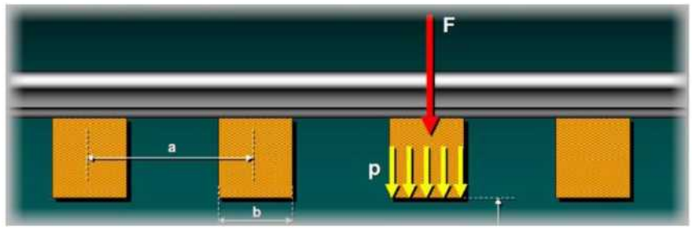
The width of the sleeper, mentioned above as 2.00 m can vary this value up to 2.20 m due to the used clearance.

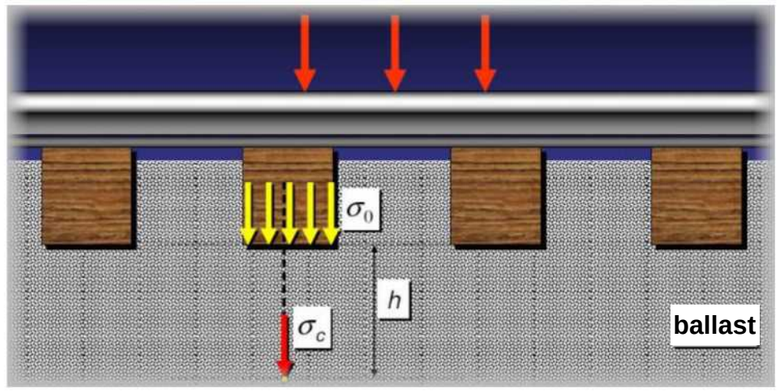


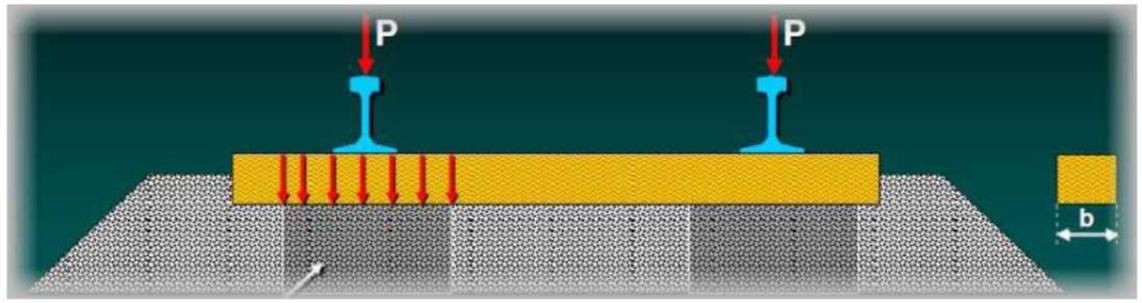
Sleeper Type	Wood	Concrete	Steel	Plastic
Sleeper No. / KM	1,833	1,667	1,833	1,833

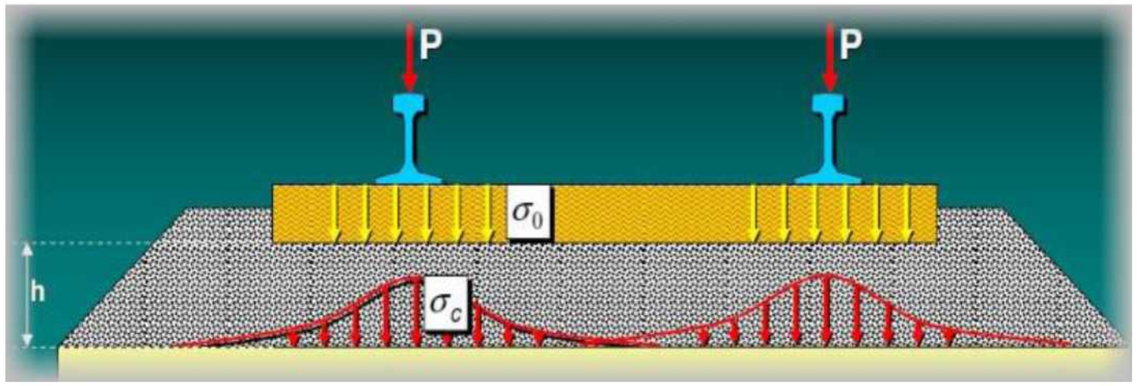


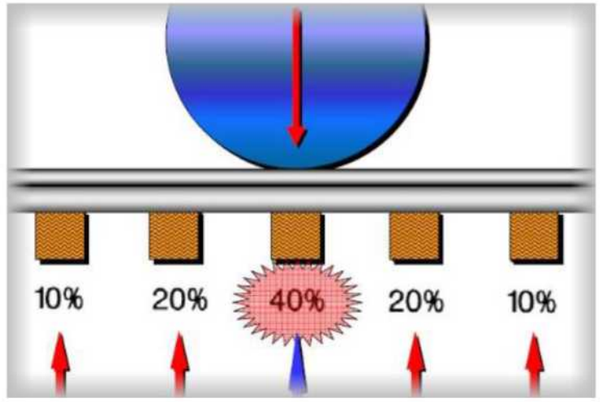

maximum stress points in the sleeper, ballast and lower bed

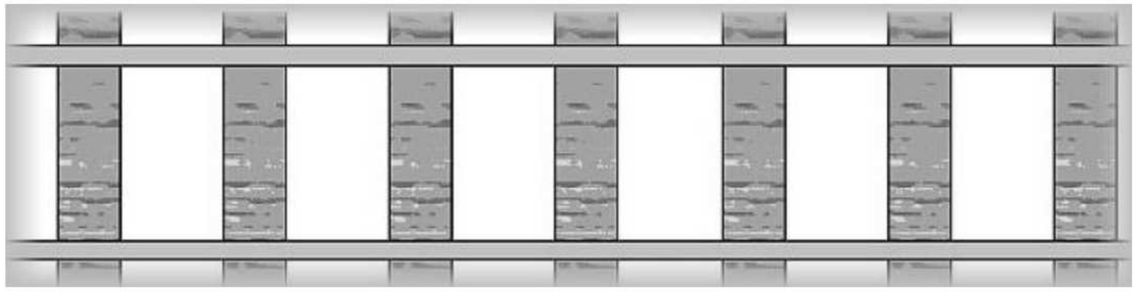

F
a
p
b

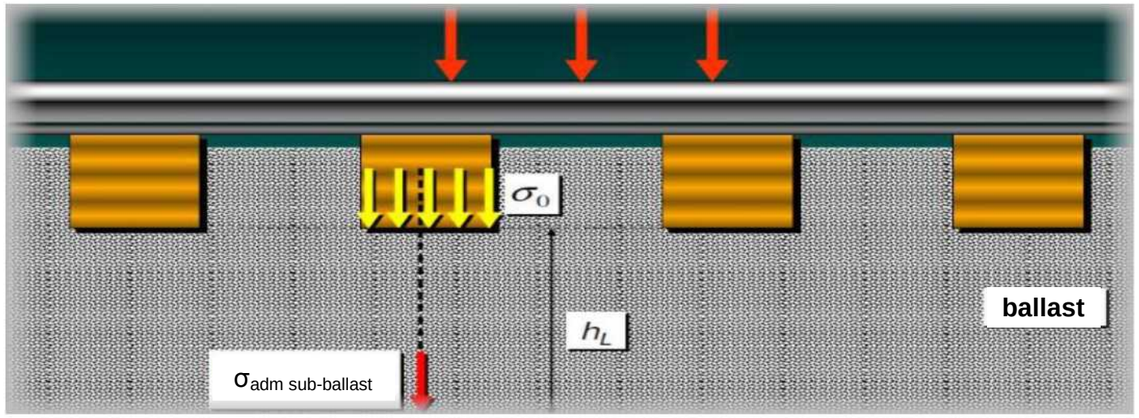

σ_0
σ_c
h
ballast

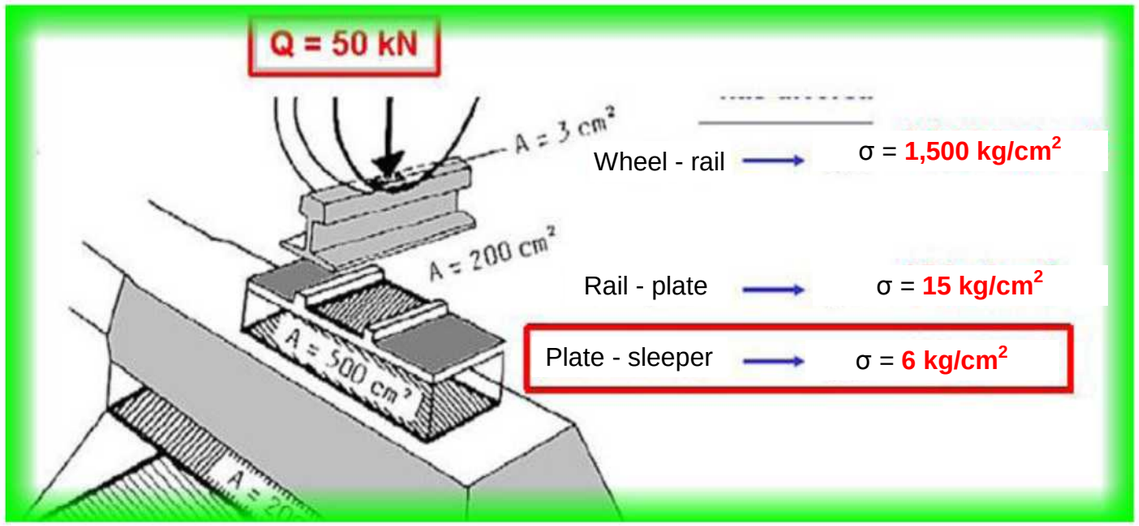

P
P
b

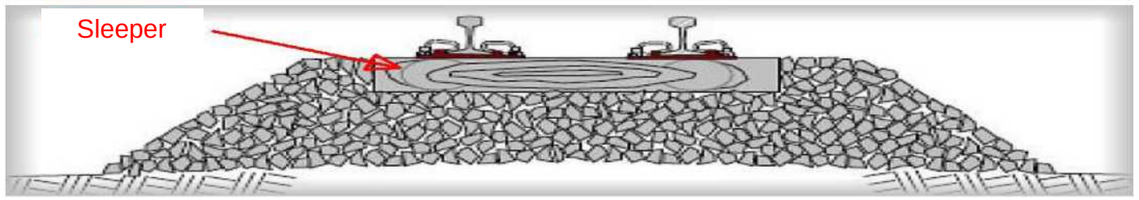

P
P
σ_0
σ_c
h


10%
20%
40%
20%
10%



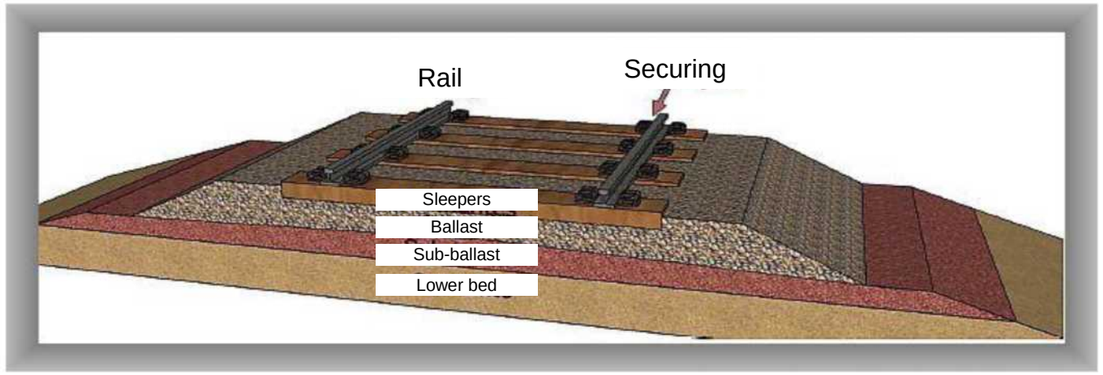

σ_0
h_L
ballast
$\sigma_{adm\ sub\text{-}ballast}$


Q = 50 kN
A = 3 cm²
A = 200 cm²
A = 500 cm²
Wheel - rail → σ = 1,500 kg/cm²
Rail - plate → σ = 15 kg/cm²
Plate - sleeper → σ = 6 kg/cm²


Sleeper

Ballast

It is a layer, usually made of crushed stone, where the sleepers are settled. The ballast supports and distributes to the infrastructure, the efforts transmitted by sleepers, preventing the displacement thereof, produced by temperature variation and the movement of trains.



The purpose of the ballast is to distribute the load applied on the largest surface as possible, keep the sleepers horizontally, remove rainwater from the superstructure and provide elasticity to the platform.

The following are the main functions of the ballast:

- ✓ Distribute conveniently on the platform (sub-ballast) efforts resulting from the loads of vehicles, producing a lower work rate on the platform;
- ✓ Form a support, up to some elastic limit, reducing the vibrations resulting from the passage of vehicles;
- ✓ Superimposed on the platform, remove the irregularities, forming a continuous and uniform surface for the sleepers and rails;
- ✓ Prevent the displacements of the sleepers either in the longitudinal direction or the transversal direction;
- ✓ Facilitate draining of the superstructure.

Materials for Ballast → The following are the characteristics of the materials for ballast:

Land - It is the cheapest, but also the worst. The saturate water is often found, causing unevenness on the line, even causing accidents to trains. An uneven line is what is called the railway practice, "lacquered line" and is the most frequent cause of derailment.

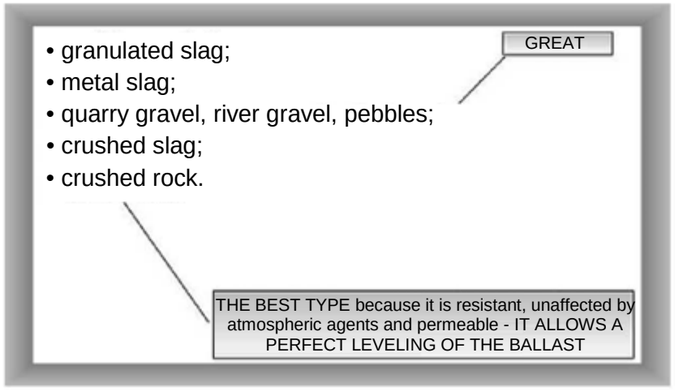
Sand - It has the quality of being slightly compressible and permeable. However, it is easily carried by water. It also has the disadvantage of producing a very hard dust grain (quartz) that by being introduced between moving parts of vehicles, causes wear and tear thereof.

Gravel - It is a great kind of ballast, especially when broken, forming sharp edges. It is sometimes used as is in the form of "materials of mineral origin", but for the lines of more traffic, the gravel should be washed, to separate it from the land and impurities.

Slag - Some slag from metallurgical plants have hardness and sufficient strength to be used as ballast and are used in the lines next to the plants.

Crushed stone - it is the best kind of ballast because it is resistant, unaffected by atmospheric agents and permeable, allowing perfect leveling (tamping) of the ballast. It is limitedly elastic and does not produce dust. One should choose the crushed stone from hard rock.

Usually, it is not admitted ballast other than that made of crushed stone; exceptionally gravel, when it has excellent quality.



Ballast Quality →

- sufficient resistance to the efforts transmitted by sleepers;
- have sufficient elasticity to soften the shocks;
- have dimensions that allow its interposition between and under the sleepers, filling the platform depressions or sub-ballast and allowing the perfect leveling of the rails;
- have resistance to atmospheric agents;
- have permeability to make the drainage of rainwater;
- not being subject to wear producing dust;
- allow efficient tamping by mechanical means (punchers, vibrators).

Specifications → The following are the specifications of materials for ballast, commonly used in our country:

- ✓ Minimum specific weight: 2.7.

- ✓ Tensile strength: 700 kg/cm^2.
- ✓ Solubility - there can be no discoloration of the stone when subjected to the test;
- ✓ Absorption < 8 g/dm^3.
- ✓ Harmful substances - Harmful substances and clay clods < 1% (determined by MB8 method of ABNT);
- ✓ Abrasion resistance - Los Angeles Test - this coefficient should be at most 35%.
- ✓ Particle size - The ballast stones should not be large dimensions, since in that case they act as "wedges" and leveling would be very durable, on the other hand, too small dimensions would cause rapid "sealing" of the ballast and lose the draining function. The modern specifications require that the ballast stones having dimensions between 3/4" and 2" (2 - 6 cm).

The table below shows the particle size, i.e., the percentages of different diameters for most common type of ballast to the line. According to the specifications used, these percentages are:

	Cumulative percentages in the sieves					
Sizing	63.5 mm	50 mm	38 mm	25 mm	19 mm	12.7 mm
50 mm to 25 mm	0	0 - 5	35 - 65	85 - 100	90 – 100	95 – 100

Criteria for use →

- the choice of material for ballast must comply with the economic criteria, subject to the provisions of technical standards;
- the ballast or sub-ballast should only be released on the platform properly regulated, leveled, compacted, bulged and have adequate drainage condition;
- the tamping of the ballast should be carried out preferably by mechanical process and be made in any case in layers of about 15 cm, being recommended to reduce this value to 10 cm in lines of great responsibility.

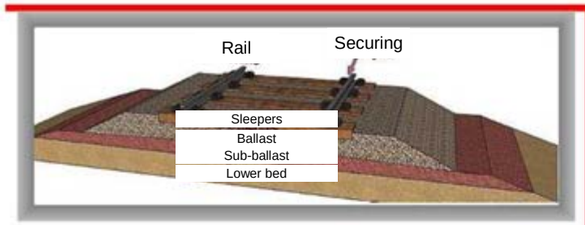
Height of the Ballast under the Sleepers → The table below lists the ballast thicknesses commonly used depending on the loads per axis of the design vehicles, the clearance and the spacing between sleepers.

Parameters	Thickness of the layer / materials used in the ballast
Thickness of the ballast (h)	6” (15.2 cm) 9” (22.9 cm) 12” (30.5 cm) 18” (45.7 cm) 25” (63.5 cm)

Sub-ballast

The sub-ballast layer is formed by a material selected and placed on the platform for further receipt of the ballast layer.

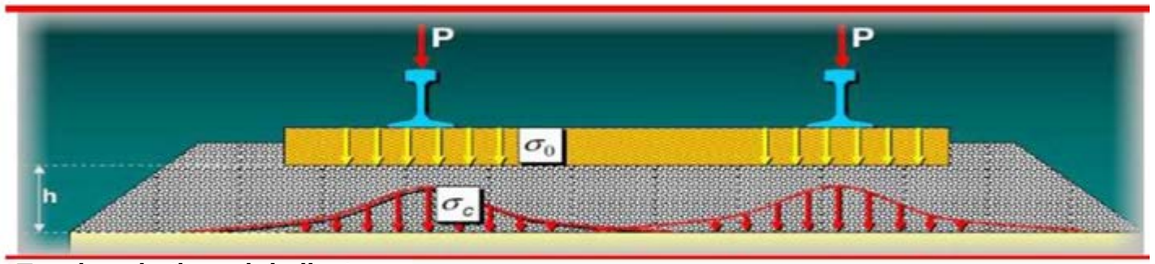
The sub-ballast is the layer of material that completes the platform and receives the ballast. Its function is to absorb the forces transmitted by the ballast and transfer them to the underlying land, the appropriate rate to the carrying capacity of that land. Its operation is similar to the sub-base of road pavements. Furthermore, the sub-ballast does not allow penetration of the aggregate at the bottom of the ballast and also has to provide a perfect draining of water from it.



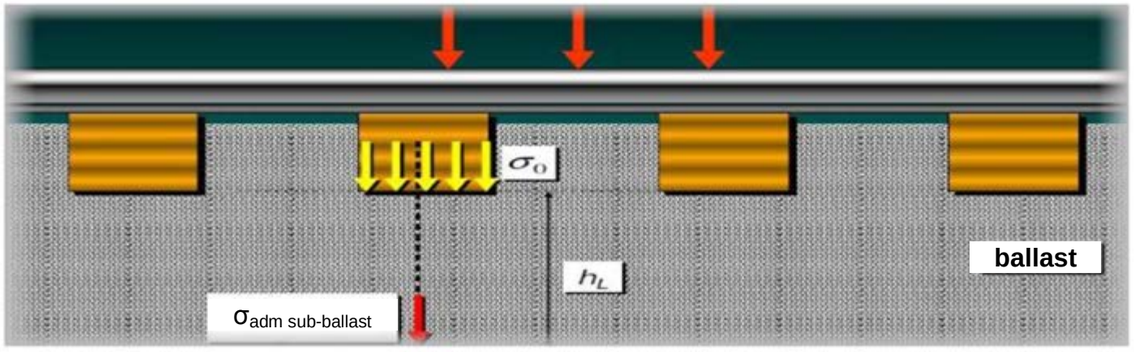
Structure →

- increase the platform support capabilities, so as to increase the work rate on the land - lower height of the ballast layer (and consequent reduction in cost);
- avoid penetration of the ballast on the platform;
- increase the bed resistance to erosion and penetration of water, aiding in the drainage process of the track (prevents the increase of sludge);
- allow relative elasticity to the ballast support, so the permanent track is not rigid.

Functions →



Tensions in the sub-ballast →



Materials for sub-ballast → The following are the most commonly used materials: crushed stone, gravel, slag, soils and clay. These materials to be used must meet the following characteristics:

- ✓ IG (Group Ratio) - equal to 0 (zero);
- ✓ LL (Liquidity Threshold) - maximum 35;
- ✓ IP (Plasticity Ratio) - maximum 6;
- ✓ Material that fits preferably in the A1 group of H.R..B soil classification;
- ✓ Maximum expansion of 1%;
- ✓ CBR (California Bearing Ratio) - minimum of 30.
- ✓ The granulometric composition must fit into the classifications A, B, C and D of AASHO.
- ✓ Liquidity Threshold of the fraction passing the sieve No. 40 should be < 25%. For lateritic soils it is assumed LL < 35%.
- ✓ The Plasticity Ratio of the fraction passing through the sieve No. 40 should be < 6%. For lateritic soils, it is assumed IP < 10%.
- ✓ The "Los Angeles Abrasion Ratio" of the soil that pass through a sieve No. 10 should be < 50%.
- ✓ The minimum California Bearing Ratio is 20, with maximum expansion of 0.5%.
- ✓ It is allowed to mix the soils with sand, aggregate or cement in order to achieve the specified particle size.

*** material that fits, preferably in group A1 of the HRB *(Highway Research Board)* soil classification:**

A1 - Soil well graduated consisting mainly of rubble and sand, but containing a small amount of fine materials.

- **The clayey soils (A4 to A7) are subject to wide variations in the resistance during the drying and moistening cycles, therefore, they are undesirable.**
- **The poorly graded soils, such as fine sand (A3) are difficult to be compressed to reach higher density**

Sub-ballast thickness → The thickness of sub-ballast may vary according to the transport stream characteristics, and the load per axis of the rolling stock.

- **the thickness of the sub-ballast should be such that the distribution of pressure through it entails, on its base (platform), a working rate compatible with the bearing capacity thereof.**
- **usually, a sub-ballast with a thickness of 20 cm is sufficient.**

CBR (sub-ballast)	σ_{adm} (KPa)
3	26.77
4	35.79
5	44.71
6	53.64
7	62.56
8	71.49
9	80.41
10	89.33
11	98.26
12	107.28

Sub-ballast thickness → The thickness of sub-ballast may vary according to the transport stream characteristics, and the load per axis of the rolling stock.

It is very important the relationship between the CBR of the lower and the allowable bearing ratio of it, in order to allow dimensioning of the sub-ballast.

Sizing

Theoretically, the railway should only support the resulting efforts of the weights of vehicles and the centrifugal force exerted by them, in the corners. However, the action of normal forces is modified by abnormal forces (due to the track and the rolling stock), which play an important role in the resistance of the track and derive from the characteristics inherent thereto and in relation to the constructive particularities of the vehicle.

The perfect knowledge of the effort that act on the track will be useful, not only to better scale the elements that compose it, as well as to identify defects that appear and fix them by a service and scheduled maintenance.

Vertical Efforts →

- ✓ Static load - It is the load caused by the weight of vehicles. It occurs only when the vehicles are stopped on the way, for in movement, the vertical loads are dynamic.
- ✓ Vertical centrifugal force - any eccentric mass of the rolling stock and provided with rotary motion will generate a vertical centrifugal force, and changes of positions, sometimes decreasing the load, sometimes increasing the load, causing shocks whose intensity is proportional to the square of the speed.
- ✓ Galloping movement - due to track irregularities and especially in the case of "parallel" and defective joints, it originates from a movement in full vertical plane parallel to the rails, which overloads sometimes the front axis, sometimes the rear axis.
- ✓ Vibration movement - it is a movement similar to the above, caused by track irregularities, but in which the springs of the bogies, front and rear, are pressed at the same time, causing a "vibration" that overloads all axes.
- ✓ Rocking or *roulis* movement - it also occurs due to track irregularities, it is common to develop a movement in the direction perpendicular to the track, overloading sometimes the wheels on one side of the vehicle, sometimes the wheels on the other side.
- ✓ Uneven weight distribution - since the super elevation in the outer rail is given for a particular speed when the trains run along a curve with a greater or lesser speed than that served to calculate the super elevation, the resultant of the forces ceases to pass through the center of the track, moving closer to one side, in which the rail receives an overload.
- ✓ Defects in the line - in general, any defect in the line causes an overload on the distribution of vertical loads.
- ✓ Defects of the rolling stock - the defective rolling stock also causes shock on the track, which increase the static load, for example, "callus" on wheels, generating a "hammering" on the rails.

Longitudinal efforts →

- ✓ Dilation - the increase or decrease of temperature of the rails can generate compressive tensions and traction in the rails.
- ✓ "Reptation" motion - with the passage of the wheels, the rail undergoes elastic deformation, which makes it flexed, creating compressive tensions and traction therein.
- ✓ Wheel blows in the tops of the rails - the wheels of the vehicles when finding the top of the rails, especially in defective joints, can generate a force component, which tends to move the rail forward.
- ✓ Tractive effort - the tractor effort on the wheel, due to the "stickiness" (static friction) generates a force parallel to the rail.
- ✓ Braking - braking of trains produces a frictional force in the head of the rails, in the longitudinal direction and in the same direction of movement.
- ✓ Attrition of wheel flanges on the rails - it can also generate a component of longitudinal force to the track.

Transversal Forces →

- ✓ Centrifugal force - in the curves, the centrifugal force not compensated by the super elevation of the outer rail produces a transversal force in the said rail.
- ✓ *Lacêt* movement - on the straight paths, due to irregularities in the track or defects in the rolling stock, there is a movement of the vehicle around an axis normal to the plane of the rails, causing the outer wheel sometimes on one side, sometimes on the other, transversely shock to the rail, to extend the clearance.
- ✓ Wind - since the rolling stock offers considerable exposed surface, a strong wind can make a force of the wheel flanges, in the transversal direction to the line.

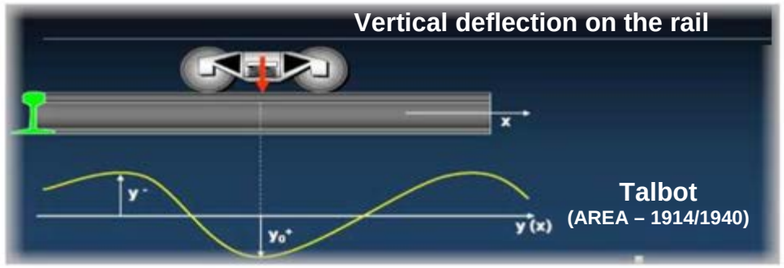
Rail Floor Dimensioning → The following activities were developed, in order to achieve the proposed objectives in the research:

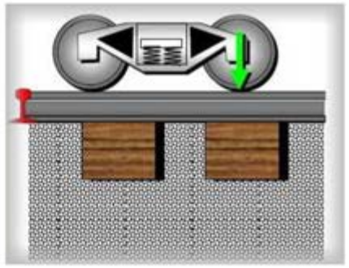
- ✓ Survey of existing design data
- ✓ CBR design calculation;
- ✓ Floor rail dimensioning, based on the data obtained above;
- ✓ Setting the grade for the railroad deployment;
- ✓ Survey of costs for deployment of the design.
- ✓ Determination of costs for deployment of the railroad design;

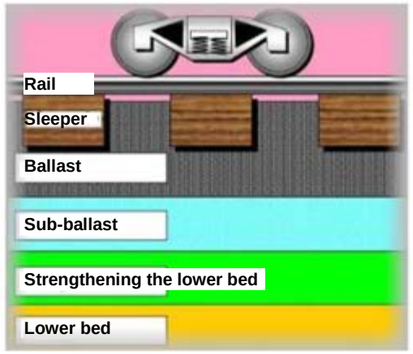
It was set according to the characteristics of the railway network of the Railroad, the clearance of the line, type of rail and sleeper, the maximum speed of the locomotive, tonnage per axis and sleepering rate used for determining the characteristic section of the railroad.

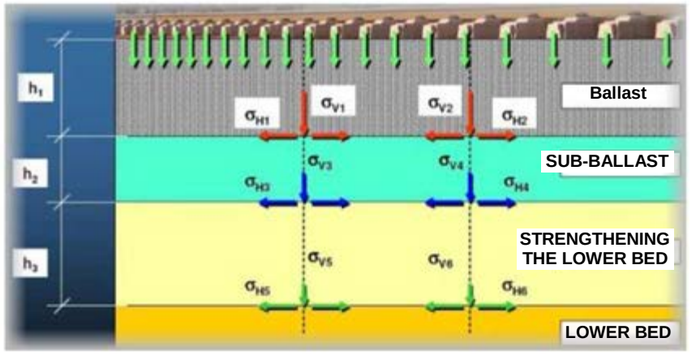
Clearance	International
Rail	TR_45
Sleeper → Monoblock prestressed concrete	2.20 m x 0.25 m x 0.15 m
Design Speed	80 km/h
Dredge per wheel	5,000 kg
Wheelbase	2.20 m
Sleepering rate	1,667 sleepers / km
DBR of the sub-ballast	30%

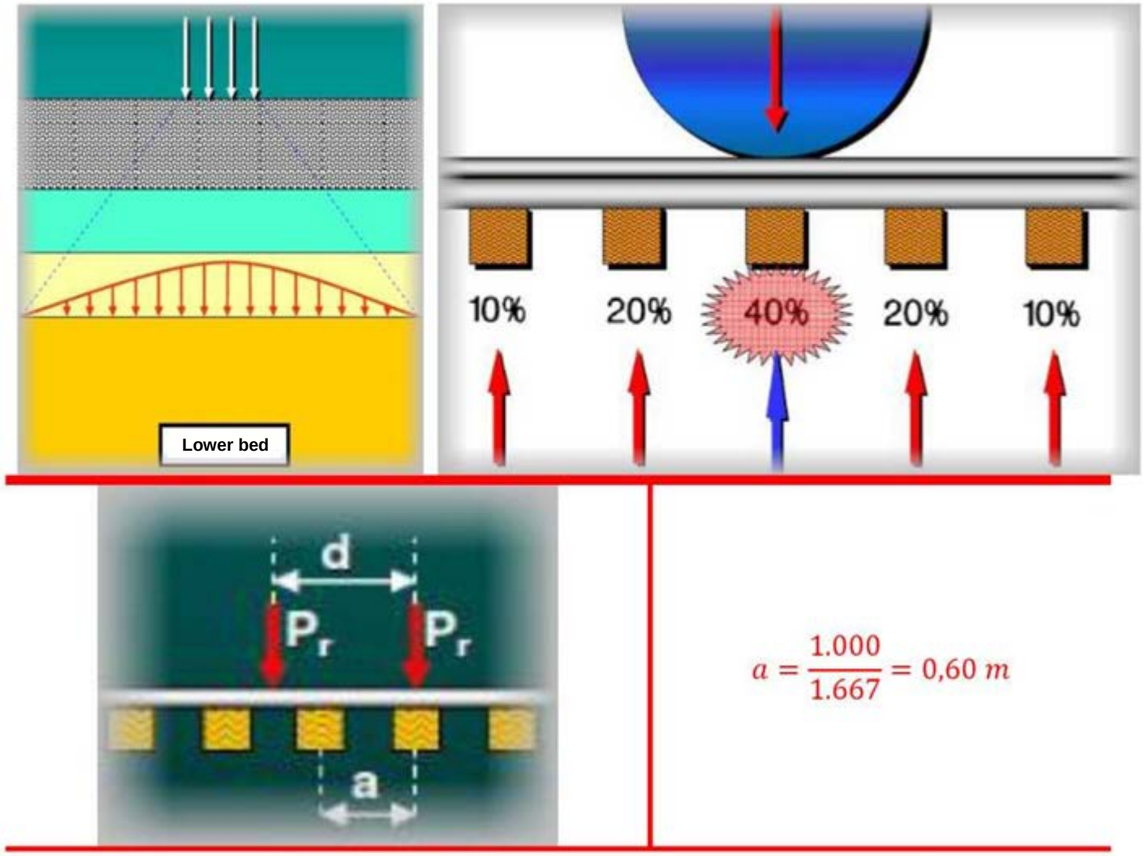
Tensions in the Rail Floors









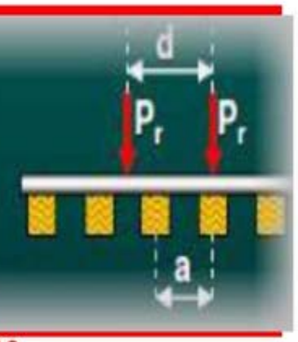


$$a = \frac{1.000}{1.667} = 0{,}60\ m$$

Spacing between sleepers → 60 cm

Reducing coefficient

$$n = \frac{d}{a} = \frac{\text{wheelbase}}{\text{distance between centers of the sleepers}}$$



d → 2,20 m a → 0,6 m	$n = \frac{2{,}20}{0{,}6} = 3{,}6674$
V = 80 km/h	$Cd = 1 + \frac{80 \text{ x } 80}{30.000} = 1{,}213$

Cd = dynamic impact coefficient (AREA)

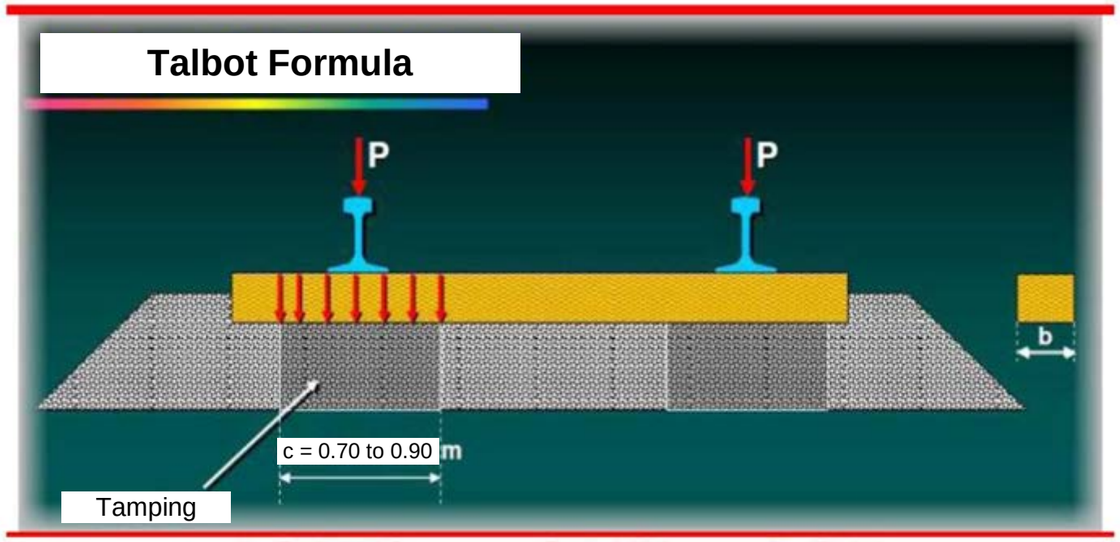
v (km/h)

$$C_d = 1 + \frac{v^2}{30.000} \geq 1{,}4$$

Dynamic impact coefficient used - 1.4

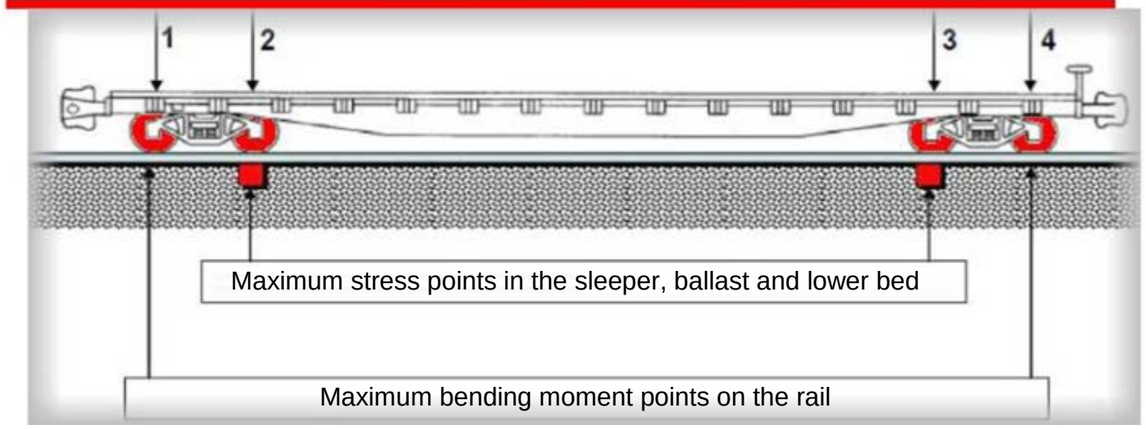
(*) Brina (1983, p. 17) considering the possibility of a fault in the rail line

Talbot Formula



P_r → 5.000 kg n → 3,6674 C_d → 1,4

Load on sleeper → 1,908.709 kg



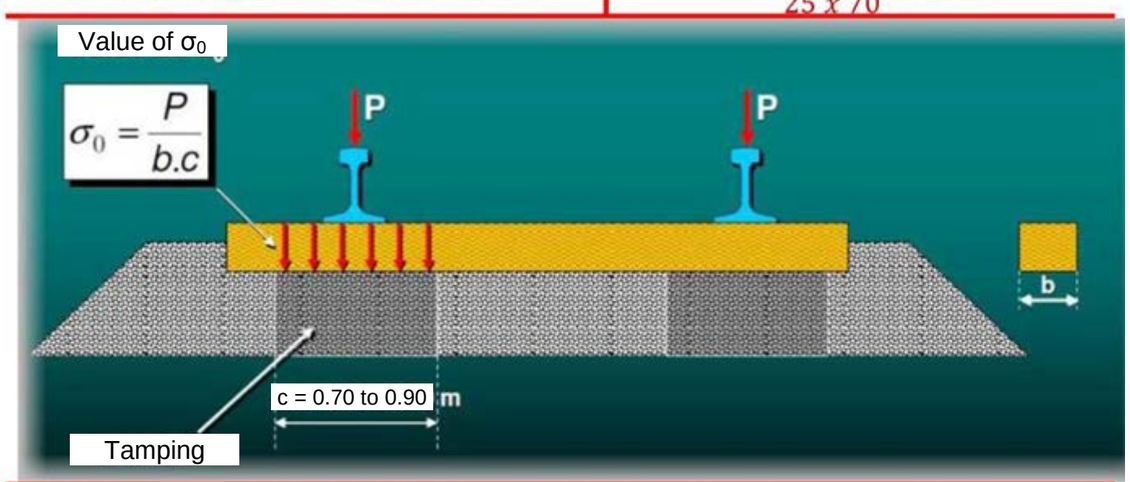
Tensions and Loads received and transmitted by Sleepers

$P = 5.000$ kg $b = 25$ cm $c = 80$ cm

$$\sigma = \frac{5.000}{25 \, x \, 70} = 2{,}857$$

Value of σ_0

$$\sigma_0 = \frac{P}{b.c}$$



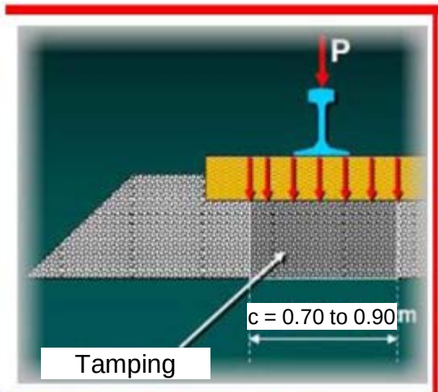
Tension in the sleeper base → σ = 2.857 kg/cm^2

Load on sleeper

$$P = \frac{P_r}{n} C_d$$

$$P = \frac{5.000}{3{,}6674} \, x \, 1{,}4 = 1.908{,}709 \, kg$$

Tamping Area



$$Ab = (220 - 80)x\ 25 = 3.500\ cm2$$

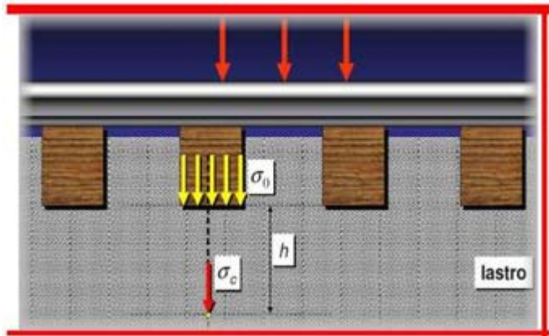
$$Ab = (l - s)\ x\ b$$

Tamping Area Ab - Schramm:

l ➔ 2,20m s ➔ 0,80 m b ➔ 0,25 m

Tamping Area - 3,500 cm^2.

Tensions in the Ballast and Sub-ballast



$$\sigma c = \frac{1.908,709}{3.500,00} = 0,545\ kgf/cm2$$

P ➔ 1.908,709 kg Ab ➔ 3.500 cm^2

$$\sigma c = \frac{P}{Ab}$$

Pressure on the sub-ballast - 0.545 kg/cm^2.

$$p = \frac{70\ x\ 30}{100} = 21\ kgf/cm2$$

$$p = \frac{70\ x\ CBRsl}{100}$$

Estimated burst pressure of the sub-ballast, considered for the sub-ballast a minimum CBR of 30% - 21 kgf/cm^2.

$$Ph = \frac{21}{5,5} = 3,82$$

$$Ph = \frac{p}{5,5}$$

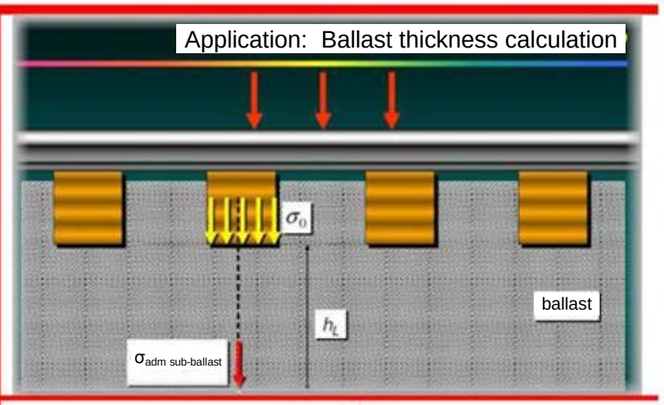
Permissible tension in the sub-ballast, according to Brian (1983, p. 18) - 3.82 kg/cm^2.

Thickness of the Ballast

Metric units

$$\sigma_c = \frac{53,87\sigma_0}{h^{1,25}}\ (kg/cm^2)$$

cm



$$h = \left(\frac{53,87\ x\ \sigma}{Ph}\right)^{\left(\frac{1}{1,25}\right)}$$

$$h = \left(\frac{53,87\ x\ 2,857}{3,82}\right)^{\left(\frac{1}{1,25}\right)} = 19,24\ cm$$

Since the standard considers a minimum thickness of 25 cm, we used as the thickness of the ballast the value of - 25 cm.

Findings according to Eisenmann (1974)

$$Ph = \frac{0,006\ x\ CBRsl\ x\ 100}{1 + 0,7\ x\ logN}$$

$$Ph = \frac{0,006\ x\ 30\ x\ 100}{1 + 0,7\ x\ log2.200.000} = 3,31\ kgf/cm2$$

Admissible tension cited in Stopatto (1987, p. 119) - 3.31 kg/cm^2.

Where N = 2.2 • 10^6 used to represent the most critical situation, according to the distribution of Railroads Groups assumed by RFFSA.

$$h = \left(\frac{53,87\ x2,5}{3,31}\right)^{\left(\frac{1}{1,25}\right)} = 19,39\ cm$$

$$h = \left(\frac{53,87\ x\ \sigma}{Ph}\right)^{\left(\frac{1}{1,25}\right)}$$

We used as a minimum thickness of the ballast the value of - 25 cm.

Rail Ballast - Dimensioning		
Clearance	International	
Sleeper - length	2.20	m
Sleeper - width	0.25	m
Sleeper - height	0.15	m
Maximum Speed	80	Km/h
Load per Axis	10	ton/axis
Wheelbase	2.20	m
Sleepering rate	1,667	sleeper/km
Tamping rate	0.70	m
CBR_p of the sub-ballast	30	%
Safety factor - values between 5 and 6	5.5	adm
Spacing between sleepers - a	0.60	m
Wheelbase / space between sleepers - n	3.6674	adm
Weight of the heavier wheel - P_r	5,000	kg/wheel
Impact Coefficient - Cd	1,213	1.40
Tamping Area - A_b	3,500,000	cm^2
Load to be considered - R	1,906,709	kgf
Tension at the base of the sleeper - Pm	2.857	kgf/cm^2
Estimated burst pressure in the sub-ballast - p	21,000	kgf/cm^2
Admissible tension in the sub-ballast - Ph	3,818	kgf/cm^2
Average pressure on the lower part of the sleeper - P_o	1,091	kgf/cm^2
Calculated thickness of the ballast - he	0.19	m
Used thickness of the ballast - h ≥ 0.25 m	0.25	m

Thickness of the Sub-ballast

Considering for the lower bed a minimum CBR of 2%, below which is mandatory replacement of the lower bed.

$$p = \frac{70 \text{ x } 2}{100} = 1{,}4\ kgf/cm2 \qquad p = \frac{70 \text{ x } CBR_{lower\ bed}}{100}$$

Estimated burst pressure of the lower bed, considered a CBR for the sub-ballast

minimum 2% = 1.4 kgf/cm^2.

$$Ph = \frac{1{,}4}{5{,}5} = 0{,}255 \qquad Ph = \frac{p}{5{,}5}$$

Admissible tension in the lower bed. According to Brina (1983, p. 18) → 0.255 kg/cm^2.

$$Ph = \frac{1.908{,}709}{3.500} = 0{,}545 \qquad Ph = \frac{P}{Ab}$$

Admissible tension in the lower bed. According to Brina (1983, p. 18) → 0.545 kg/cm^2.

$$h = \left(\frac{53{,}87 \text{ x } 0{,}545}{0{,}255}\right)^{\left(\frac{1}{1{,}25}\right)} = 44{,}60\ cm \qquad h = \left(\frac{53{,}87 \text{ x } \sigma}{Ph}\right)^{\left(\frac{1}{1{,}25}\right)}$$

Thickness of the sub-ballast = Total thickness - Thickness of the ballast → 45 - 25 = 20 cm

$$Ph = \frac{0{,}006 \text{ x CBRsl x } 100}{1 + 0{,}7 \text{ x log N}} \qquad Ph = \frac{0{,}006 \text{ x } 2 \text{ x } 100}{1 + 0{,}7 \text{ x log} 2.200.000} = 0{,}22\ kgf/cm2$$

Admissible tension cited in Stoppato (1987, p. 119) → 0.22 kg/cm^2.

$$h = \left(\frac{53{,}87 \text{ x } 0{,}545}{0{,}22}\right)^{\left(\frac{1}{1{,}25}\right)} = 50{,}14\ cm \qquad h = \left(\frac{53{,}87 \text{ x } \sigma}{Ph}\right)^{\left(\frac{1}{1{,}25}\right)}$$

Thickness of the sub-ballast = Total thickness - Thickness of the ballast → 51 - 25 = 26 cm

Considering this third case as the most conservative one, even if we accept a CBR of 2%, a thickness of the ballast equals to 25 cm and sub-ballast equals to 25 cm.

Rail sub-ballast - Sizing		
Clearance	International	
Sleeper - length	2.20	m
Sleeper - width	0.25	m
Sleeper - height	0.15	m
Maximum Speed	80	Km/h
Load per Axis	10	ton/axis
Wheelbase	2.20	m
Sleepering rate	1,667	sleeper/km
Tamping rate	0.70	m
CBR_p of the lower bed	2	%
Safety factor - values between 5 and 6	5.5	adm
Spacing between sleepers - a	0.60	m
Wheelbase / space between sleepers - n	3,6674	adm
Weight of the heavier wheel - P_r	5,000	kg/wheel
Impact Coefficient - C_d	1,213	1.40
Estimated rupture pressure in the lower bed - p	1,400	kgf/cm^2
Admissible tension in the sub-ballast - ph	0.255	kgf/cm^2
Thickness of the sub-ballast + ballast - h	0.45	m
Thickness of the sub-ballast - h ≥ 0.10 m	0.20	m
According to Eisenmann Ph	0.22	kgf/cm^2
According to Eisenmann - h	0.50	m
Thickness of the sub-ballast - h ≥ 0.10 m	0.25	m

Width of the Sub-ballast			
Length of the sleeper	b	2.20	m
Sleeper height in meters	d	0.15	m
Ballast thickness in meters	h	0.25	m
Slope of the ballast slope – 1: m - 1:1.5	m	1.50	m
Slope of the lower bed slope - n % - 3 %	n	3.00	%
Ballast banquette width - between 0.15 and 0.40 m	v	0.15	m
Ballast banquette width - between 0.50 and 1.00 m	W	0.50	m
Ballast platform width in meters	f	1.85	m
Sub-ballast thickness in meters		0.25	m
Wheelbase		4.30	m
Total width of the track below the ballast		8.00	m
Total width of the track below the sub-ballast		8.75	m

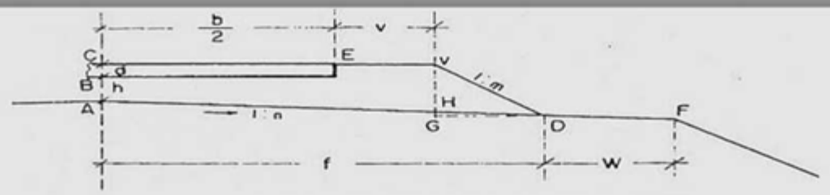
It should be noted that Calçada - Paripe railway has been operating for more than a century, in metric clearance, using a much heavier type train, twice the load of the LRV (20 ton), without records of any defect in the superstructure, except in some landslides on the side slopes, which has nothing to do with the sizing of the superstructure. During these more than 100 years in operation, freight trains have been circulating through the track to the Port of Salvador and routinely passenger trains.

It also should be noted that the reclassification proposed to modify the design type train (LRV) complemented by the adoption of international clearance, wider (1.435 m), promotes a significant reduction in requests on the superstructure.

The scaled values (ballast thickness of 25 cm and sub-ballast thickness of 25 cm) under the conditions of the design, which provides for an adjustment of the existing ballast and when we add the material of it, in the old existing sub-ballast, this new sub-ballast reaches thicknesses much greater than the minimum required for the most critical situations of CBR and loading, despite the lowest CBR possible, which is 2%.

Geometry of the section of the line → The design has the following section:

The ballast height is equal to 25 cm and the sub-ballast height will be 25 cm.



Geometric characteristics of the section.
Source: Stopatto (1987), p. 2.

Wherein:
b - sleeper length
d = sleeper height
h = ballast thickness

$$f = \frac{m \cdot (h + d) + 0{,}5 \cdot b + v}{1 - \frac{m}{n}}$$

$$l = 2 \cdot (f + w)$$

According to Stopatto (1987, p. 3), v is the width of the shoulder and ranges between 15 and 40 cm, w has values from 50 cm to 1.0 m, the slope of the ballast slope (m) is 1.5 and the platform surface slope (n) is 3%.

Geometric conditioning of Boarding and Disembarkation Stops - PED

The boarding and disembarkation stops of the section Calçada - Paripe are divided into those existing and new ones to be built. The existing stops should have their boarding and disembarkation platforms demolished to enable accessibility to the LRV's low floor and its structure should be completely re-adapted to provide the necessary accessibility and viability of facilities and equipment. The new stops should be implemented at the appropriate places and in accordance with the Preliminary Design - Volume 1. The following are the Boarding and Disembarkation Stops of the section - Calçada-Paripe.

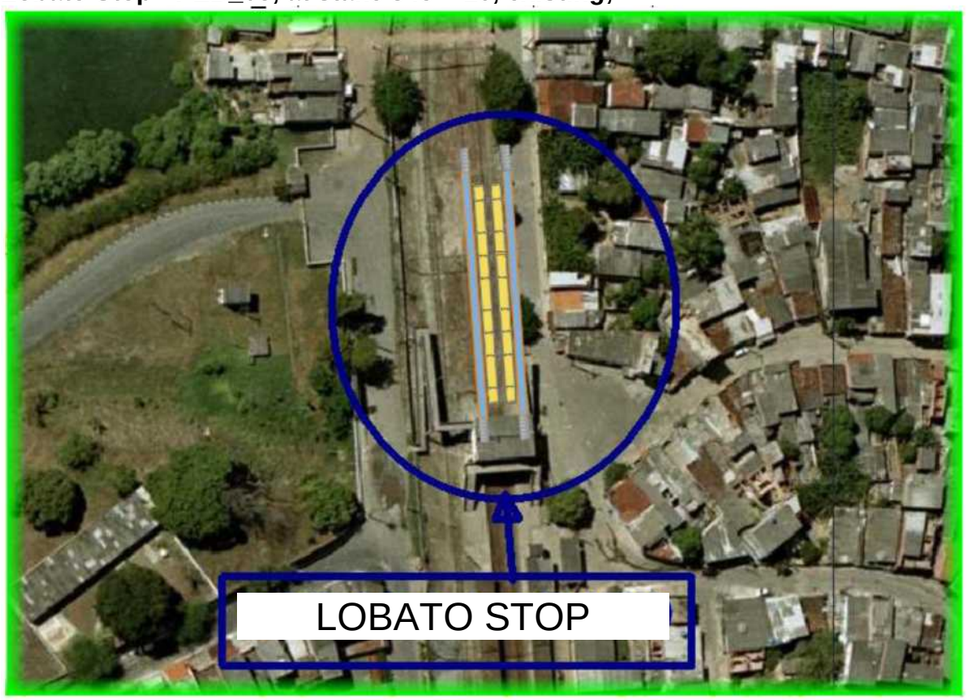
- ✓ **Calçada Stop - PED_01 at stake 177 + 10, existing;**

- ✓ **Baixa do Fiscal Stop - PED_02, at stake 227 + 10;**

- ✓ **Santa Luzia Stop - PED_03, at stake 265 + 10, existing;**

- ✓ **Viaduto da Suburbana Stop - PED_04, at stake 328 + 10;**

✓ **Lobato Stop - PED_05, at stake 345 + 10, existing;**



✓ **São João Stop - PED_07, at stake 445 + 10;**

✓ **União Stop - PED_06, at stake 396 + 10;**

✓ **Plataforma Stop - PED_08, at the stake 471 + 10;**

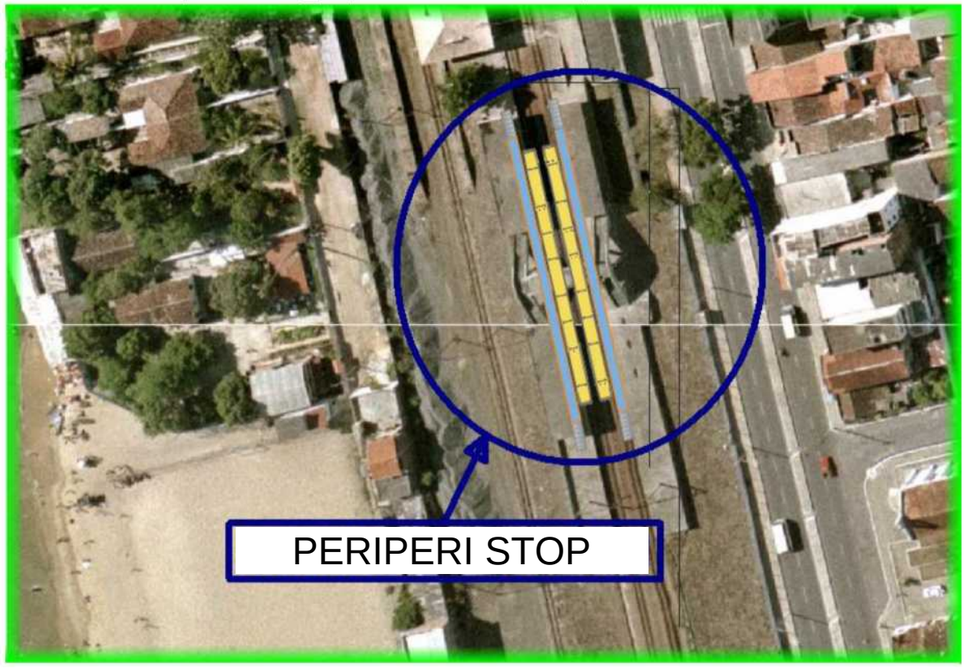
✓ **São Brás (Mocotó) Stop - PED_09, at stake 519 + 10;**

✓ **Escada Stop - PED_11, at stake 598 + 10, existing;**

✓ **Itacaranha Stop - PED_10, at stake 567 + 10, existing;**

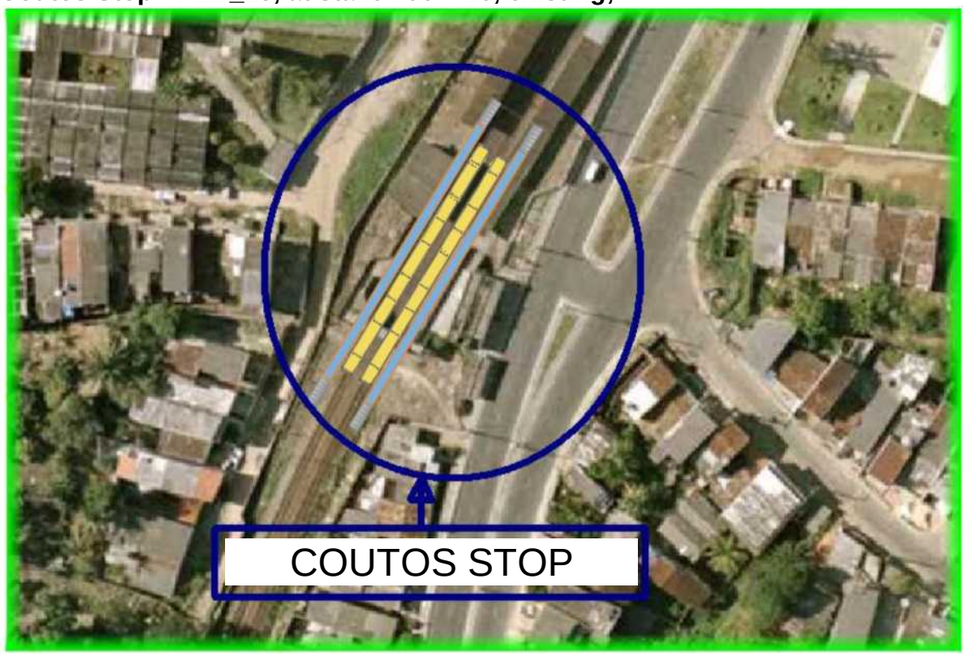
✓ **Praia Grande Stop - PED_12, at stake 665 + 10, existing;**

✓ **Periperi Stop - PED_13, at stake 704 + 10, existing;**



✓ **Setúbal Stop - PED_14, at stake 750 + 10;**

✓ **Coutos Stop - PED_15, at stake 796 + 10, existing;**



✓ **Paripe Stop - PED_16, at stake 842, existing.**

Geometrical and Structural Conditioning of the Level Passages

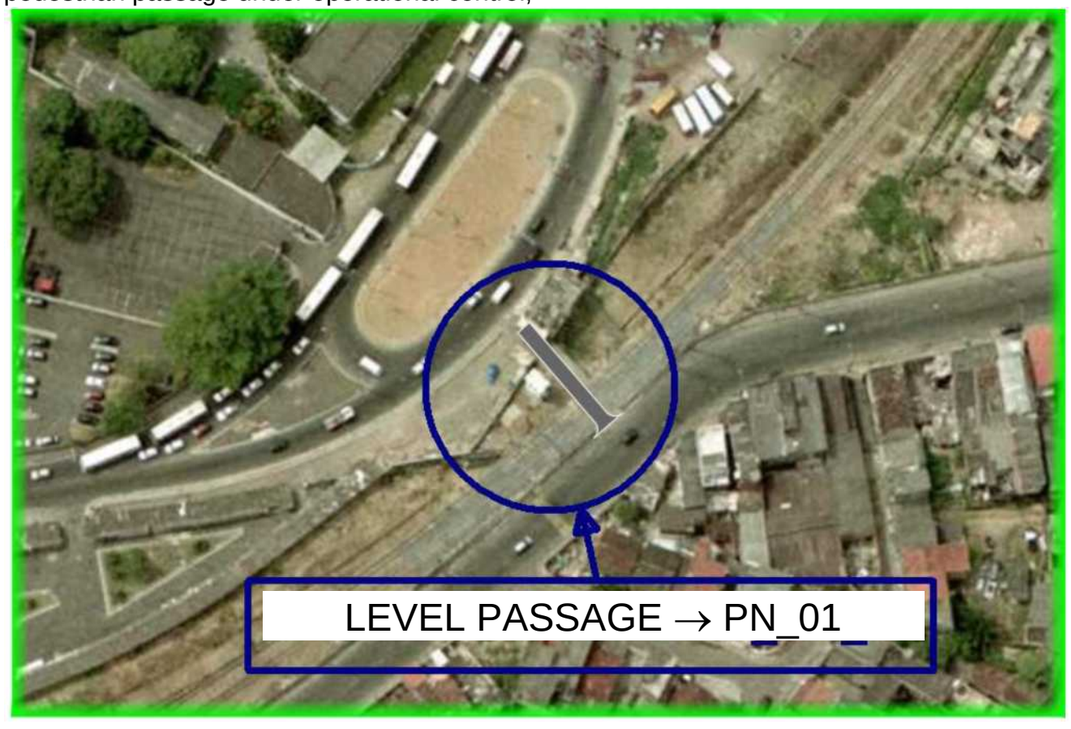
In the Section - Calçada-Paripe, they kept all existing and official level passages. Due to irregular occupation that has been developed over the suburban area, some "clandestine" level passages were created and made possible the expansion of communities along the path of the railway. These "clandestine" passages are being incorporated into the Design as a conventional level passages, with car crossings, or as pedestrian level passages, provided they have been identified as the only access possible. These certifications should be confirmed along with ANTT.

The level passages for vehicles should be structured with concrete coating and side protections for rails (rail-protection). It should have the same operational security and control mechanisms used for the section - Comércio-Calçada.

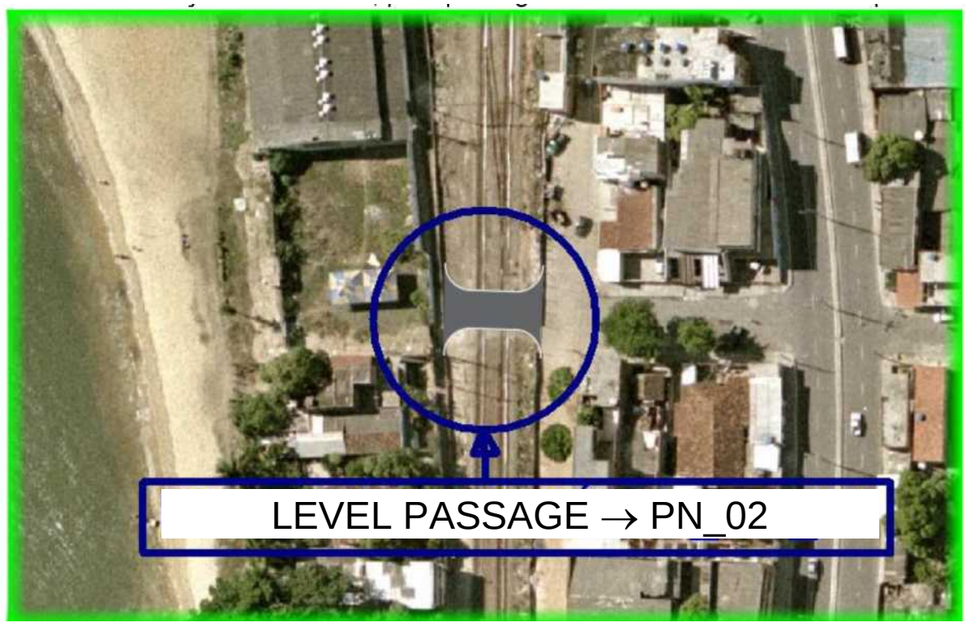
Each boarding and disembarkation stop will be provided with two pedestrian level passages, in addition to these, others were incorporated into the design because they have their use already established. The pedestrian passages will be structured in concrete without the need for protection for the rails, where it is not possible passage of any vehicle and must have its operating control regulated by the CTB.

The following are the Level Passages considered.

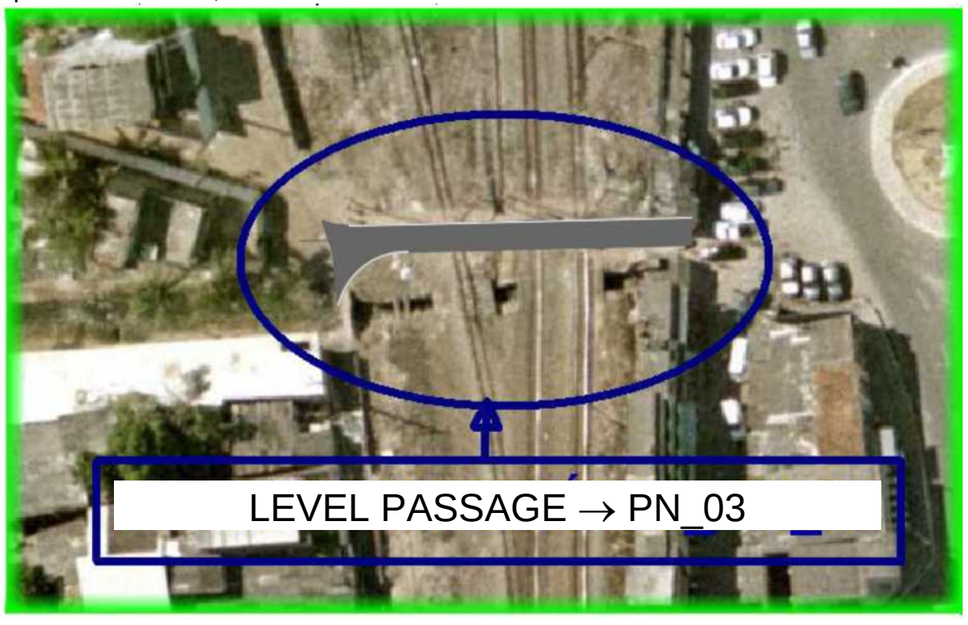
- ✓ Special treatment of the railway level crossing - PN_01, at stake 215 + 4, in Baixa do Fiscal, for pedestrian passage under operational control;



- ✓ Special treatment of the railway level crossing - PN_02, at stake 688 + 15, in front of the Araketu facilities, for vehicles passage under operational control;



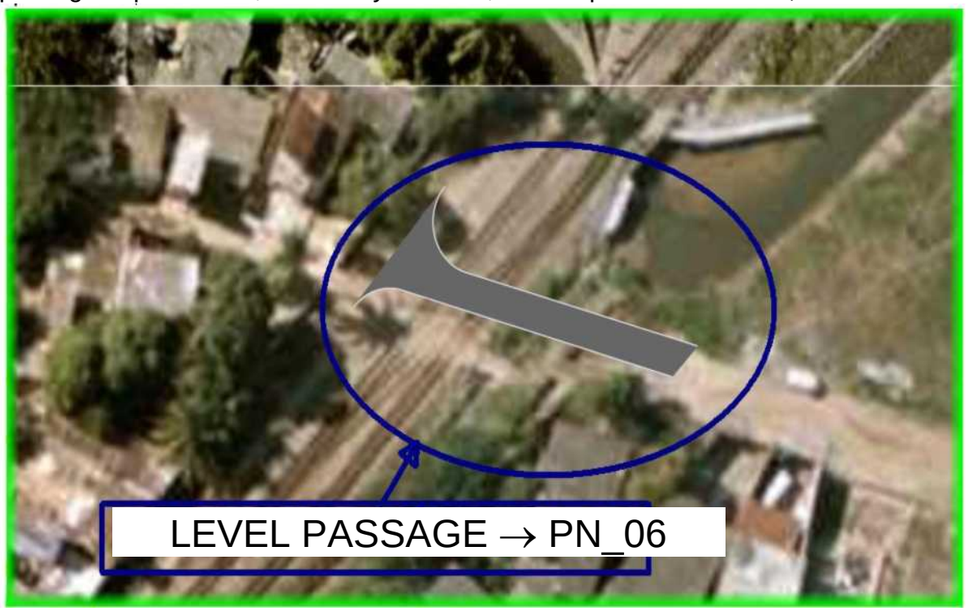
- ✓ Special treatment of the railway level crossing - PN_03, at stake 695 + 7, in front of Largo de Periperi (Largo da Igreja), for pedestrian passage, eventually vehicles passage, under operational control;

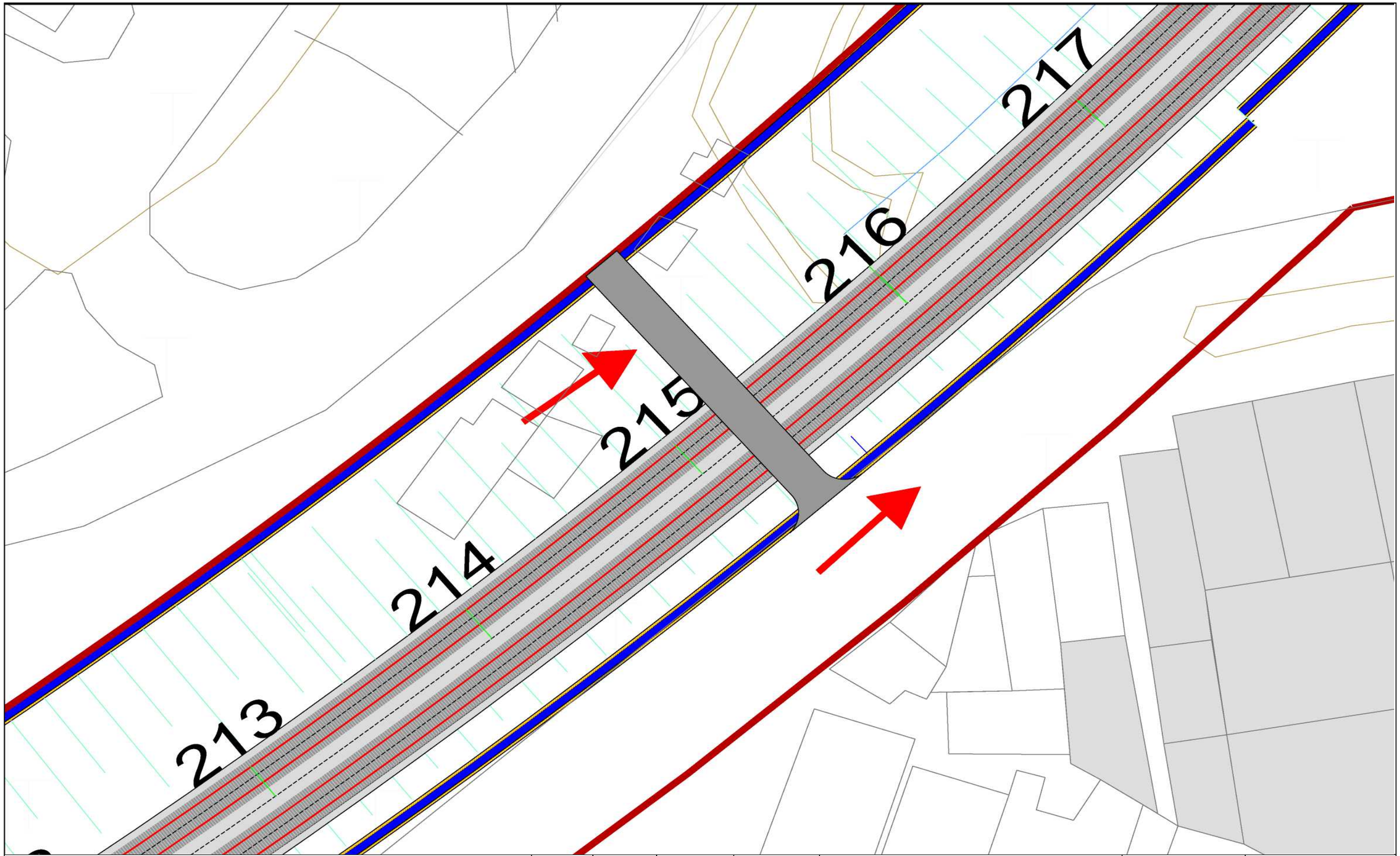


- ✓ Special treatment of the railway level crossing - PN_04, at stake 718 + 10, in front of Av. Afrânio Peixoto, near the mini-traffic circle of Paraguarí River, for passage of vehicles under operational control;

- ✓ Special treatment of the railway level crossing - PN_05, at stake 800, shortly after Coutos Stop for passage of vehicles under operational control;

- ✓ Special treatment of the railway level crossing - PN_06, at stake 831, before Paripe Stop for passage of pedestrian, eventually vehicles, under operational control;

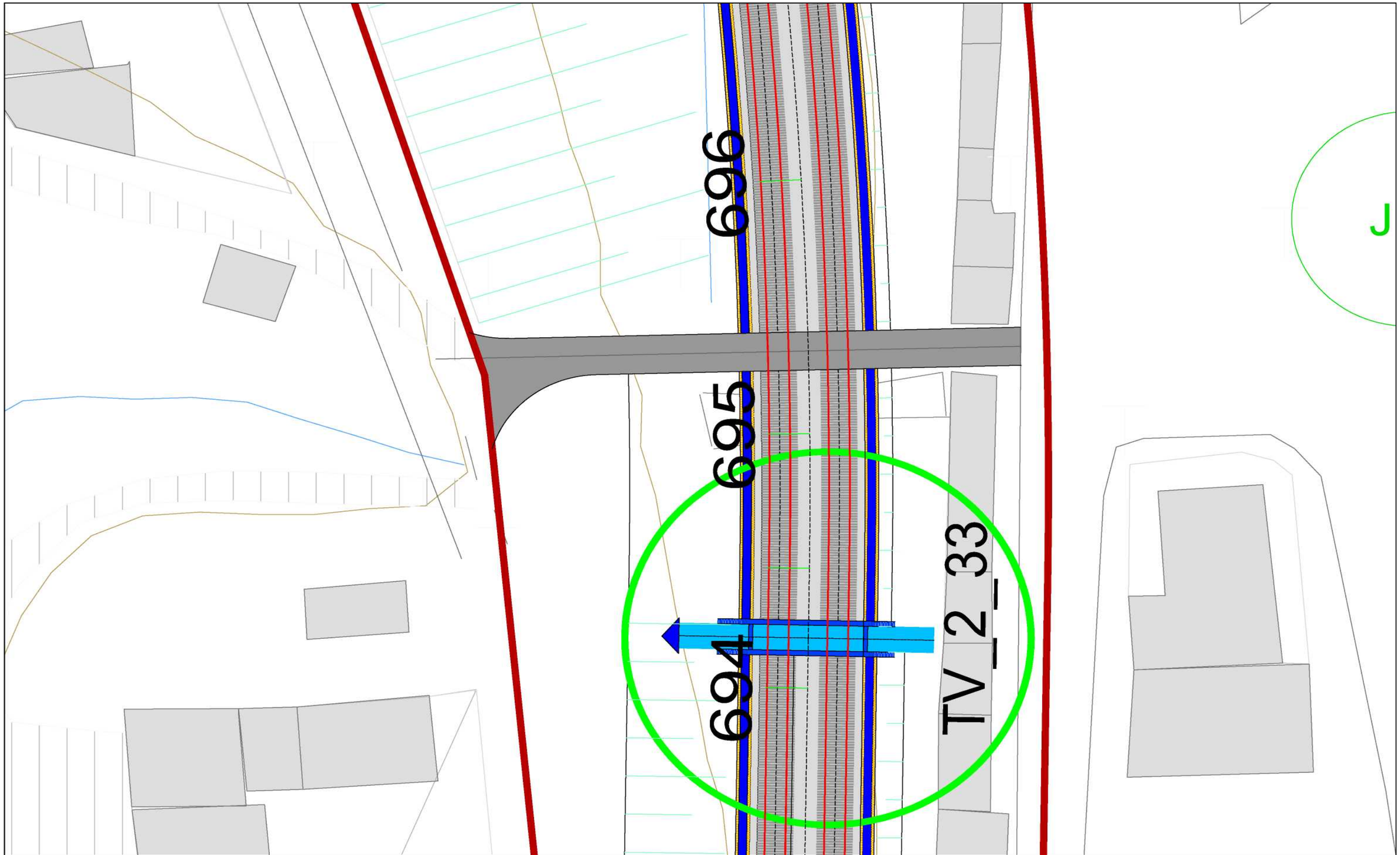




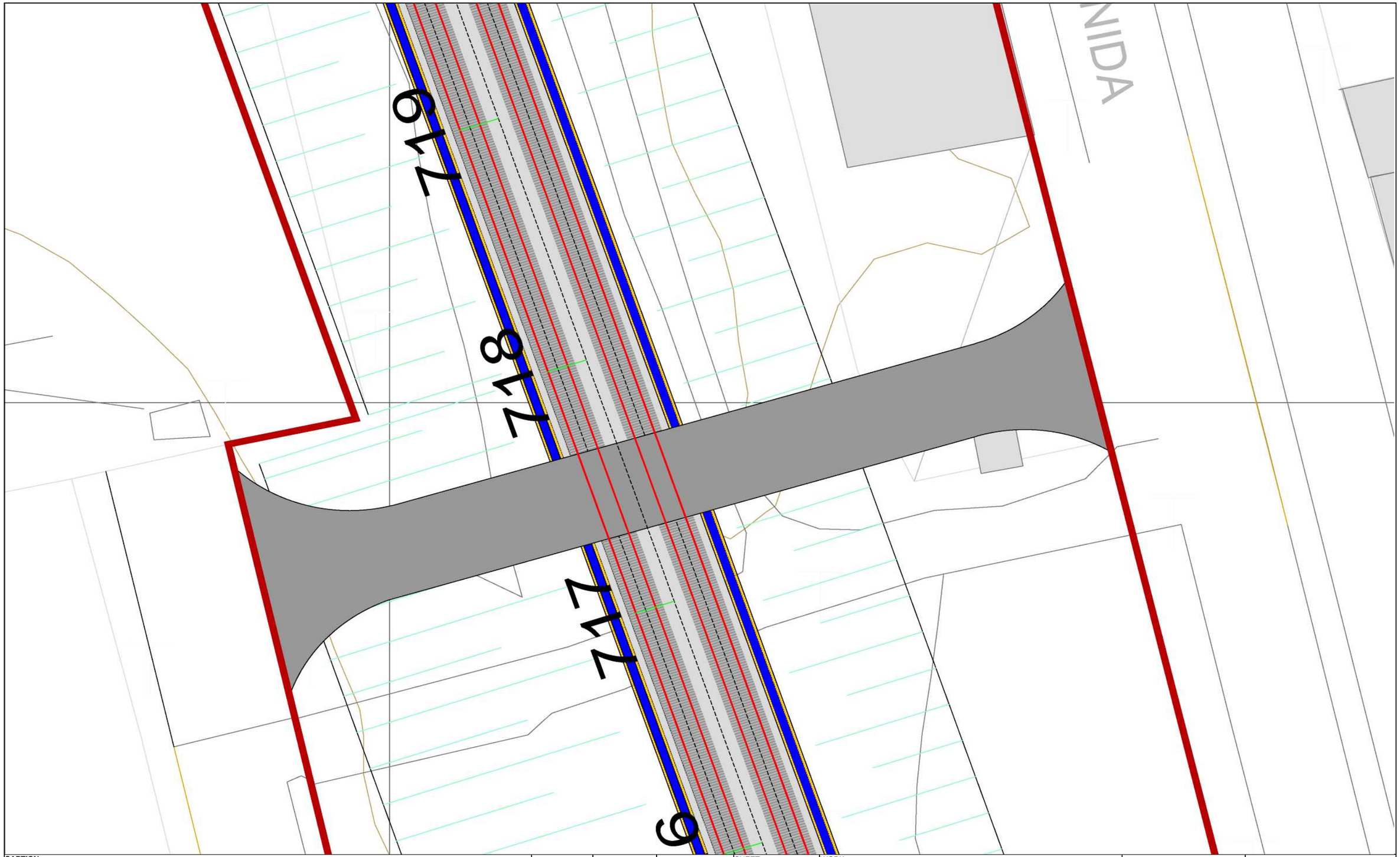
CAPTION				SHEET 01/06	WORK: SECTION - PARIPE - SÃO LUÍS	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /			
	CHECKING		/ /	SCALE 1:250	MUNICIPALITY SALVADOR	
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT LEVEL PASSAGE 01 – PEDESTRIAN - BAIXA DO FISCAL FLOOR PLAN	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				
	NOTE					

CAPTION				SHEET 02/06	WORK: SECTION - PARIPE - SÃO LUÍS	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /		MUNICIPALITY SALVADOR	BAHIA GOVERNO DO ESTADO · CJB
	CHECKING		/ /	SCALE 1:250		
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT LEVEL PASSAGE 02 – PERIPERI (ARAKETU) FLOOR PLAN	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				
	NOTE					

Robério Bezerra & Cynthia Brito & André Cury

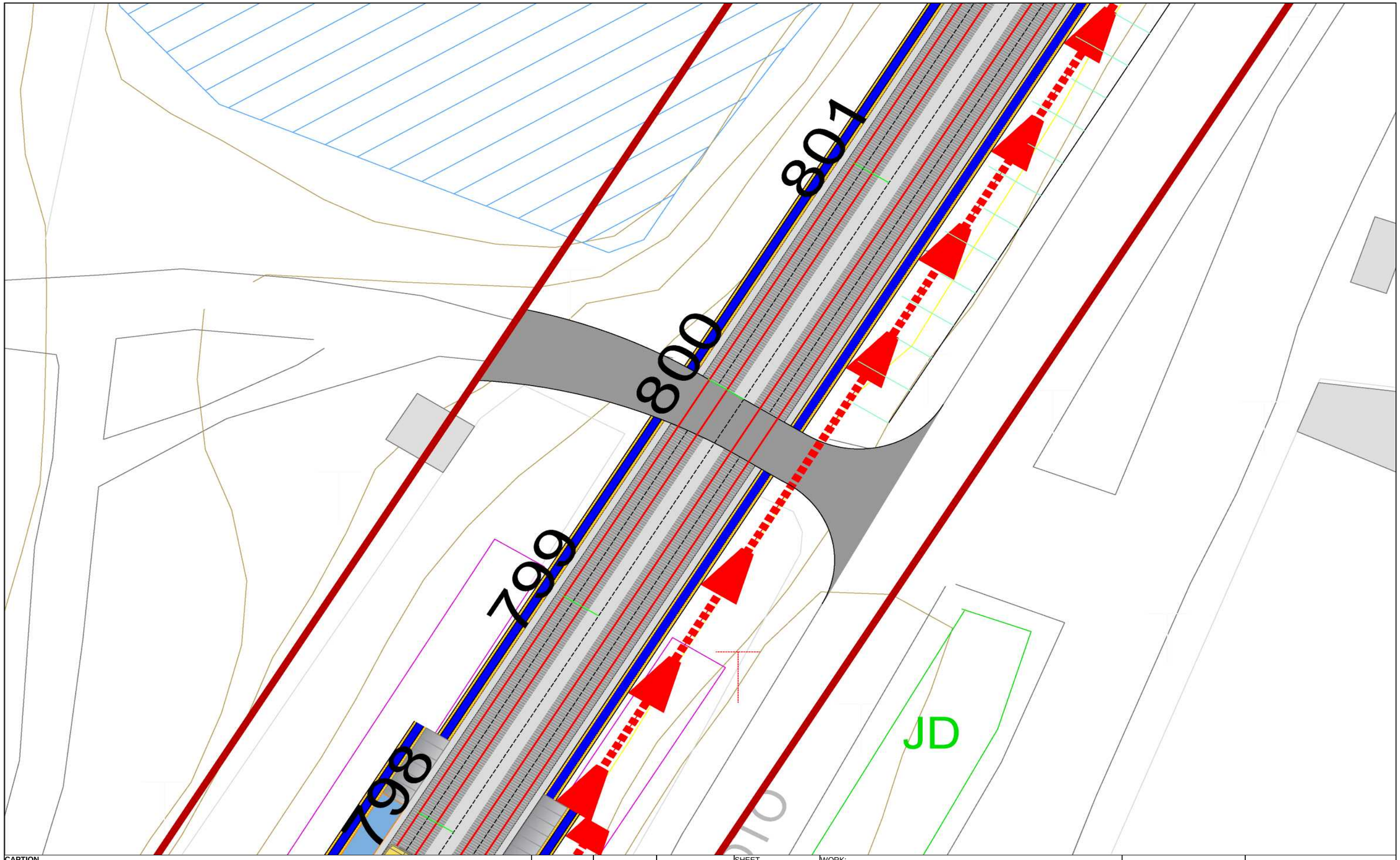


CAPTION				SHEET 03/06	WORK: SECTION - PARIPE - SÃO LUÍS	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /			
	CHECKING		/ /	SCALE 1:250	MUNICIPALITY SALVADOR	
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT LEVEL PASSAGE 03 – PEDESTRIAN – RUA AGENOR FREITAS DE PERIPERI FLOOR PLAN	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				
	NOTE					

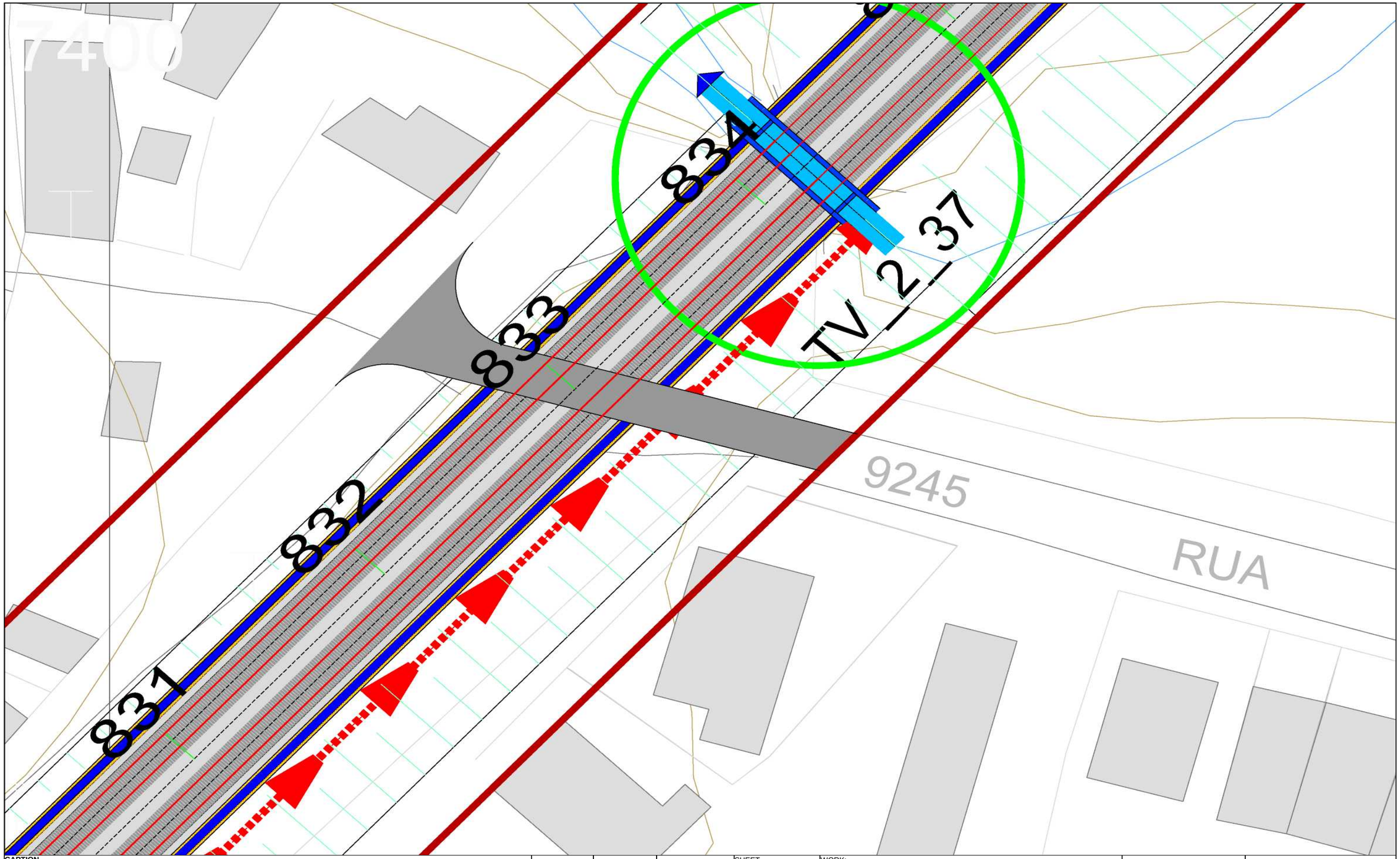


CAPTION				SHEET	WORK: SECTION - PARIPE - SÃO LUÍS	DEPARTMENT OF URBAN DEVELOPMENT	BAHIA GOVERNO DO ESTADO / CJB
	DRAWING		/ /	04/06			
	CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR		
	APPROVAL		/ /	1:250			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT LEVEL PASSAGE 04 – PERIPERI YARD FLOOR PLAN	LIGHT-RAIL VEHICLE LRV	
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA					
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA					
	NOTE						

Robério Bezerra & Cynthia Brito & André Cury



CAPTION				SHEET 05/06	WORK: SECTION - PARIPE - SÃO LUÍS	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /		MUNICIPALITY SALVADOR	
	CHECKING		/ /	SCALE 1:250		
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT LEVEL PASSAGE 05 – COUTOS FLOOR PLAN	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				
	NOTE					



CAPTION				SHEET 06/06	WORK: SECTION - PARIPE - SÃO LUÍS	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /			
	CHECKING		/ /	SCALE 1:250	MUNICIPALITY SALVADOR	
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT LEVEL PASSAGE 06 – PARIPE FLOOR PLAN	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				
	NOTE					

Drainage

The drainage system deployed at the time of construction of the railroad was supported in traditional capped gully holes, short and open at the top, for easy cleaning and maintenance, usually located in the thalweg crossing lines of each valley formed along the coast. These unique structures endured for over 150 years and continue to function despite the increase in the local soil sealing due to disordered and dense anthropic occupations, initially bordering the railroad and then climbing all the slope that border the whole suburb.

With the occupation came the garbage, erosions resulting from opening of upstream ditches to build housing, promoting a growing and constant silting process, partially clogging the whole system. The increasing soil sealing, is now verging values of about 80%, difficult to be admitted years ago.

The degradation process of the whole railway system, including operation and maintenance, has affected the entire drainage system, which currently has the entire system of damaged and clogged gutters and gully holes operate with no more than 30% of its drainage capacity.

Living with this degradation scenario has become natural behavior, inducing a routine admission of stopping the services in the event of flooding due to heavy rains.

The upstream contributions due to the large number of retentions by localized interference actually favor the flow process if considered the unit of time. However, the almost total blockage of downstream channels has caused constant and large-size flooding, that eventually paralyze transport services, every more intense rain.

With the Redevelopment Design of the Railroad for use of lighter and lower vehicles - LRV, the situation worsens requiring measures in order to re-evaluate the functionality condition of the existing drainage systems.

It is not enough to build broader crossings because the critical element is the release discharge channel.

Because it is a track bordering the coast, the railroad deployment heights are very close to the tidal variations heights, the region reaches values of about 1.80 m at its maximum average variation, extraordinarily reaching values of about 2.20 at maximum variation *maximorum*. Thus, the deployment heights are limited by the annual variation of the tides damaging even more the release conditions in the receiving body, the sea.

As a preliminary measure, it is essential, therefore, a geometrized cleaning of the release channels to the sea, taking into consideration that the entire area is partially occupied.

The indication of natural structures capped due to the recovery of facilities, expansion and even maintenance and cleaning, as well as its functionality feature, even with the height limitation imposed by the height difference between the lower generatrix of the device and variations in tidal heights.

It must also provide these wings gully holes structured with angle opening of 45 degrees to improve the loading and unloading conditions and in consequence of the conveyed flow.

It should also be incorporated in the opportunity of preparation of the Basic Design, lined and structured load and unload ditches for crossing flows, within the Right of Way.

The side-longitudinal ditch system should be recomposed, for recovery of those existing, if possible, or through incorporation of new ones.

In the preliminary design indicated, as appropriate, the deployment of an extensive line of deep drains in order to channel the basis contributions from the neighboring side slopes, as to dissipate results of the hydraulic gradient due to the height difference in saturated areas and, the main purpose, lower the water level in order to remove it from the superstructure of the permanent track.

As a result of human occupation marginal to the railroad, it has been routinely released garbage, building materials debris and other debris on the surface of the right of way, scattered and stacked making difficult the natural runoff conditions.

In order to remedy this latter situation, it was indicated a geometrized regularization of the entire right of way, where possible, to direct the surface runoff into the side drainage channels.

Studies and consequent Design presented in the preliminary design has merely conceptual purpose, in order to establish principles and parameters to be considered in the preparation of the Basic Design, involving and incorporating new knowledge during the preparation of records and surveys, as well as the need for evaluation of the existing drainage systems in the streets of the towns that abound and cross the railway.

It was incorporated in the preliminary design, aiming functionality optimization, aggregation of smaller contribution basins directed to more appropriate points of release.

Points given for crossing were in principle directed to the existing structures, but it considers that the priority should be the release conditions, due to height restrictions related to the change of tides already referred to above. Consequently, it is expected that in the preparation of the Basic Design is indicated a qualitative and quantitative reordering, of these structures consisted of the evaluation of data resulting from topographic registration.

Time of concentration

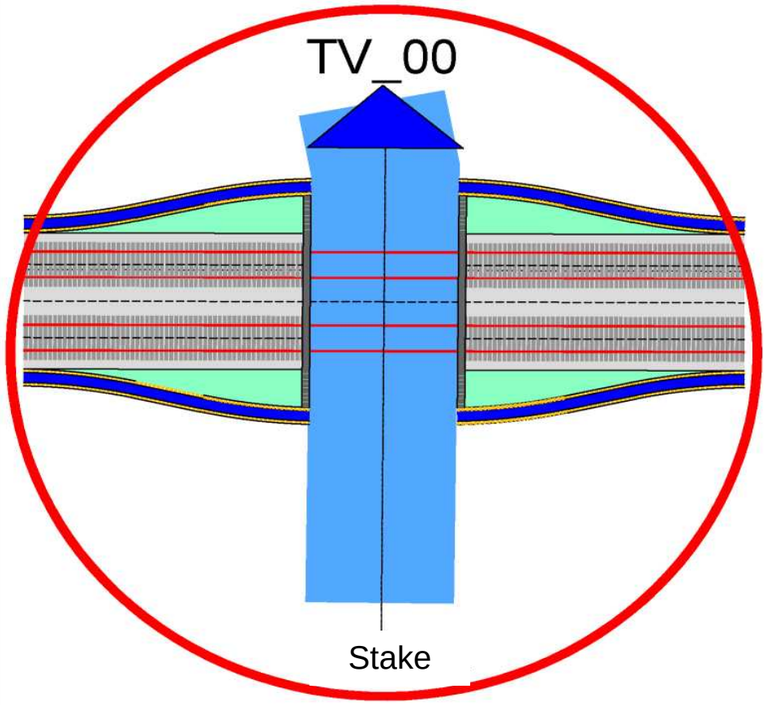
AC	Area	Extension	Height Diff.	Slope	t_c
number	m^z	L - m	H - m	%	minutes
TV_2_01	269.67	2,673.00	68.50	2.56	34.86
TV_2_02	22.18	928.00	68.50	7.38	10.27
TV_2_03	11.13	725.00	68.50	9.45	7.72
TV_2_04	7.15	237.00	71.50	30.17	5.00
TV_2_05	13.15	269.00	63.50	23.61	5.00
TV_2_06	3.71	591.00	68.50	11.59	6.10
TV_2_07	27.85	228.00	68.50	30.04	5.00
TV_2_08	6.82	580.00	60.50	10.43	6.26
TV_2_09	36.50	269.00	63.50	23.61	5.00
TV_2_10	4.06	768.00	68.50	8.92	8.26
TV_2_11	1.60	269.00	63.50	23.61	5.00
TV_2_12	1.88	269.00	63.50	23.61	5.00
TV_2_13	13.53	269.00	63.50	23.61	5.00
TV_2_14	1.95	146.00	23.50	16.10	5.00
TV_2_15	11.95	283.00	45.50	16.08	5.00
TV_2_16	1.87	231.00	51.50	22.29	5.00
TV_2_17	1.96	212.00	52.50	24.76	5.00
TV_2_18	2.52	242.00	58.50	24.17	5.00
TV_2_19	2.27	113.00	36.50	32.30	5.00
TV_2_20	2.42	236.00	56.50	23.94	5.00

Time of concentration

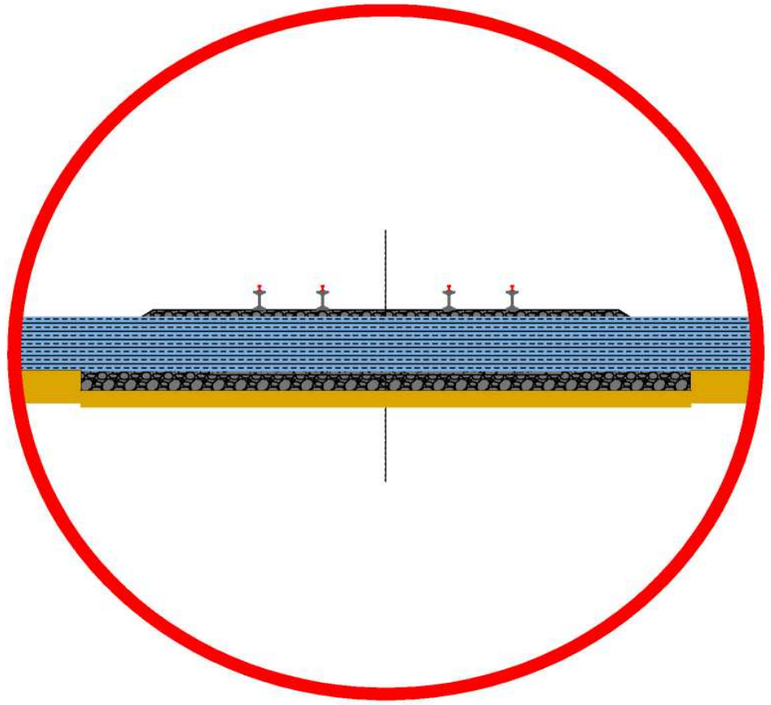
AC	Area	Extension	Height Diff.	Slope	t_c
number	m^2	L - m	H - m	%	minutes
TV_2_21	2.17	303.00	57.50	18.98	5.00
TV_2_22	4.31	348.00	56.50	16.24	5.00
TV_2_23	3.15	134.00	33.50	25.00	5.00
TV_2_24	3.00	764.00	58.50	7.66	8.72
TV_2_25	8.26	436.00	50.50	11.58	5.00
TV_2_26	8,,54	143.00	56.50	39.51	5.00
TV_2_27	29.94	753.00	60.50	8.03	8.46
TV_2_28	19.96	511.00	80.50	15.75	5.00
TV_2_29	51.98	999.00	58.50	5.86	11.89
TV_2_30	3.63	148.00	30.50	20.61	5.00
TV_2_31	5.60	181.00	20.50	11.33	5.00
TV_2_32	19.43	524.00	46.50	8.87	6.16
TV_2_33	49.92	846.00	56.50	6.68	9.94
TV_2_34	20.03	100.00	16.50	16.50	5.00
TV_2_35	14,51	415.00	46.50	11.20	5.00
TV_2_36	14.76	474.00	53.50	11.29	5.20
TV_2_37	94.08	1,436.00	50.50	3.52	19.13
TV_3_01	2.32	100.00	16.50	16.50	5.00
TV_3_02	13.91	522.00	49.50	9.48	5.99
TV_3_03	17.35	326.00	48.50	14.88	5.00

CAPPED GULLY HOLE

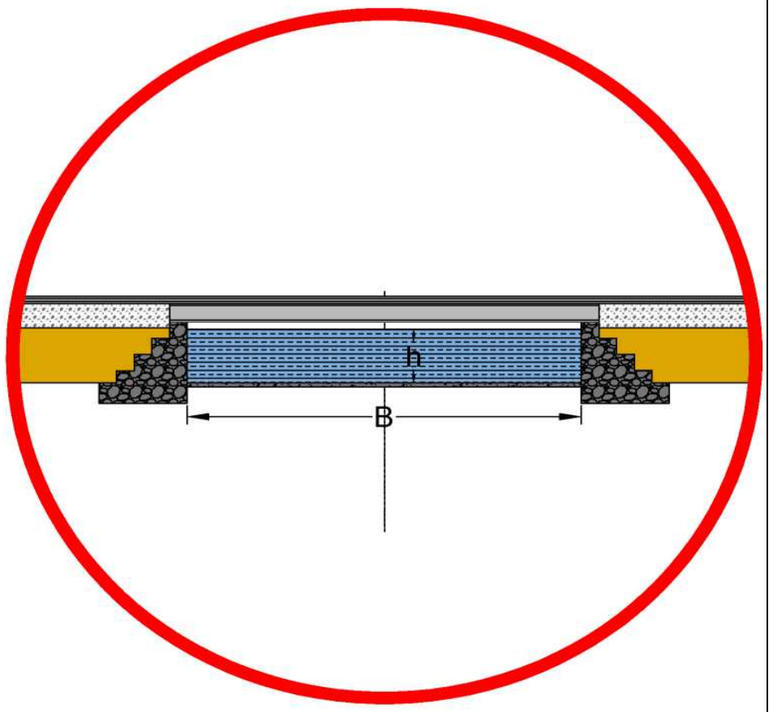
FLOOR PLAN



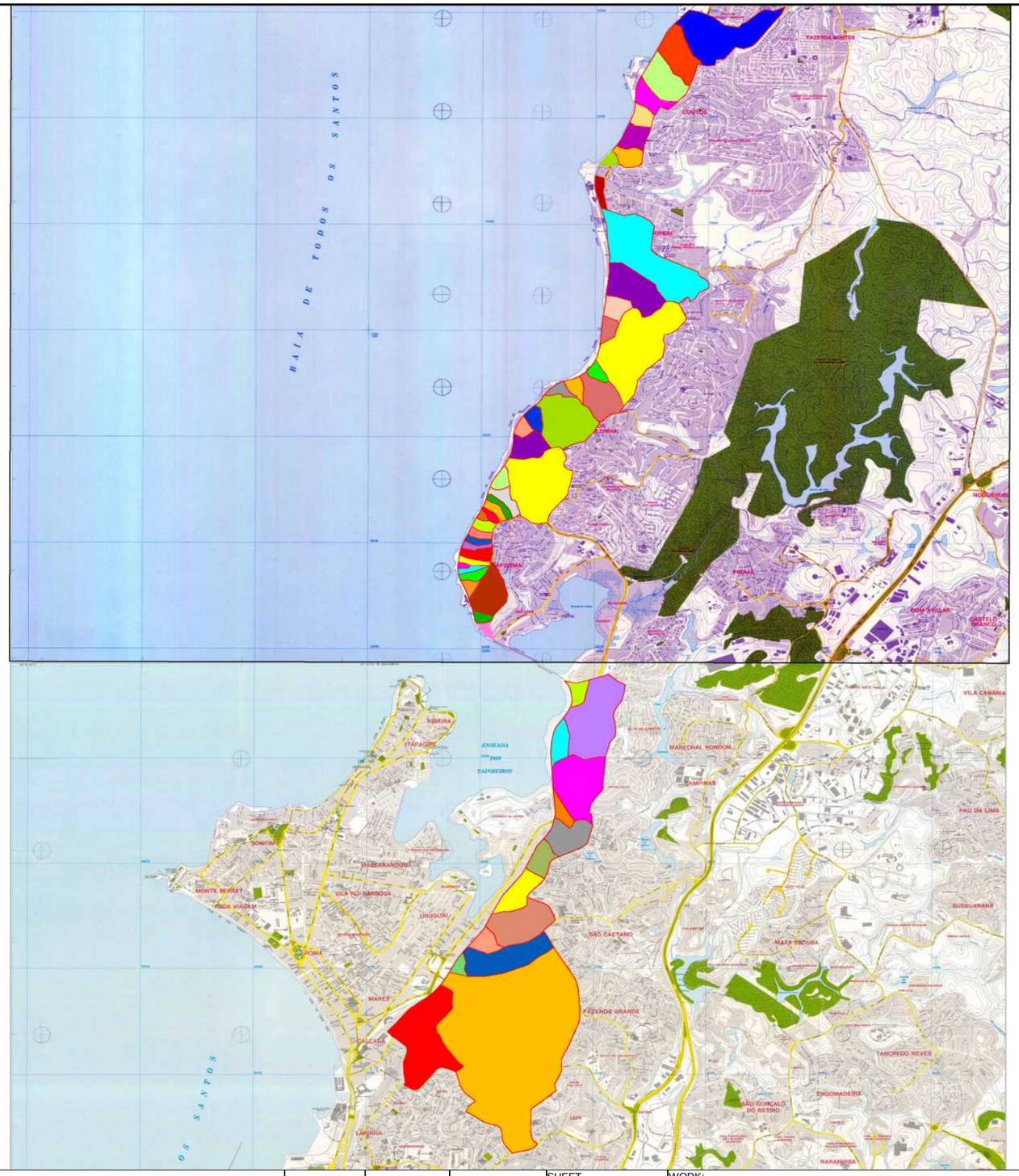
SECTION



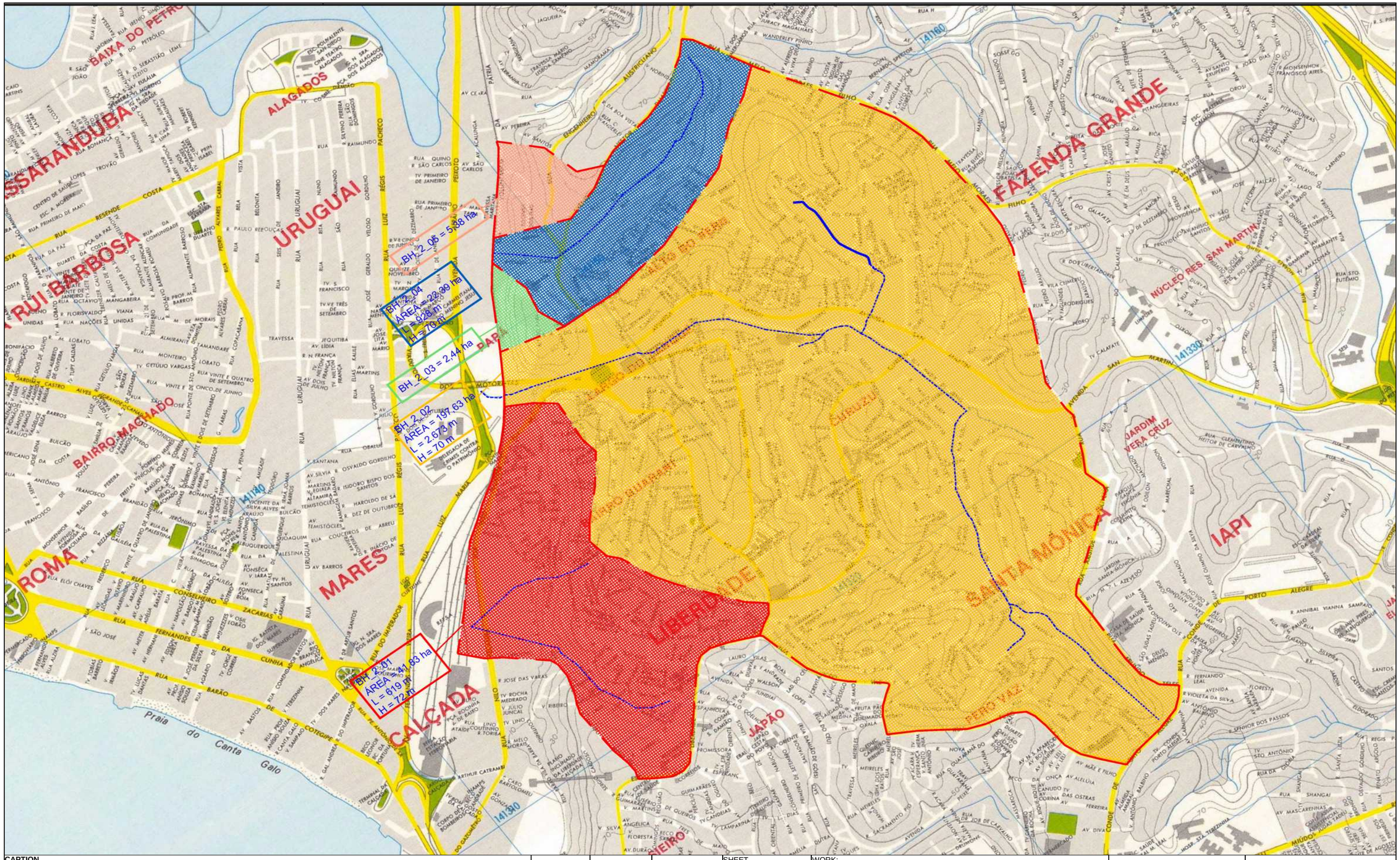
PROFILE



CAPTION				SHEET 01/01	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT	BAHIA GOVERNO DO ESTADO / CJB
	DRAWING		/ /				
	CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR		
	APPROVAL		/ /	NO SCALE			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE - CAPPED GULLY HOLES PLANT, SECTION AND SIDE PERSPECTIVE	LIGHT-RAIL VEHICLE LRV	
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA					
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA					



CAPTION				SHEET 01/01	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /			
	CHECKING		/ /	SCALE	MUNICIPALITY	
	APPROVAL		/ /	NO SCALE	SALVADOR	
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE OF CONTRIBUTION BASINS - BLOCK 2	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				



CAPTION						
	DRAWING		/ /	SHEET 01/07	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR	BAHIA GOVERNO DO ESTADO / CJB
	APPROVAL		/ /	NO SCALE		
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE OF THE CONTRIBUTION BASINS - BLOCK 2_01	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				

Sizing Worksheet

Capped Gully Holes - Sizing

Crossing	01	Tr =	25	C	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_01	0.20%	34.86	242.22	269.67	36,055.99	2.75	11.00	1.20	1.19

This block consists of four basins, two large-, one medium- and one small-size. The first is part of the so-called Calçada Basin, it has its upstream limits on the slopes of the Liberdade slope, descending sharply into intense short-term floods, but causing significant flooding.

The second basin, the largest in the suburban region called Baixa do Fiscal Basin, though its course is in lowland area with extremely long concentration time of 36.86 minutes, currently suffers flow retentions due to conditions of flow restriction along the entire course. The Municipal Government of Salvador, is studying the possibility of channeling the entire course with coating. This basin has been responsible for major flooding in the section of the railway crossing leading almost always stoppages of the transit of locomotives.

The sections for release of the railroad crossings to the sea, its receiver body, are relatively long and are completely blocked, requiring cleaning services. This situation should deserve the Basic Design, detail for correction to the full functionality of the release structures.

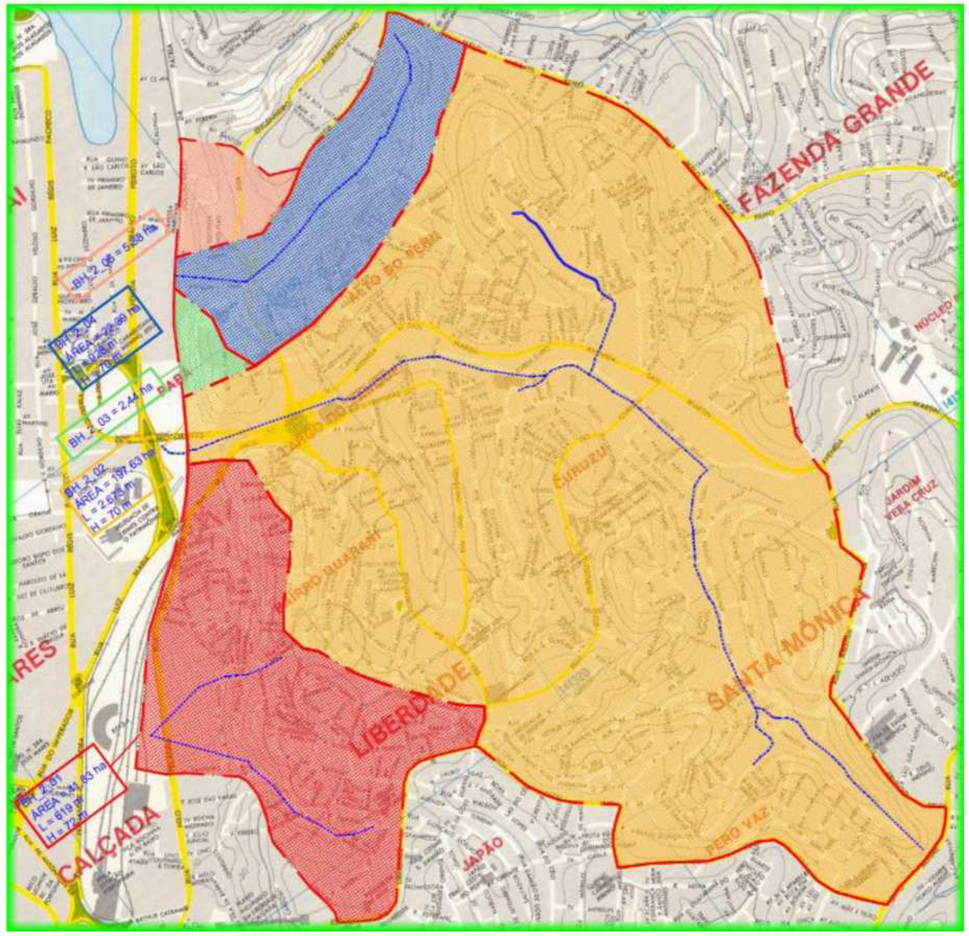
The existing crossing structures are damaged and its capacity is impaired due to growing waterproofing due to the progressive land use. We used a waterproofing coefficient of 0.80 and a 25-year recurrence period obtaining in this situation a speed of 2.75 m/s, very close to the self-cleaning speed (3 m/s).

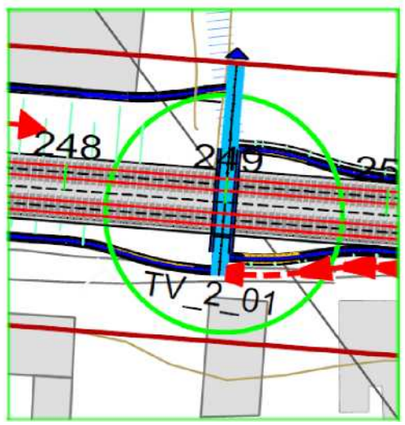
In the opportunity of the basic design, it must be checked capabilities of each flow compared to the flow section of the existing structures and suitably expanded, if necessary, in addition to structural improvement, if any. Most existing longitudinal ditches for flow within the right of way, are also damaged and need to be recovered and constructed where required.

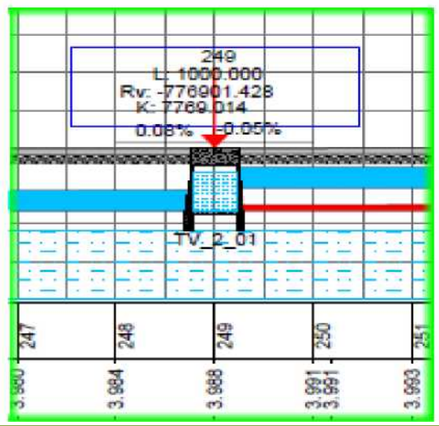
The place for deployment of this structure limits the height for the flow section due to the influence of tidal height differences that have a variation of about 1.80 m. The choice in the preliminary design for capped gully holes was due to the latter restriction and also in an attempt to shorten the length of the structures preventing water circulation in these conditions, in long covered sections. Such structure facilitates cleaning and maintenance.

In order to conform the surface of the marginal portions of the railroad bed within the right of way, it was provided a geometric adjustment of flow direction toward the side ditches, alternated for convenience of situations depending on the best position for the location of side flow ditches (see chart on the right indicating the smoothed direction slopes in blue color). This condition may favor the grouping of basins for centering crossing points - TV, whenever possible and appropriate.

Block 2_01 - Baixa do Fiscal Basin







In this case, it was indicated the grouping of the four basins in single output, in order only to optimize release conditions.

At each crossing - TV, it should be built, loading and unloading covered ditch with geometry matching the type and angle of the wings used within the limits of the right of way, proceeding from the unloading ditch with cleaning and unblocking of the existing channel until its release point at sea. At some points, depending on the flow section considered, especially with respect to the heights, you may need to consider the backwater effects, due to tidal influence.

The ditch crossing TV_2_01 was strategically placed near the stake 249, in order to facilitate the geometric orientation of the side ditches to this point due to the existence of a large extent of small slope section, very close to the top. At this point the release gets closer to the receiving body - the sea.

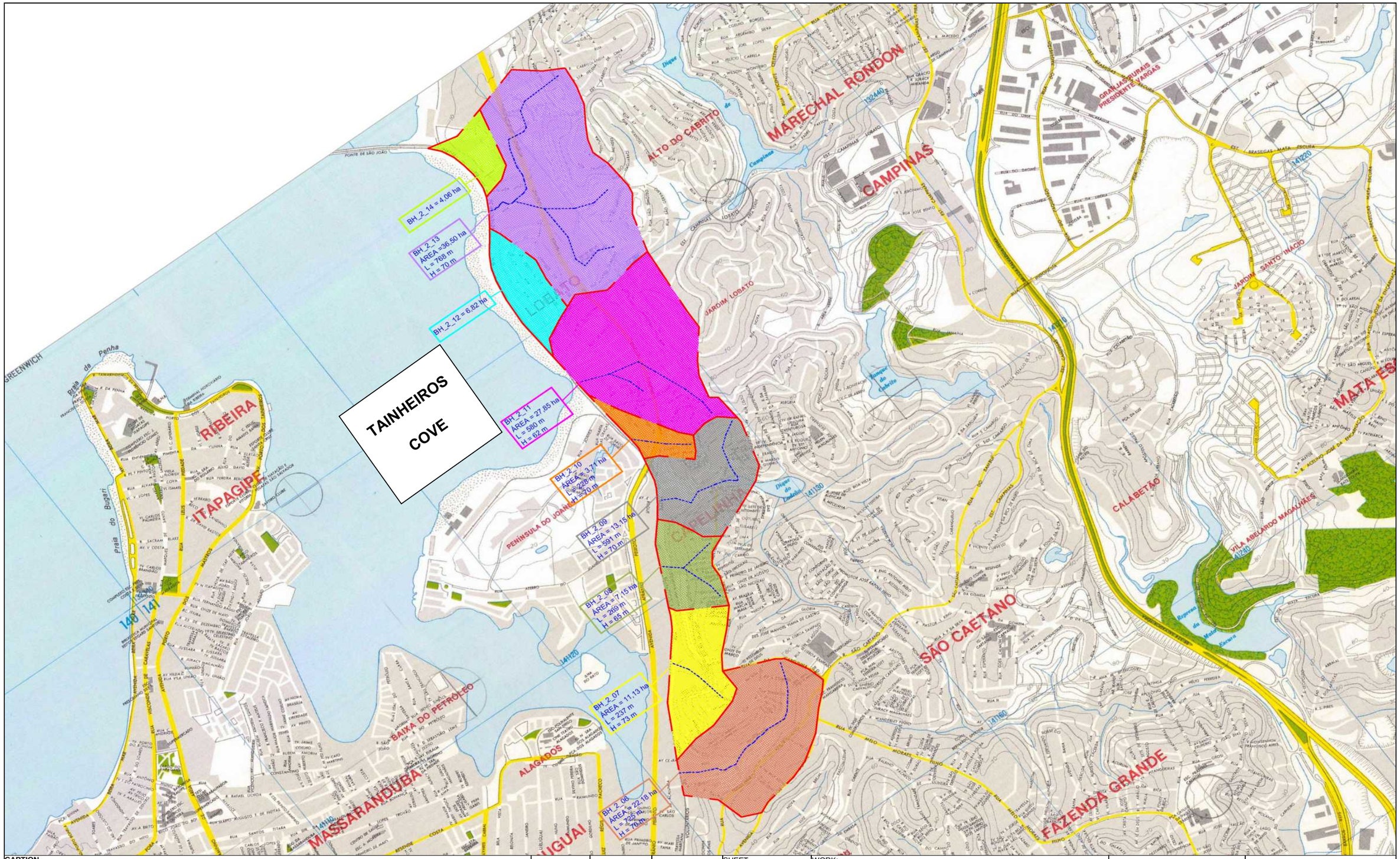
From stakes 289 to 254 on the right side, it was noted a deep drain because of the basic contribution, due to the significant hydraulic gradient generated by the slope, in this last section. In some places of the previous sections there is the same kind of contribution, but it was not possible to point out deep drains due to the presence of water from the beds, influenced by the presence of tide occurring at the approximate height of 1.80 m. The contribution limit of this block is near the stake 255, top.

As you can see in the next picture, the existing side ditches are blocked and structurally damaged requiring functional and structural recovery.

At this place, close to the release (Viaduct of Baixa do Fiscal), one can notice the exuberance of vegetation within the right of way and the occupation of the anthropic action, it has hindered the flow of water, moistened the soil, contaminating the base of the railway superstructure and even the surface of the ballast.

On the occasion of preparation of the Basic Design, this location indication for deployment of the Valley Crossing - TV_01 may be revised, if appropriate, in order to obtain the most appropriate location for combination of load conditions, flow, unload and release.

This crossing is the one with the most adverse conditions for its deployment, both in respect of spaces available, and small slope and difficulties in the channel for release, as limiting the height of the flow section.



CAPTION						
	DRAWING		/ /	SHEET 02/07	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	CHECKING		/ /	SCALE	MUNICIPALITY	BAHIA GOVERNO DO ESTADO / CJB
	APPROVAL		/ /	NO SCALE	SALVADOR	
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			DRAINAGE OF THE CONTRIBUTION BASINS - BLOCK 2_02	
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				

Sizing Worksheet

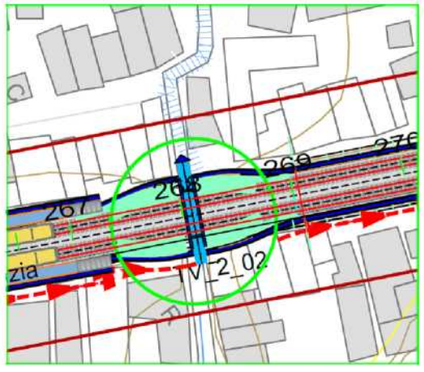
Capped Gully Holes - Sizing

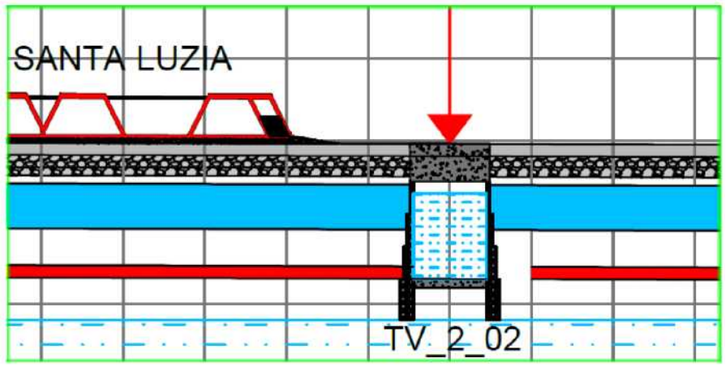
Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_02	0.20%	10.27	362.01	22.18	6,423.48	1.99	3.50	1.00	0.92
TV_2_03	0.20%	7.72	383.40	11.13	3,413.78	1.72	2.50	1.00	0.79
TV_2_04	0.20%	5.00	409.84	7.15	2,344.29	1.58	1.50	1.00	0.99
TV_2_05	0.20%	5.00	409.84	13.15	4,311.54	1.84	2.50	1.00	0.94
TV_2_06	0.20%	6.10	398.66	3.71	1,183.23	1.31	1.00	1.00	0.90
TV_2_07	0.20%	5.00	409.84	27.85	9,131.27	2.14	4.50	1.00	0.95
TV_2_08	0.20%	6.26	397.08	6.82	2,166.48	1.55	1.50	1.00	0.93
TV_2_09	0.20%	5.00	409.84	36.50	11,967.38	2.24	5.50	1.00	0.97
TV_2_10	0.20%	8.26	378.69	4.06	1,230.00	1.32	1.00	1.00	0.93

The Basins with release distributed along the railway in Lobato coast, are alternately from small to medium size, with contribution area ranging from a minimum of 3.71 ha to a maximum of 36.5 ha. The hydraulic behavior of these basins is similar, thalweg lines from short to medium length, concentration times ranging from 10.27 minutes to a minimum assumed of 5 minutes, combined with great and medium declivities due to the presence of the slope that offers hydraulic gradient conditions and due to the continuous and expressive contribution of the base.

The speeds achieved due to the deployment conditions and the hydraulic section used are reasonable favoring the self-cleaning conditions.

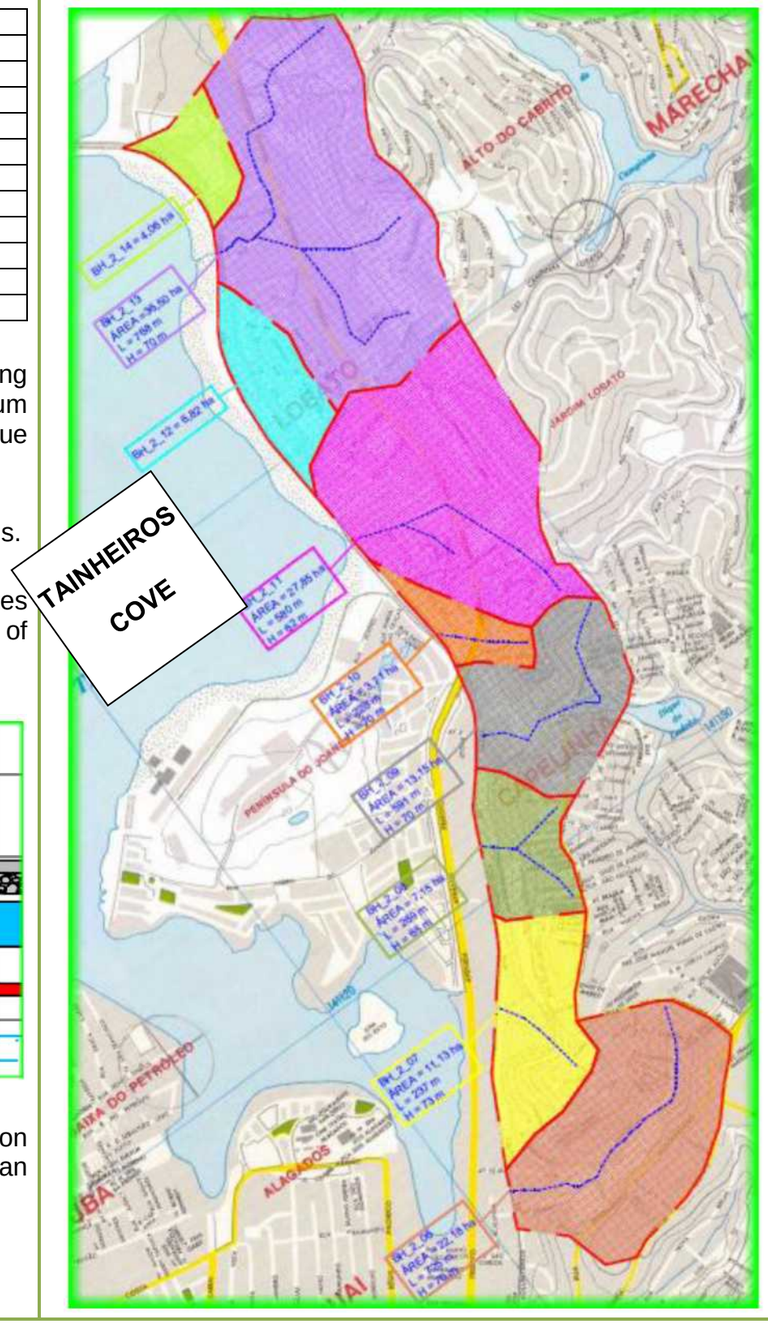
The height limitations due to the presence of the tidal height difference was more dictatorial, in this case, leading to an indication of values equal to 1.00 m only. In this section, it was indicated, due to the proximity of the slopes, pronounced hydraulic gradient and the presence of base contribution, deep drains on the left.



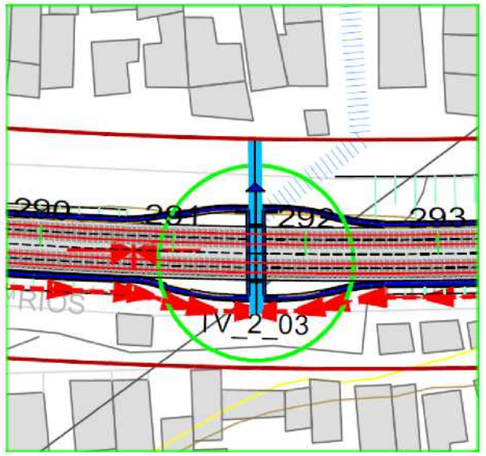


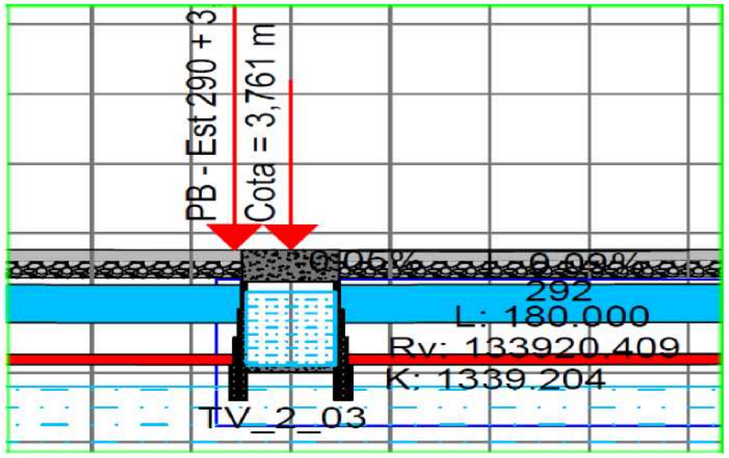
In the crossing - TV_2_02, near Santa Luzia Stop, the conditions for deployment and release are extremely critical, requiring in the preparation of the Basic Design, careful review of the geometrical conditions of load and unload ditches and the release channel, which should be clean and geometrized enough for the full flow of unload flow. It will be maintained in this situation the height limitations in just 1.0 m.

Block_2_02 - Lobato Basins



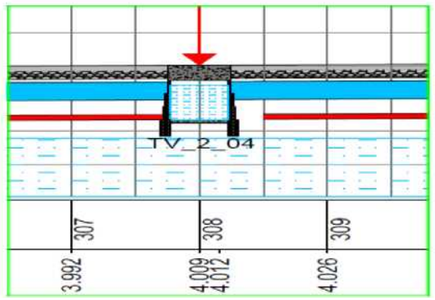
In the crossing TV_2_03, outlined in sequence, with deployment indication, at the Lower Point, the conditions are absolutely resembled to the previous one in all aspects.

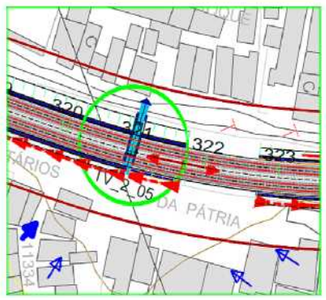


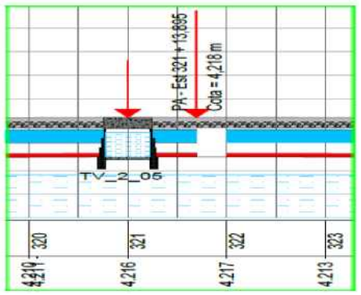


In the crossings TV_2_04 and 2_05, outlined in sequence, with deployment indication, at the stake 308 and 321, the conditions are absolutely resembled to the previous one in all aspects. It is noted the presence of slopes, which are marked in blue arrows, the flow lines and base percolation justifying the indication of deep drains. The regularization lines of the surface to promote the runoff, are indicated on both sides on slopes smoothed directed, in this case into the side ditches to the body of the Permanent Track. The release conditions in this case are difficult and the channel is partially blocked requiring cleaning services and geometric conformation.

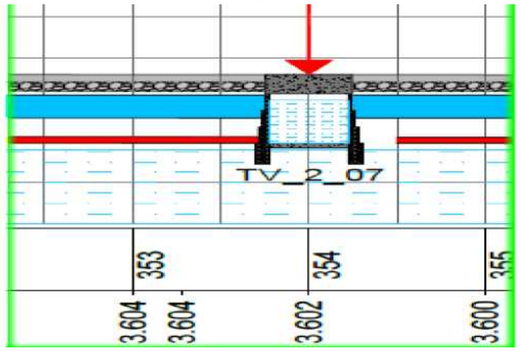
The photo above shows the slope responsible for the basic contribution and the appropriateness of the indications of deep drains.



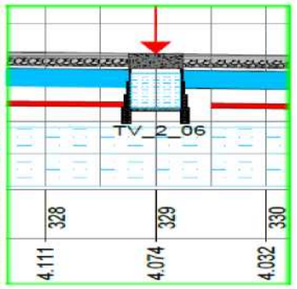




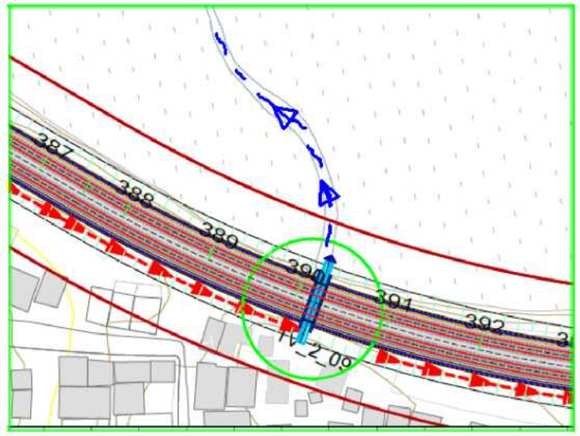
In the crossing TV_2_07, the conditions are more favorable, due to location along the coast, thus not requiring any concerns about the release. It must be made the cleaning and geometrization of loading and unloading ditches within the limits of the right of way, evaluation of structural conditions and hydraulic capacity of the existing work and repairs and expansions that are necessary.

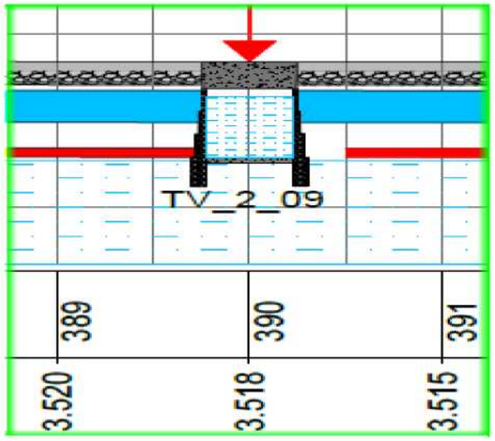


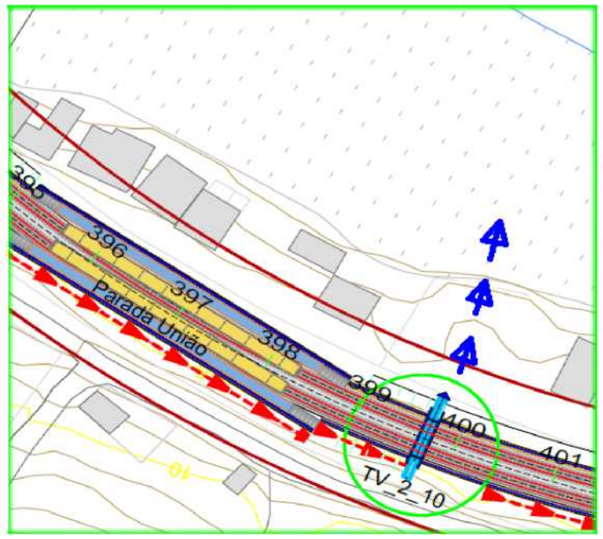
In the crossing TV_2_06, the situation is absolutely identical, highlighting major difficulties with regard to the release conditions in the receiver body - the sea. In the preparation of the Basic Design, it will be necessary to reassess the release location with the purpose of moving it a little further from the Viaduto Suburbana Stop.

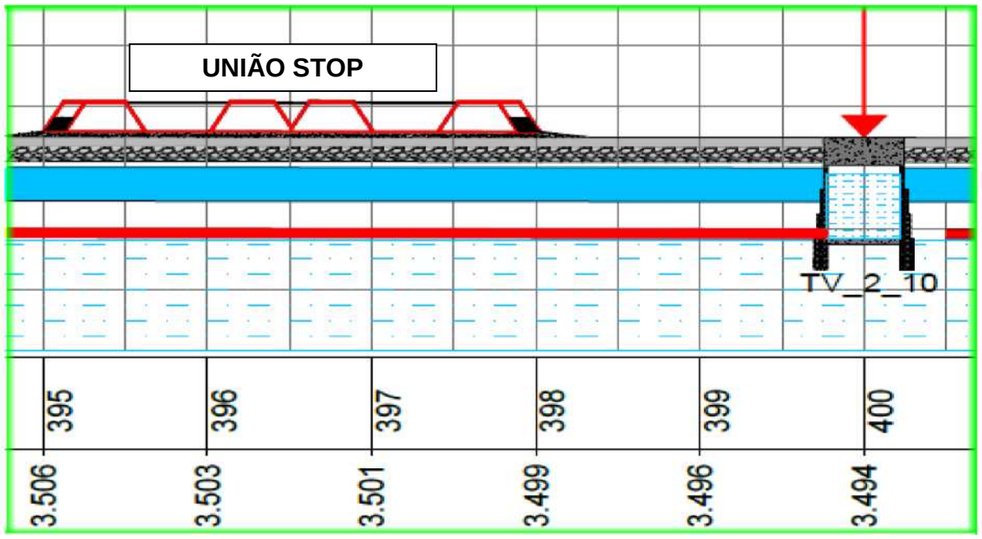


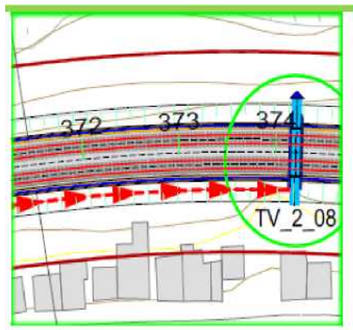
In the crossing TV_2_08, the conditions are absolutely equal to those registered for Crossing 2_07.

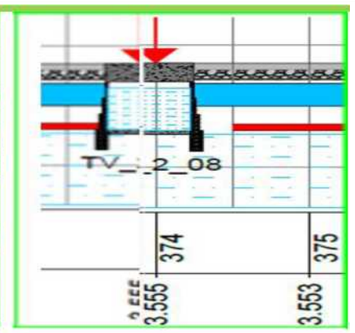










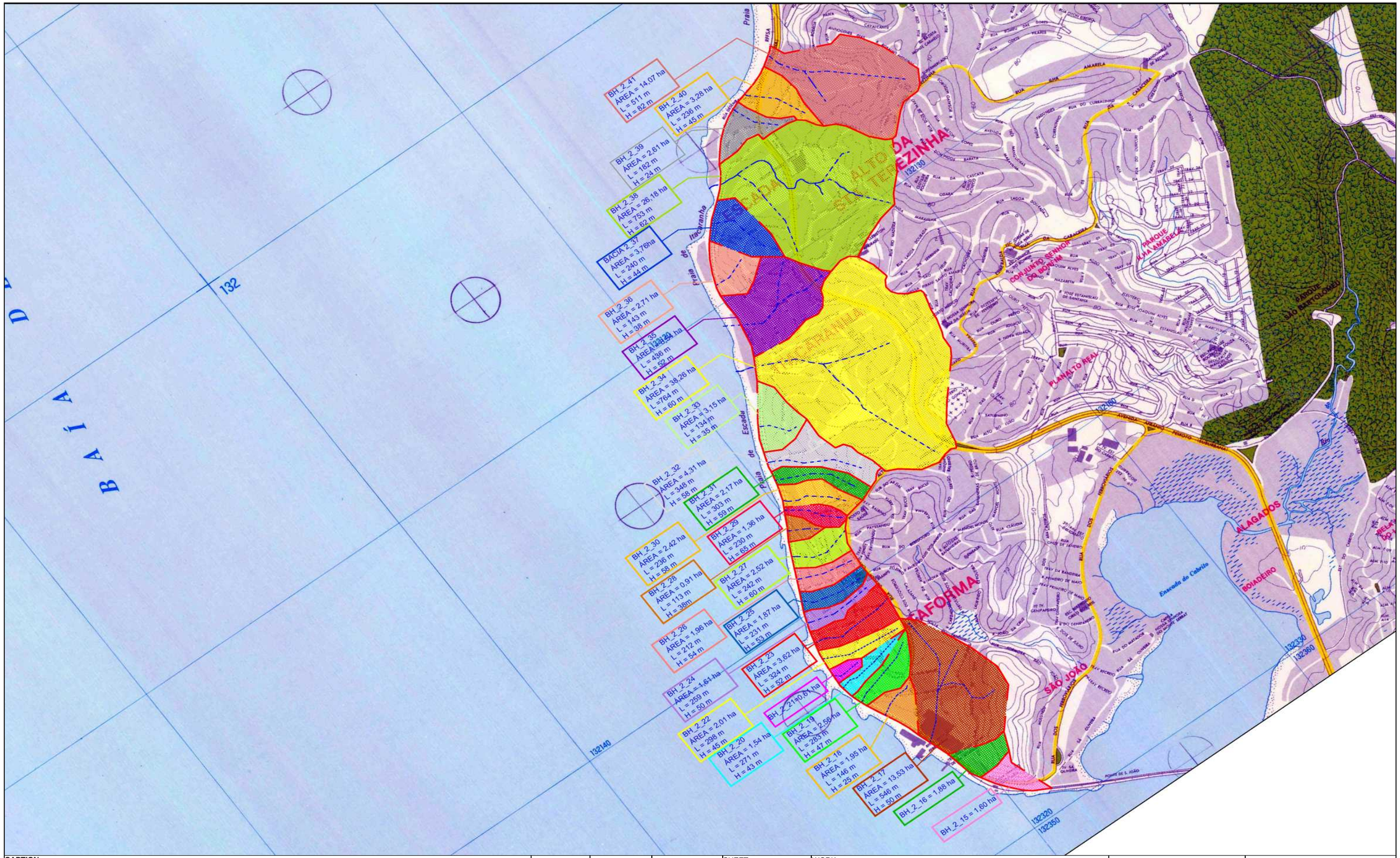


The Thalweg Crossings TV_09 and TV_10 also have the same situation with respect to the structural conditions and hydraulic capacity, and should be reviewed on the occasion of the preparation of the Basic Design.

There is no concern regarding the release conditions, because they will be deployed near the sea and must be cleaned and reconditioned.

In all cases, deep drains were deployed on the left side.

We conclude thus, we conclude the comments considered relevant on the Block B_02, to be considered at the time of preparation of the Basic Design, when these concepts will be evaluated, enhanced and reconfigured, if necessary to the correct deployment of singular hydraulic structures to be implemented, in whole, in part or expanded due to local circumstances only detected by more accurate topographical cadastral surveys, only required in the Basic Design. The limit factor of this block was São João's Bridge, over the sea.

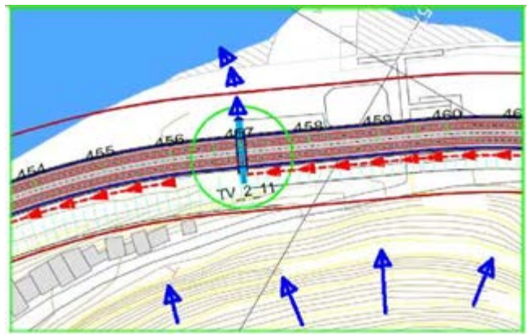


CAPTION						
	DRAWING		/ /	SHEET 03/07	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	CHECKING		/ /	SCALE	MUNICIPALITY	BAHIA GOVERNO DO ESTADO / CJB
	APPROVAL		/ /	NO SCALE	SALVADOR	
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA				
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			DRAINAGE OF THE CONTRIBUTION BASINS - BLOCK 2_03	

Sizing Worksheet

Capped Gully Holes – Sizing

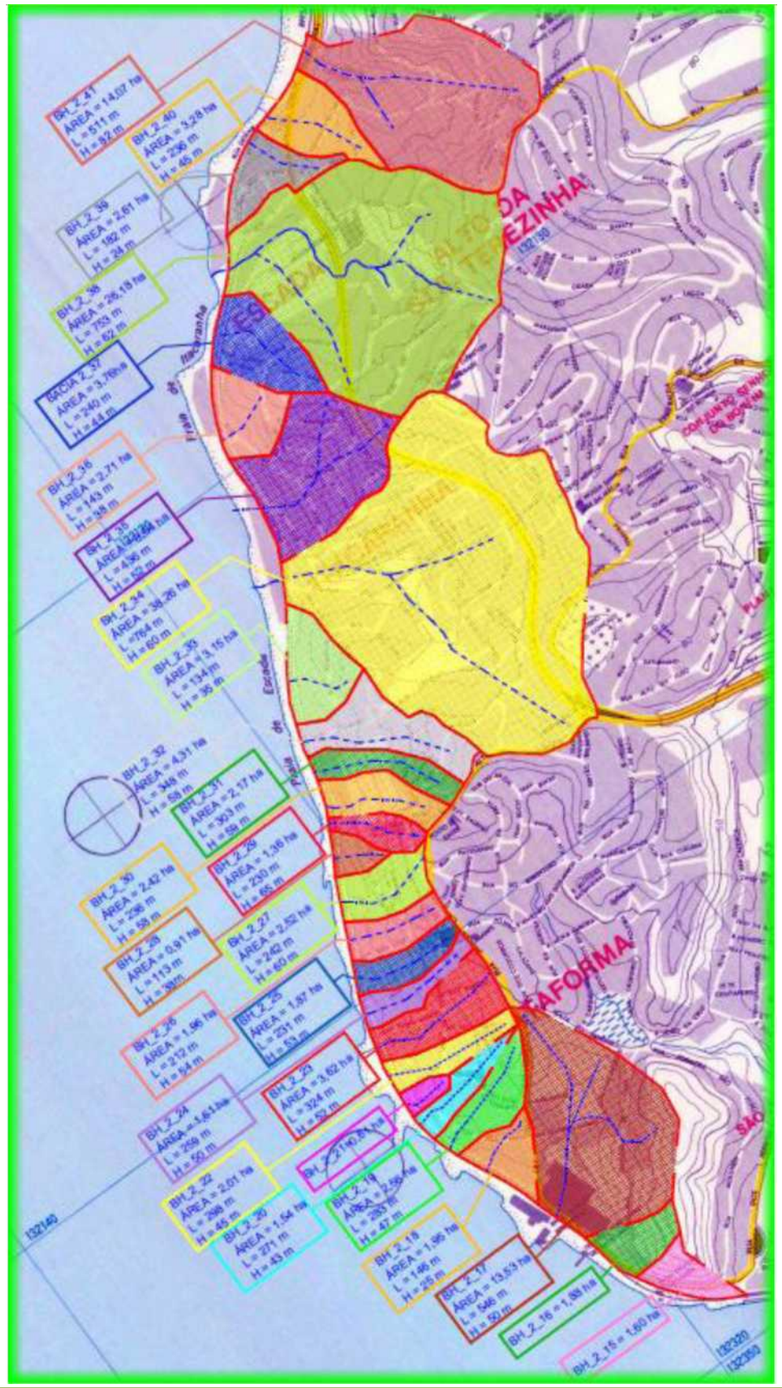
Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_11	0.20%	5.00	409.84	1.60	524.60	1.09	1.00	1.00	0.48
TV_2_12	0.20%	5.00	409.84	1.88	616.40	1.14	1.00	1.00	0.54
TV_2_13	0.20%	5.00	409.84	13.53	4,436.13	1.86	2.50	1.00	0.96
TV_2_14	0.20%	5.00	409.84	1.95	639.35	1.15	1.00	1.00	0.56
TV_2_15	0.20%	5.00	409.84	11.95	3,918.09	1.79	2.50	1.00	0.87
TV_2_16	0.20%	5.00	409.84	1.87	613.12	1.14	1.00	1.00	0.54
TV_2_17	0.20%	5.00	409.84	1.96	642.63	1.15	1.00	1.00	0.56
TV_2_18	0.20%	5.00	409.84	2.52	826.24	1.22	1.00	1.00	0.68
TV_2_19	0.20%	5.00	409.84	2.27	744.27	1.19	1.00	1.00	0.63
TV_2_20	0.20%	5.00	409.84	2.42	793.45	1.21	1.00	1.00	0.66
TV_2_21	0.20%	5.00	409.84	2.17	711.49	1.18	1.00	1.00	0.60
TV_2_22	0.20%	5.00	409.84	4.31	1,413.13	1.39	1.20	1.00	0.85
TV_2_23	0.20%	5.00	409.84	3.15	1,032.80	1.28	1.00	1.00	0.81
TV_2_24	0.20%	8.72	374.69	38.26	11,468.62	2.17	6.00	1.00	0.88
TV_2_25	0.20%	5.00	409.84	8.54	2,800.04	1.66	1.80	1.00	0.94
TV_2_26	0.20%	5.00	409.84	2.71	888.54	1.24	1.00	1.00	0.72
TV_2_27	0.20%	8.46	376.88	29.94	9,027.01	2.13	4.50	1.00	0.94
TV_2_28	0.20%	5.00	409.84	19.96	6,544.35	2.01	3.50	1.00	0.93

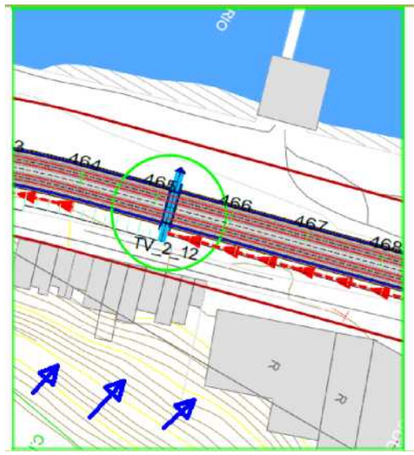


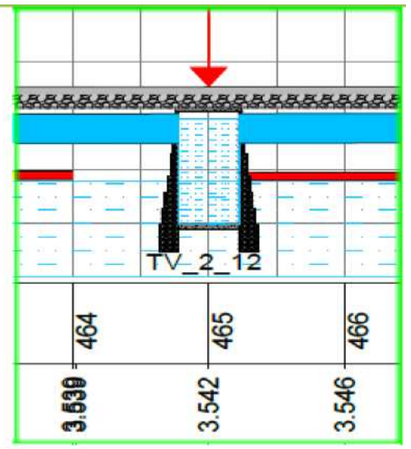
The valley crossing TV_2_11 presents critical height with respect to tidal fluctuations, indicating in consequence a maximum height of 1.00 m in the direction of improvement of release conditions, since the sea is quite close. The rather steep slope on the right side incorporates basic contributions, which led to the appointment of underground drains.

Cleaning and evaluation of existing works with respect to the functional and structural conditions should be made when preparing the Basic Design, including load, unload and release ditches, due geometrized, in order to meet the required flow sections.

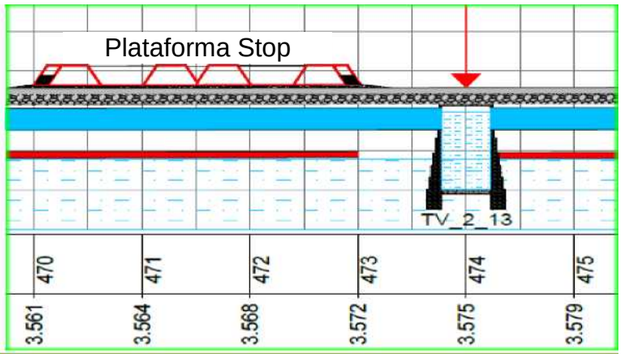
Block 2_03 – Platform Basin



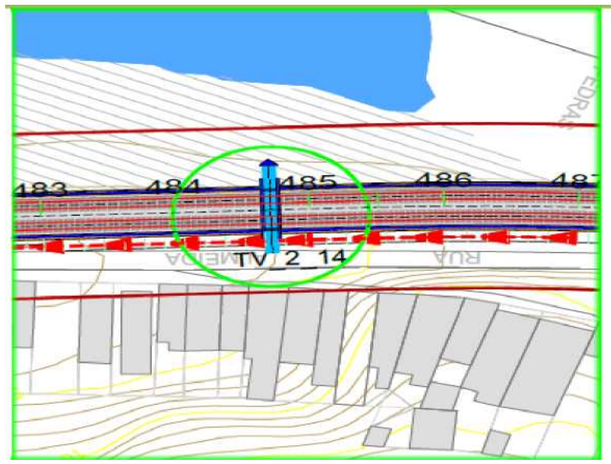


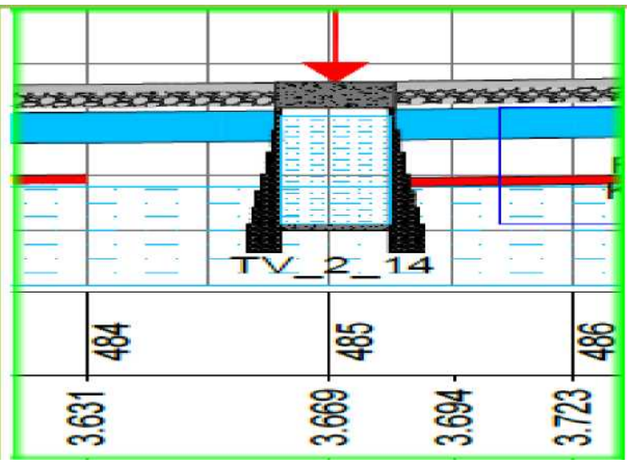


The valley crossings TV_2_12, TV_2_13, 2_14 and 2_15, have the same characteristics and restrictions of the previous TV_2_11.



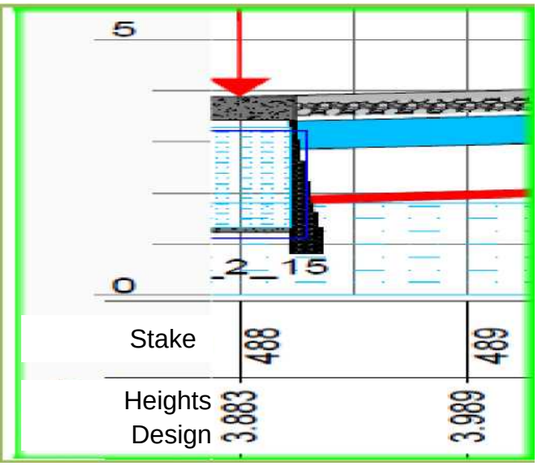
Crossing TV_2_13



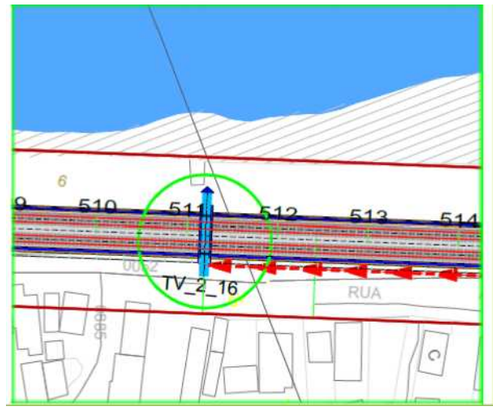


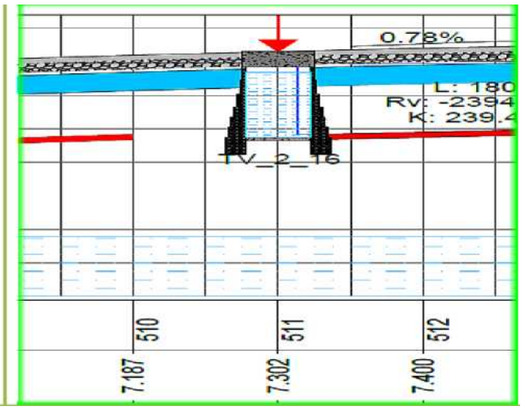
- Crossing TV_2_14

- Crossing TV_2_15



- Crossing TV_2_16

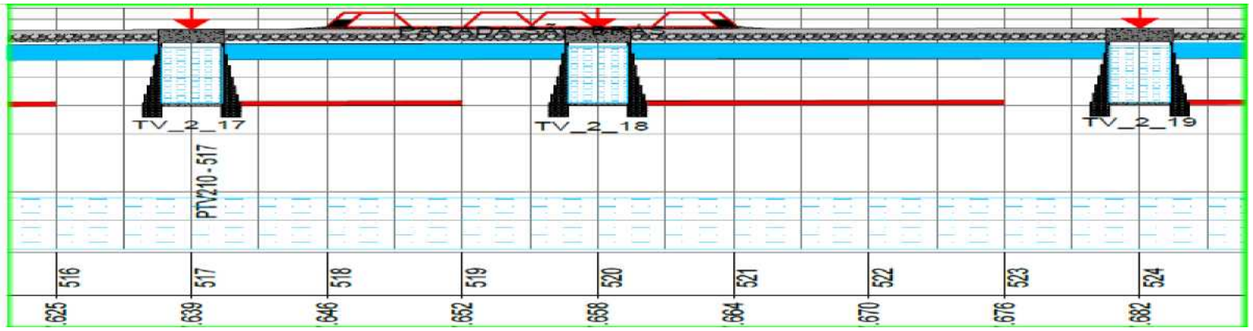




The valley crossing TV_2_16 has the same characteristics and restrictions of the previous ones, except with respect to the deployment condition that does not suffer restrictions of tidal height differences by having their deployment indication in higher heights.

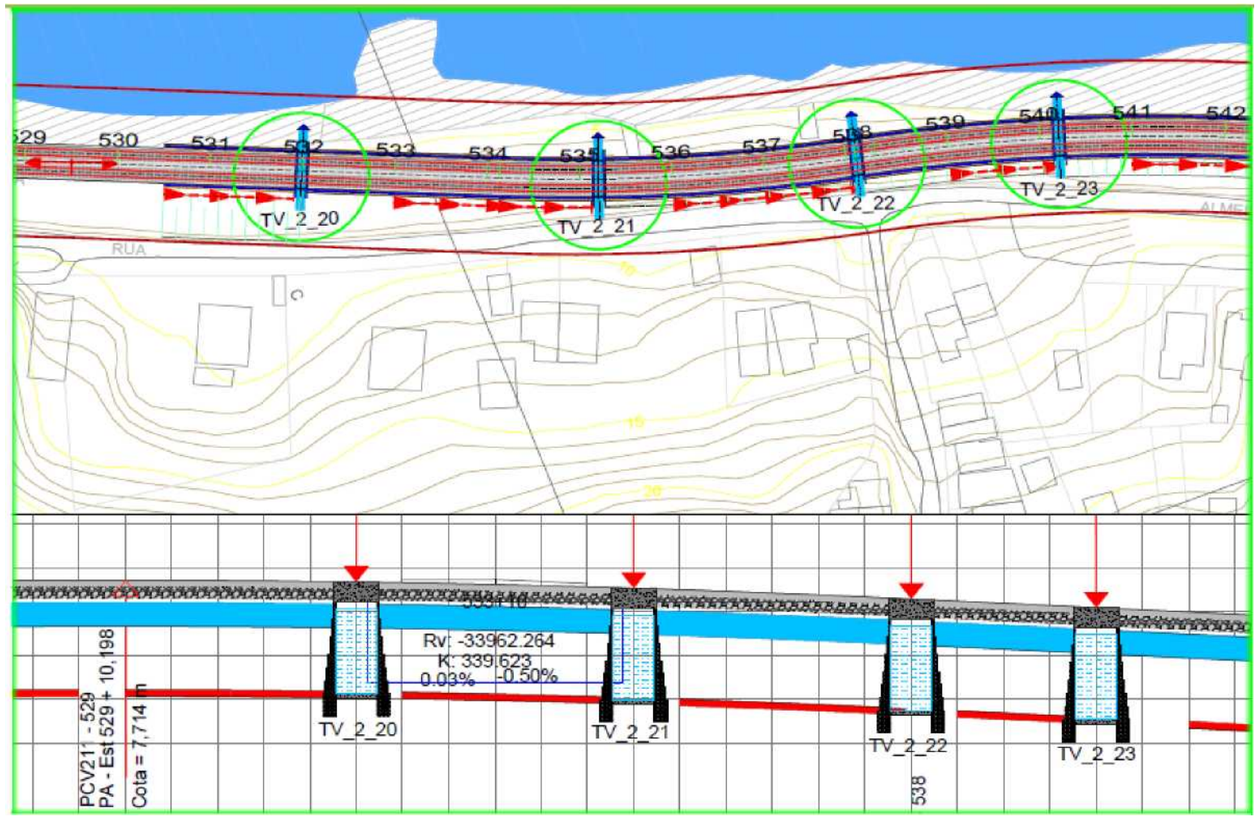
- Crossing TV_2_17, TV_2_18 and TV_2_19

- Crossing TV_2_17, TV_2_18 and TV_2_19



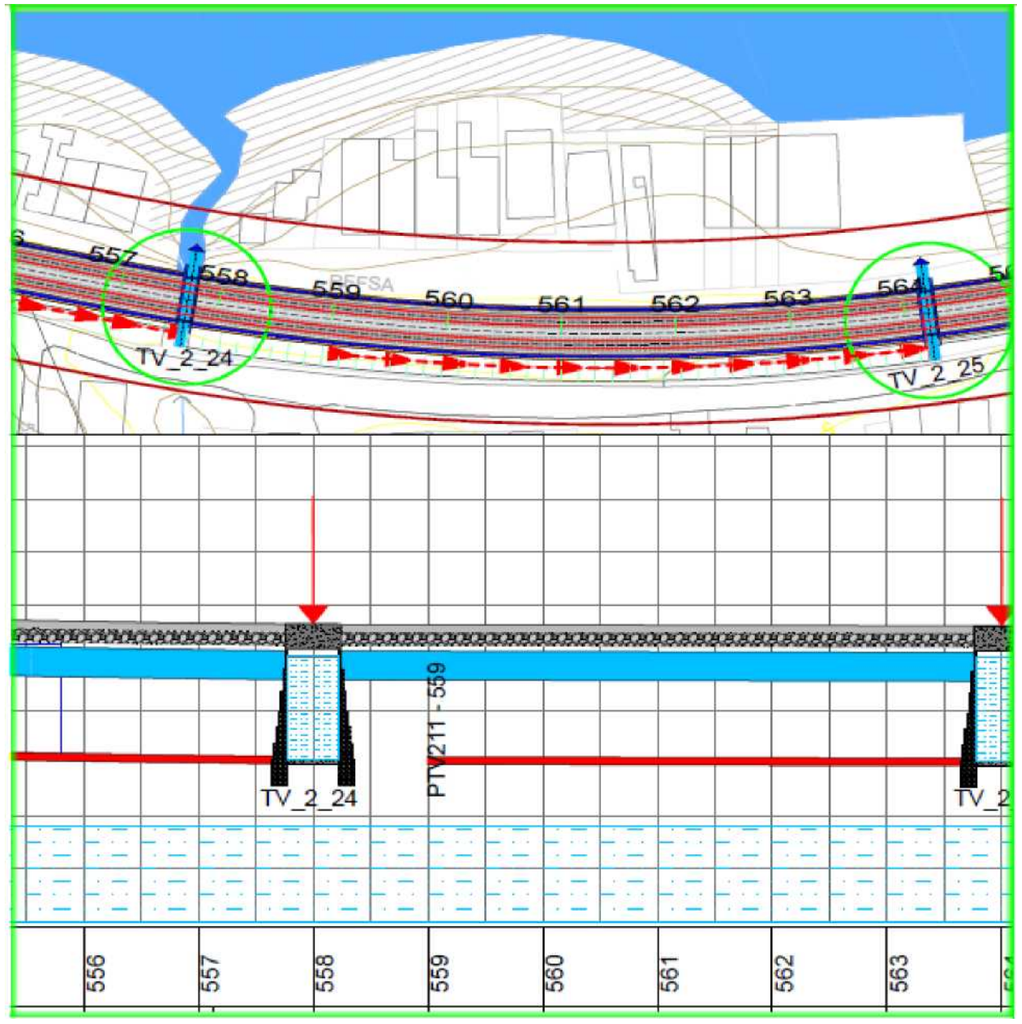
The valley crossings TV_2_17, 2_18 and 2_19 have the same characteristics and restrictions of the previous ones, except with respect to the deployment condition that does not suffer restrictions from tidal height differences, by having their deployment indications at higher heights. When preparing the Basic Design, check the possibility of release unification of these crossings in unique release at the site of TV_2_17, located in the lower height, considering that they are all small-size.

- Crossing TV_2_20, TV_2_21, TV_2_22 and TV_2_23

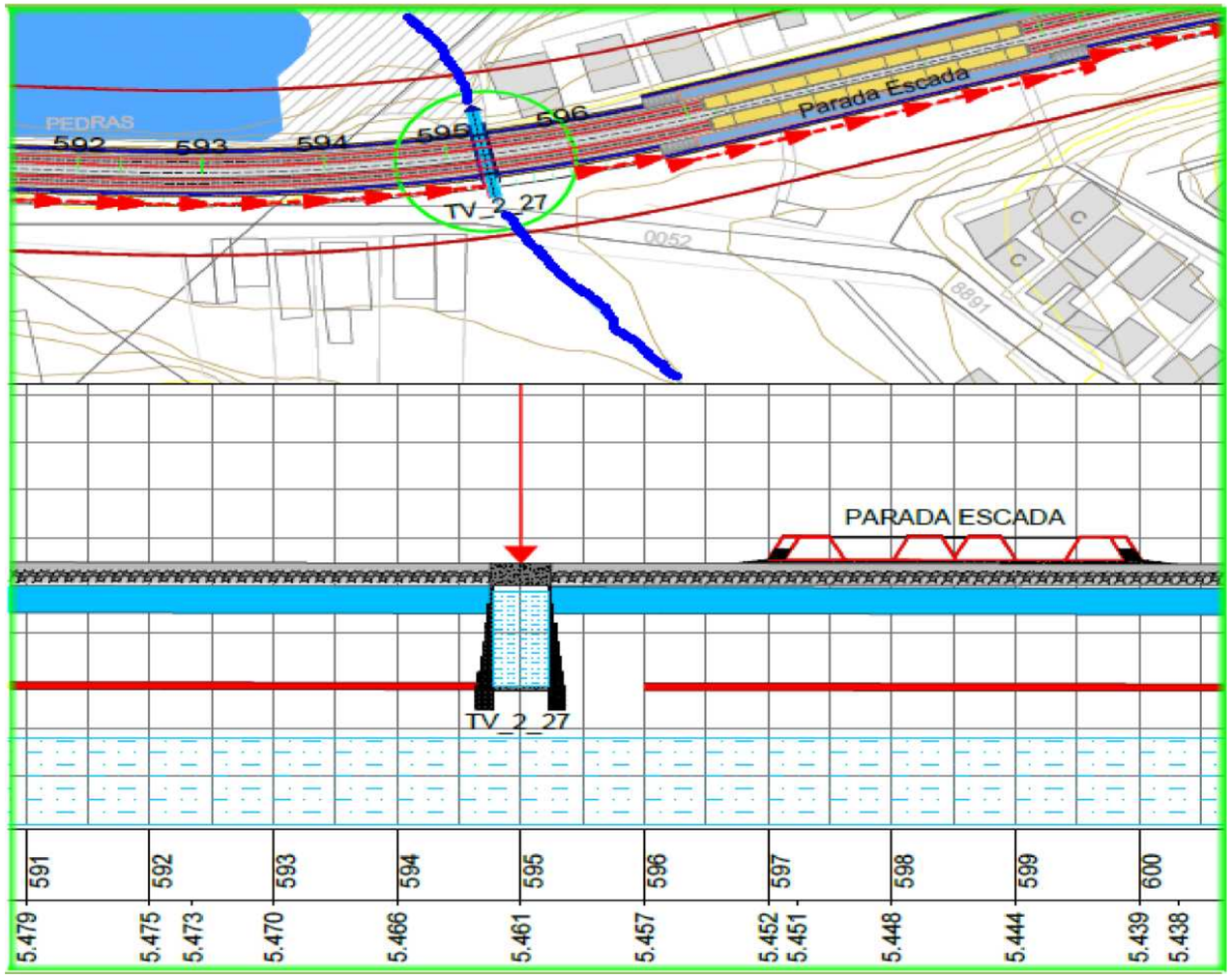


The valley crossings TV_2_20, TV_2_21, 2_22 and 2_23, have the same characteristics and restrictions of the previous ones. When preparing the Basic Design, check the possibility of release unification of these crossings in unique release at the site of TV_2_23, located in the lower height, considering that they are all small-size.

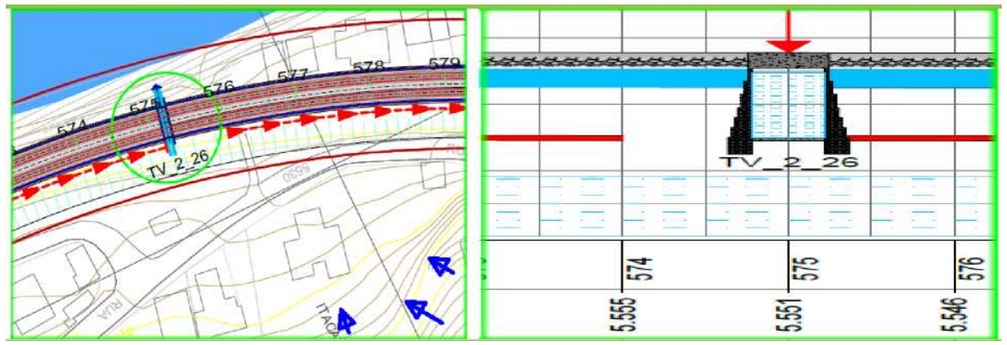
- Crossing TV_2_24, TV_2_25 and TV_2_26



- Crossings TV_2_27

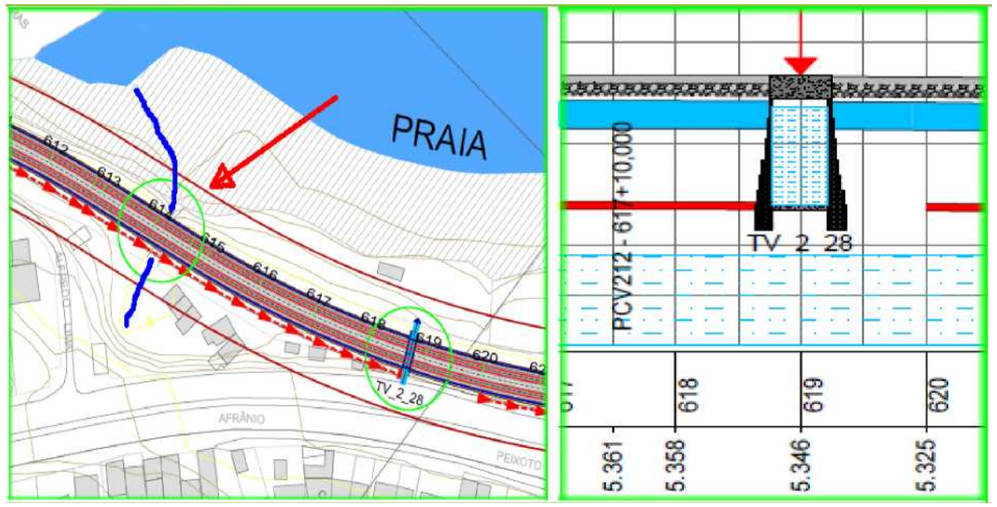


The valley crossing TV_2_27 still has the same characteristics and restrictions of the previous ones.



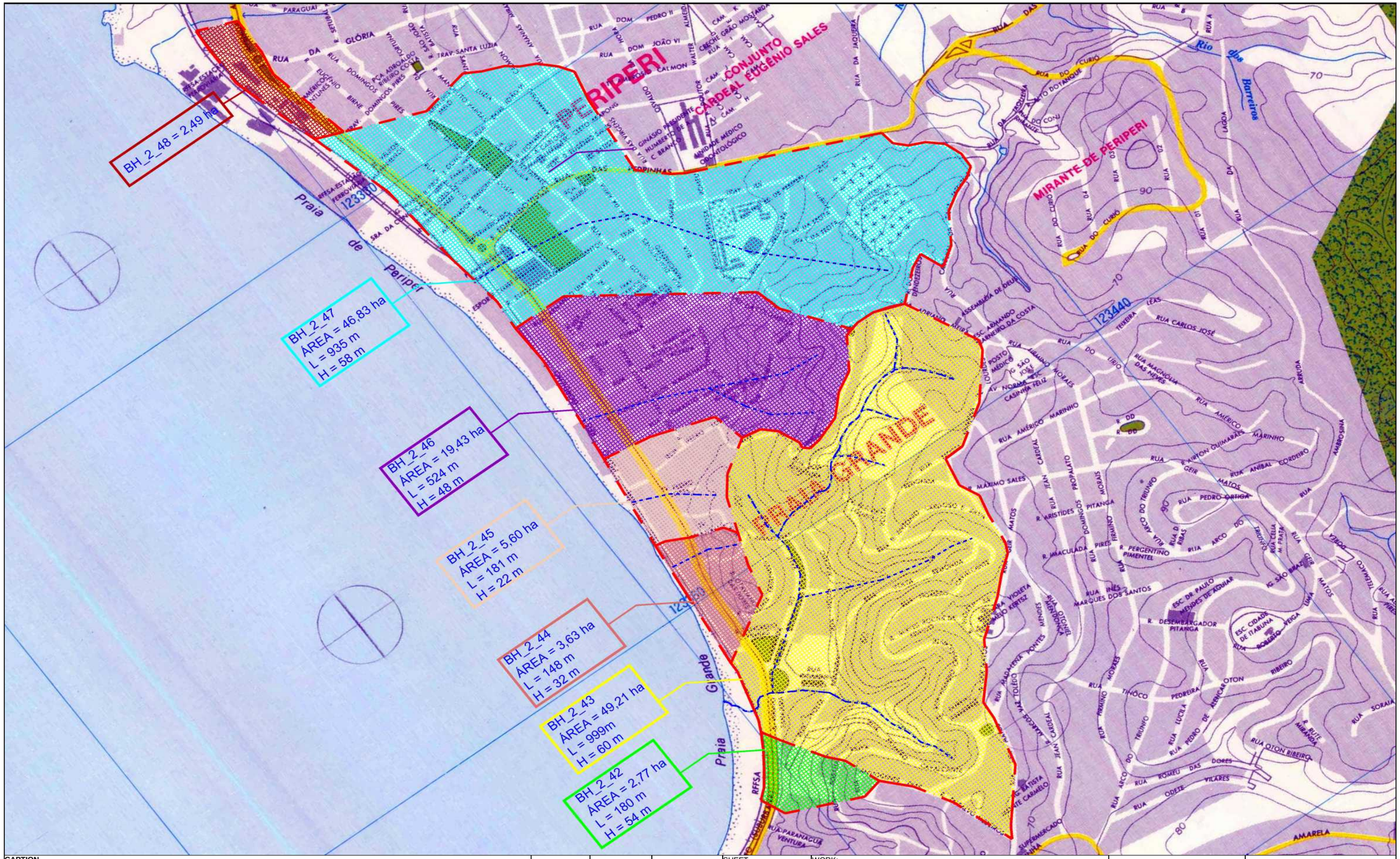
The crossings TV_2_24, TV_2_25 and TV_2_26 continue with the same characteristics as the previous ones, since TV_2_17.

- Crossings TV_2_28



Assess, at the time of preparing the Basic Design, the best place for deployment of TV_2_28 between those two pointed out. The crossing TV_2_28 continues with the same characteristics as the previous ones, since TV_2_17.

When preparing the Basic Design, the indications of locations for deployment of Valley Crossings and their configuration will be assessed, enhanced and reconfigured if necessary to the correct implementation of singular hydraulic structures, in whole, in part or extended due to local circumstances only detected by more accurate topographical cadastral surveys for combination of load, unload, surface runoff, and release conditions.



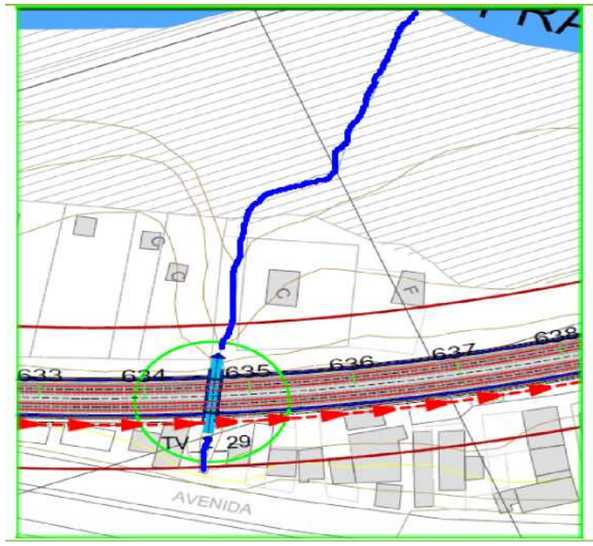
CAPTION						
	DRAWING		/ /	SHEET 04/07	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	CHECKING		/ /	SCALE	MUNICIPALITY	
	APPROVAL		/ /	NO SCALE	SALVADOR	
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA				
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			DRAINAGE OF THE CONTRIBUTION BASINS - BLOCK 2_05	

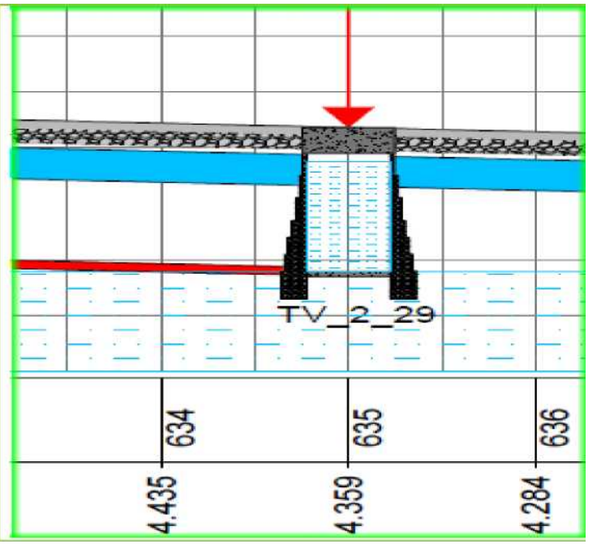
Sizing Worksheet

Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_29	0.20%	11.89	349.84	51.98	14,547.86	2.39	5.50	1.20	1.11
TV_2_30	0.20%	5.00	409.84	3.63	1,190.18	1.31	1.00	1.00	0.91
TV_2_31	0.20%	5.00	409.84	5.60	1,836.09	1.48	1.30	1.00	0.95
TV_2_32	0.20%	6.16	398.05	19.43	6,187.28	2.01	3.00	1.00	1.03
TV_2_33	0.20%	9.94	364.62	49.32	14,386.61	2.40	5.20	1.20	1.15

Valley Crossing TV_2_29



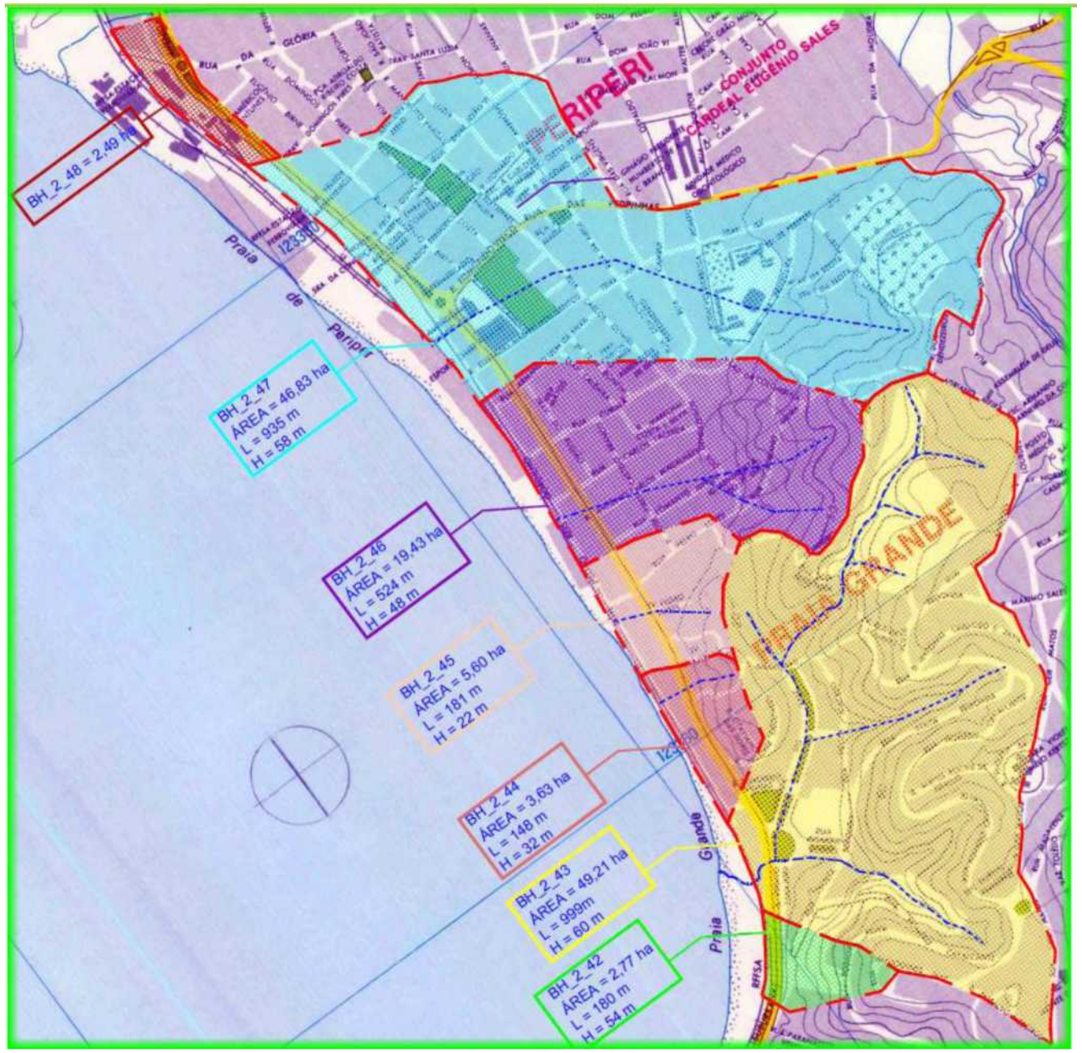


The crossing TV_2_29 has a relatively large contribution basin, of about 52 ha, actually associated with a relatively large thalweg line length although its origins are in quite high zone. This combination of circumstances added to its shape coefficient indicates, despite a relatively high concentration time, a reasonable propensity for the formation of flood peaks.

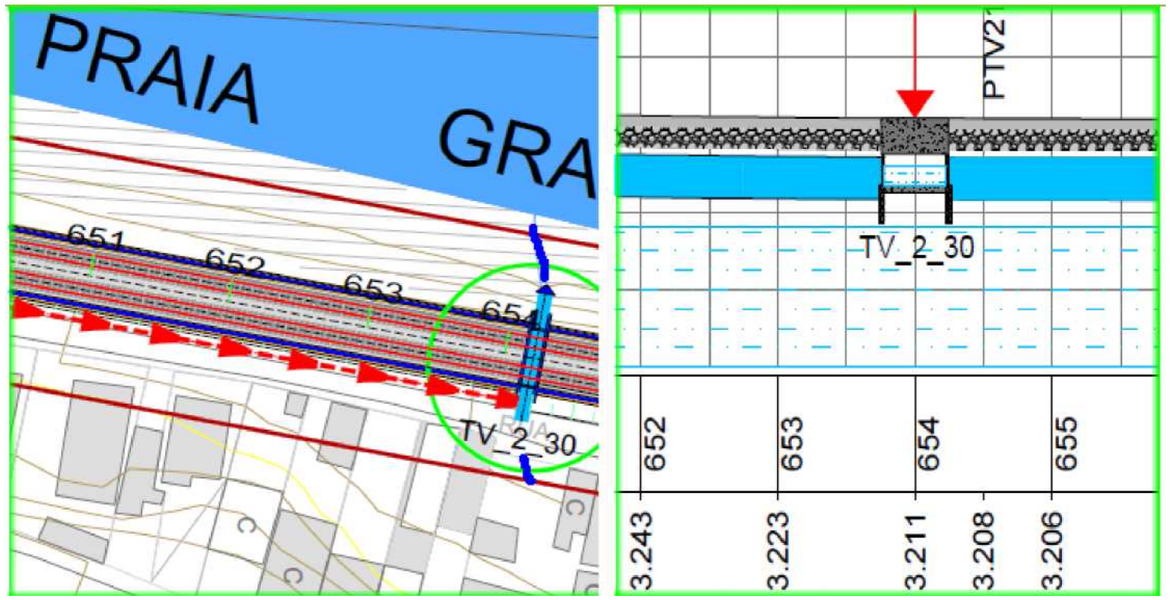
Its deployment height is located in critical condition related to tidal height differences. Its release channel although close to the receiver body - the sea, needs to be geometrized and cleaned, in order to accommodate the discharge flow rate estimated for the crossing.

At the time of preparation of the Basic Design, it should be evaluated the structural and functional conditions of the existing works, then, deciding by the use, recovery, replacement or expansion and construction of wings and load and unload ditches within the right of way. The height of the gully hole, at this point, is limited to 1.20 m, the tidal height variations, in this section is 1.80 m.

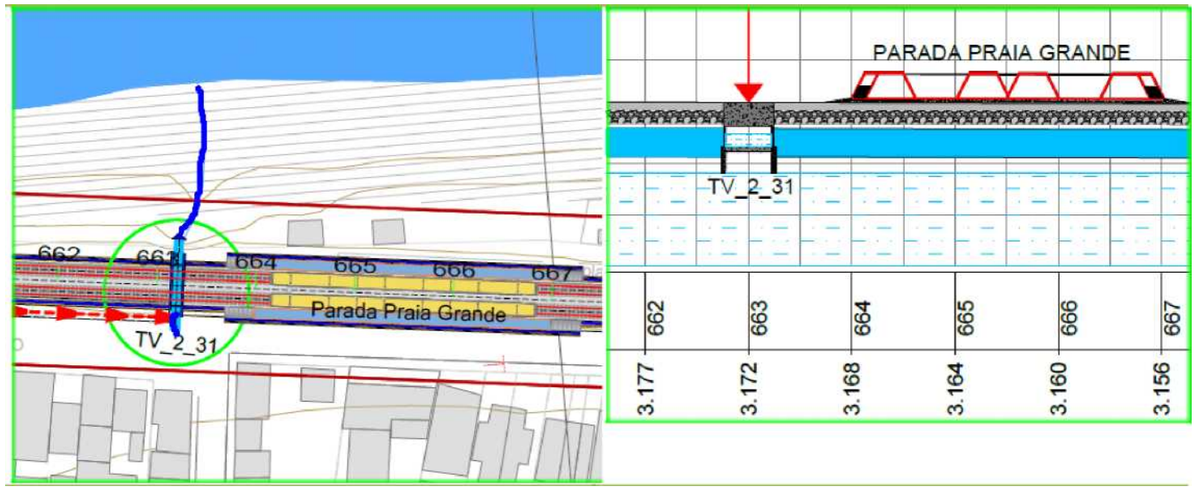
Block 2_04 - Itacaranha and Escada Basins



Valley Crossing TV_2_30

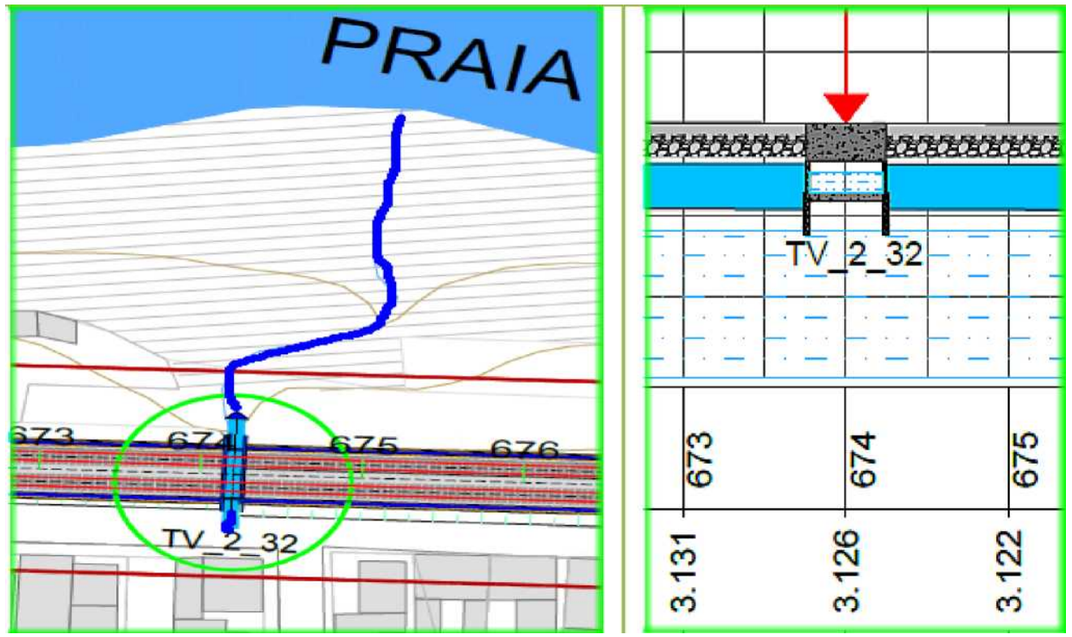


Valley Crossing TV_2_31

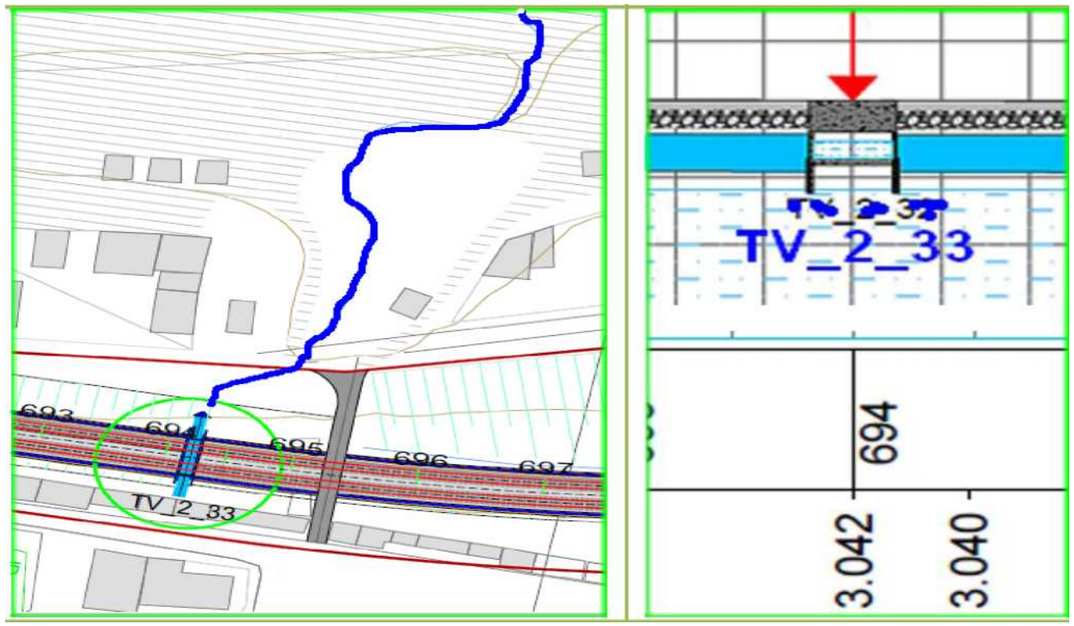


The crossings TV_2_30 and TV_2_31 have small contribution basins. Its deployment heights are located in critical conditions related to tidal height differences. Its release channels are very close to the sea, requiring only cleaning. At the time of preparation of the Basic Design, it should be evaluated the structural and functional conditions of the existing works, then, deciding by the use, recovery, replacement or expansion. The heights of the gully holes, in these points are limited to 1.00 m, by tidal height variations (of about 1.80 m).

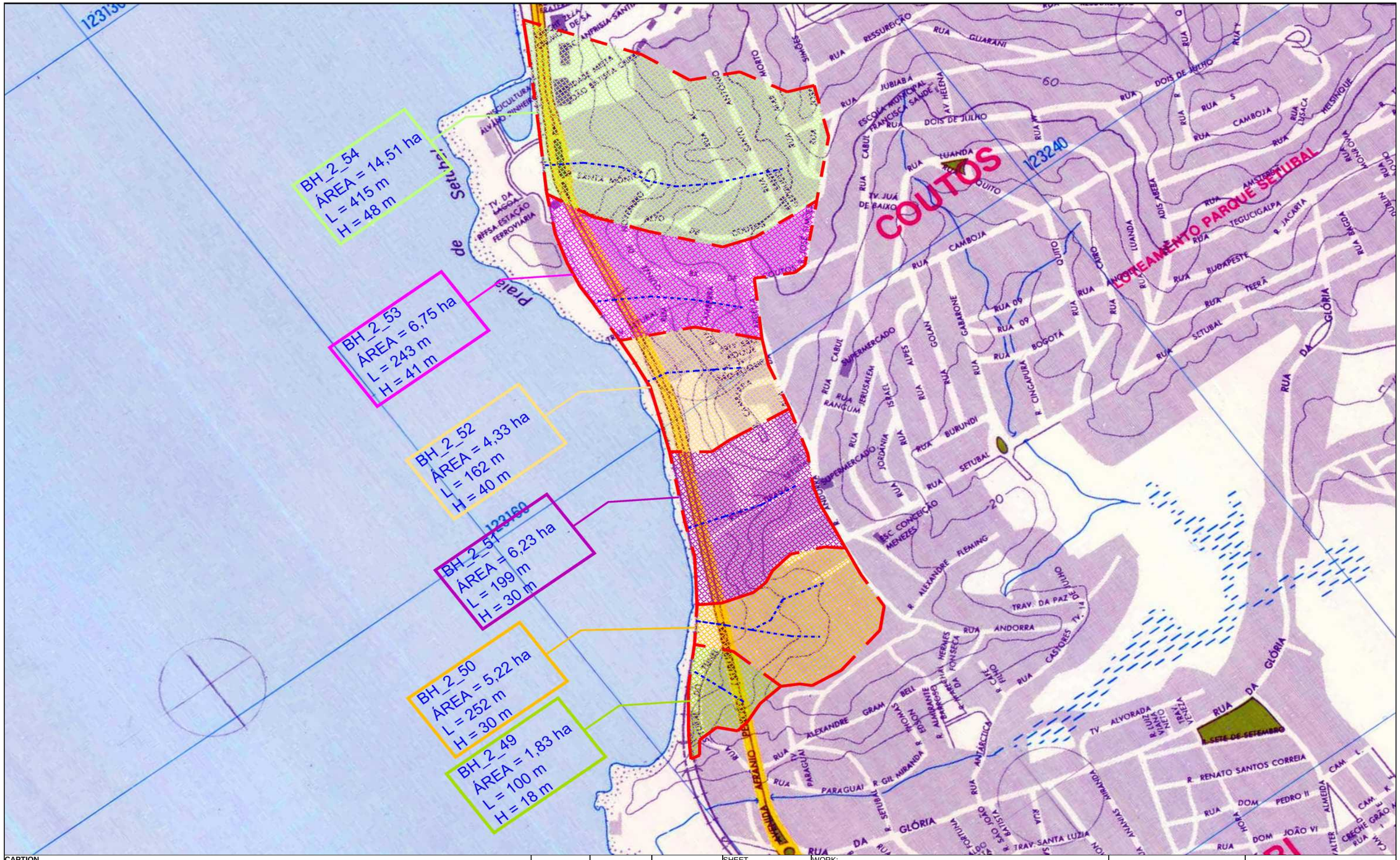
Valley Crossing TV_2_32



Valley Crossing TV_2_33



The crossing TV_2_33, has characteristics absolutely similar to the crossing TV_2_29.



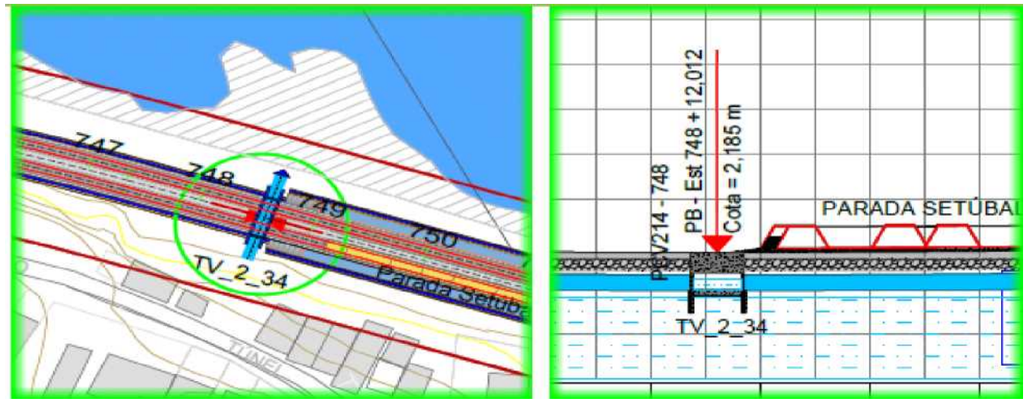
CAPTION				SHEET 05/07	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	DRAWING		/ /			
	CHECKING		/ /	SCALE NO SCALE	MUNICIPALITY SALVADOR	
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE OF THE CONTRIBUTION BASINS - BLOCK 2_05	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				

Sizing Worksheet

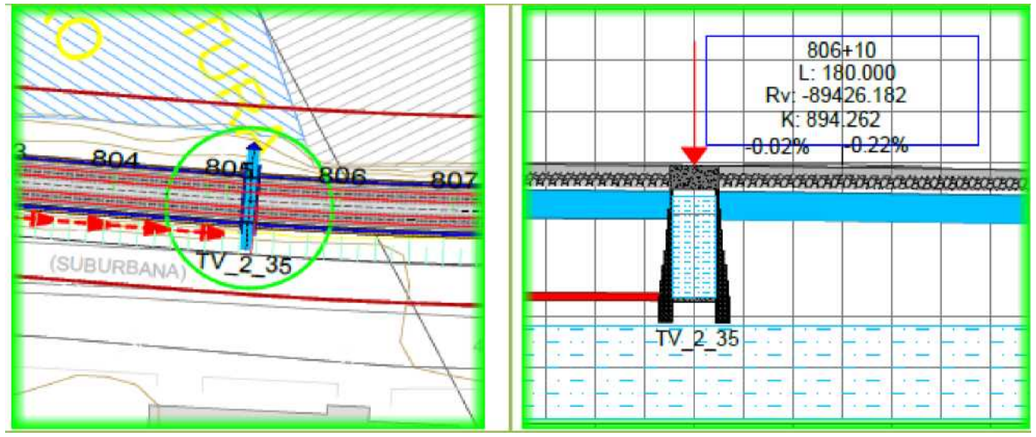
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_34	0.20%	5.00	409.84	17.61	5,773.85	1.93	3.50	1.00	0.85
TV_2_35	0.20%	5.00	409.84	21.26	6,970.59	2.04	3.50	1.00	0.97

Valley Crossing TV_2_34

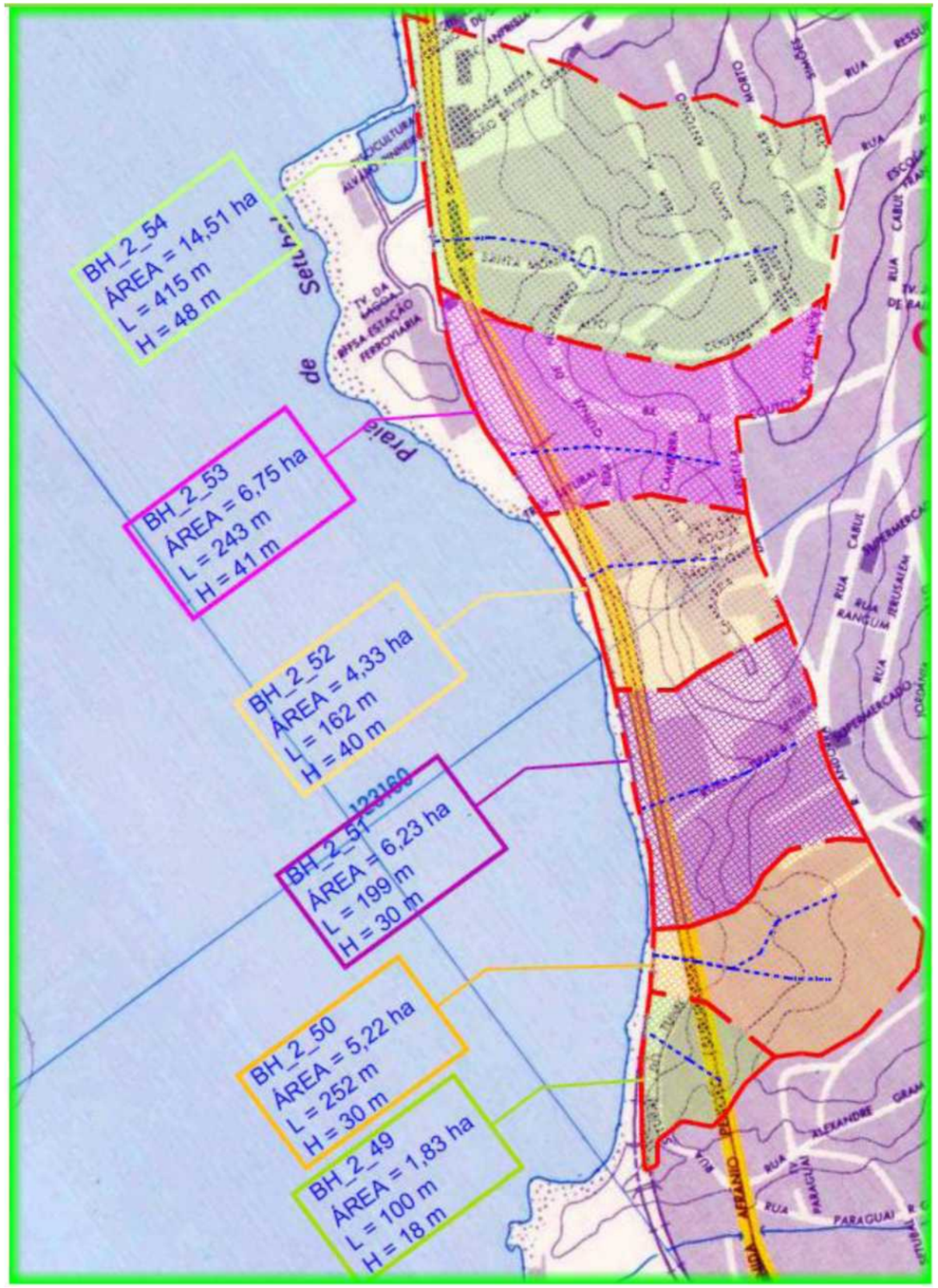


Valley Crossing TV_2_35



These crossings TV_2_34 and TV_2_35 have medium-size basins with other larger and have different hydraulic behavior due to local morphological conditions. They are basins next to a high slope, with short thalweg line originating at high heights and low concentration time. They are located in a deployment part with the influence of variations of tidal height differences. On the occasion of preparation of the Basic Design, an assessment of their functional and structural conditions should be made, in order to check their ability and decide either for structural and functional recovery or expansion, in order to meet the flow rate sections. Their load and unload ditches should be geometrized to meet the required flow rate section.

Block 2_05 - Praia Grande and Periperi Basins



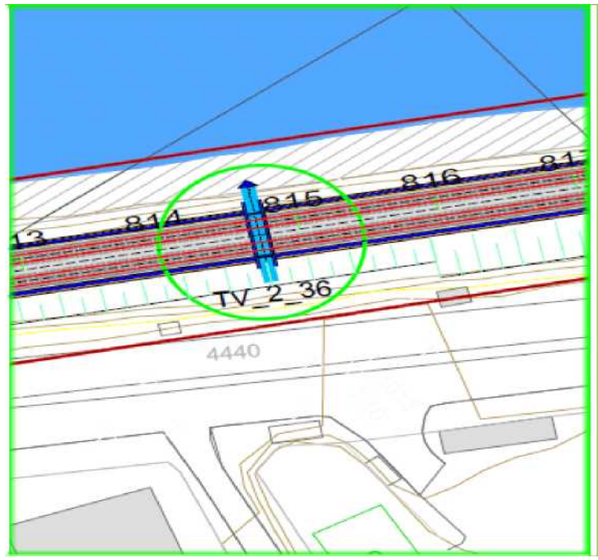
CAPTION				SHEET 06/07	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT	BAHIA GOVERNO DO ESTADO	CJB
	DRAWING		/ /					
	CHECKING		/ /	SCALE NO SCALE	MUNICIPALITY SALVADOR			
	APPROVAL		/ /					
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA						
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE OF THE CONTRIBUTION BASINS - BLOCK 2_07	LIGHT-RAIL VEHICLE LRV		
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA						

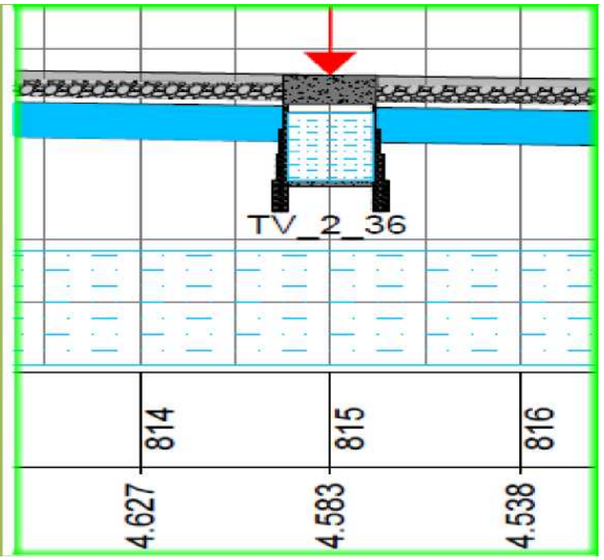
Sizing Worksheet

Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_36	0.20%	5.20	407.76	14.76	4,814.79	1.89	2.60	1.00	0.98

Valley Crossing TV_2_36

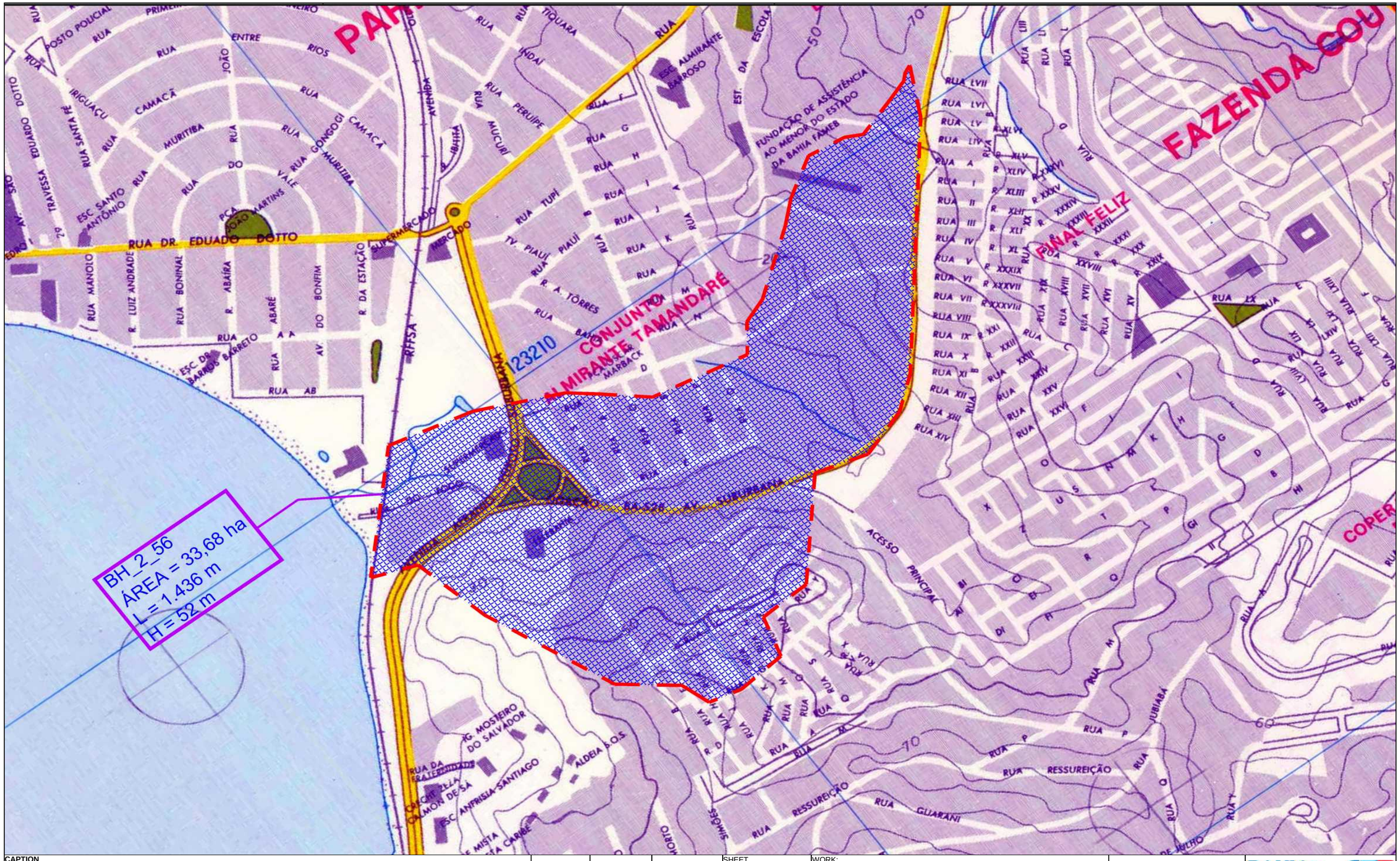




This crossing TV_2_36 is medium-size crossing and have different hydraulic behavior due to local morphological conditions. It is a basin next to a high slope, with extended thalweg line originating at high heights and low concentration time. It is located in a deployment height with no interference with the influence of variations of tidal height differences.

On the occasion of preparation of the Basic Design, an assessment of their functional and structural conditions should be made, in order to check their ability and decide either for structural and functional recovery or expansion, in order to meet the flow rate sections. Their load and unload ditches should be geometrized to meet the required flow rate section.

Block 2_06 - Mosteiro do Salvador Basin

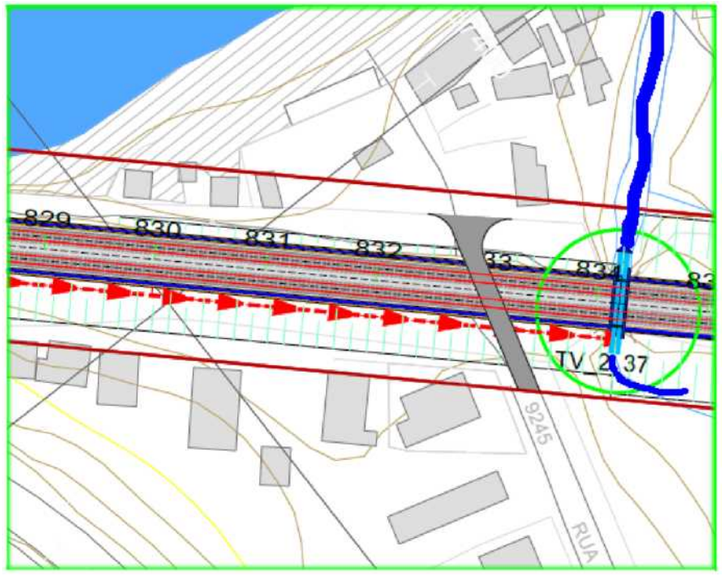


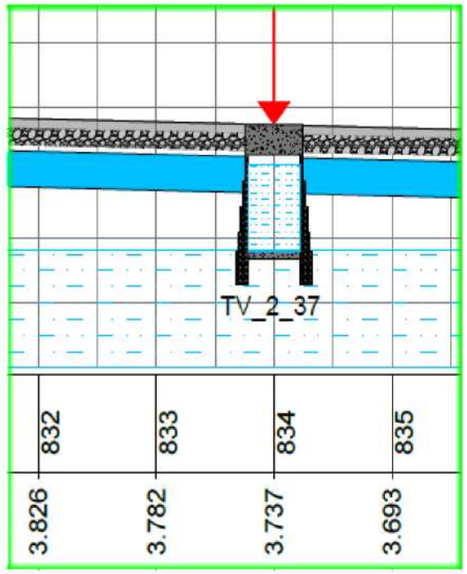
CAPTION						
	DRAWING		/ /	SHEET 07/07	WORK: SECTION – CALÇADA - PARIPE	DEPARTMENT OF URBAN DEVELOPMENT
	CHECKING		/ /	SCALE NO SCALE	MUNICIPALITY SALVADOR	
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA				
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE OF THE CONTRIBUTION BASINS - BLOCK 2_07	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				

Sizing Worksheet

Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_37	0.20%	19.13	305.19	33.68	8,222.99	2.07	4.50	1.00	0.88





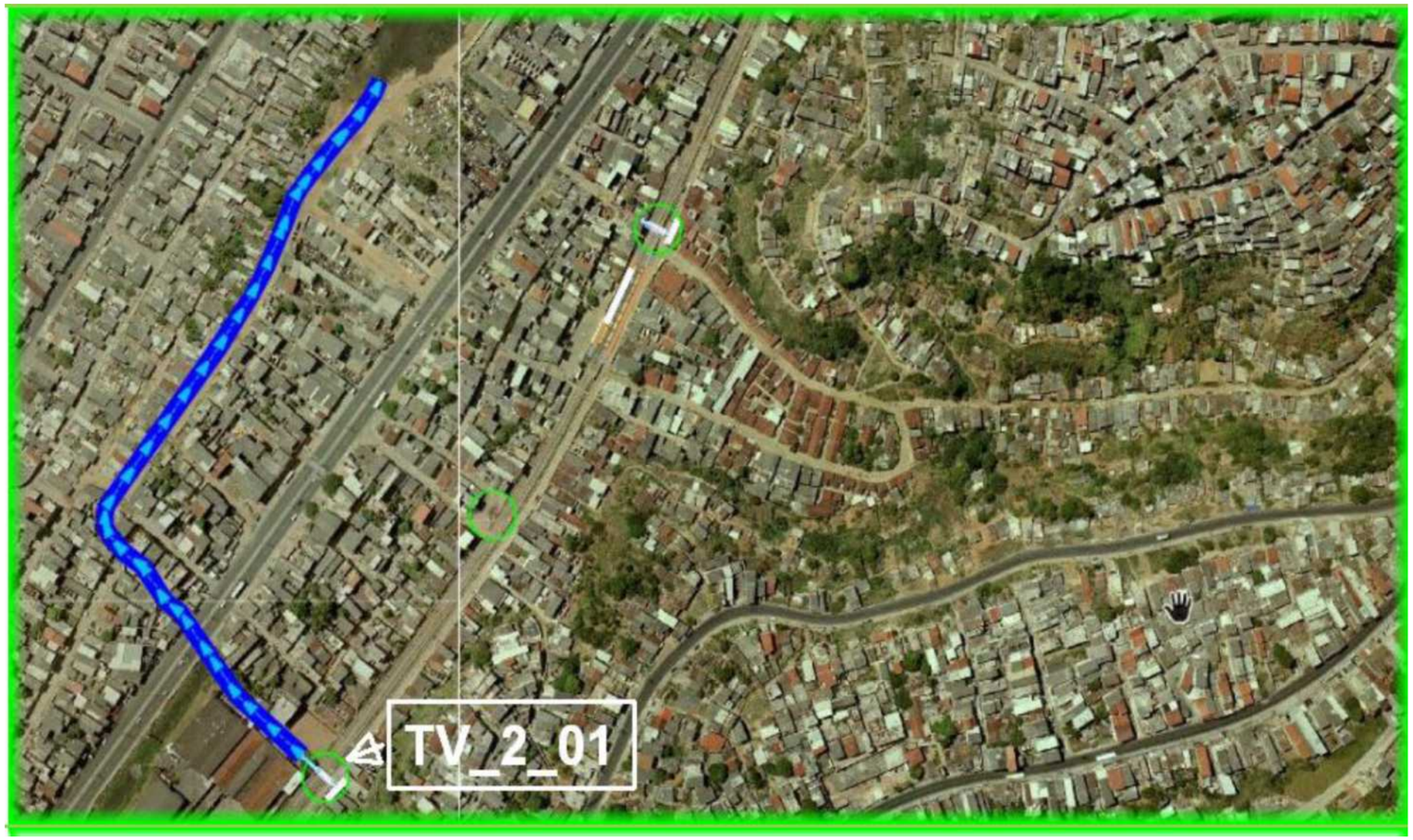
This crossing TV_2_37 is large-size and have different hydraulic behavior due to local morphological conditions. This is a low basin, with extended thalweg line originating in high heights and relatively high concentration time. It is located in a deployment height within the influence limit of variations of tidal height differences.

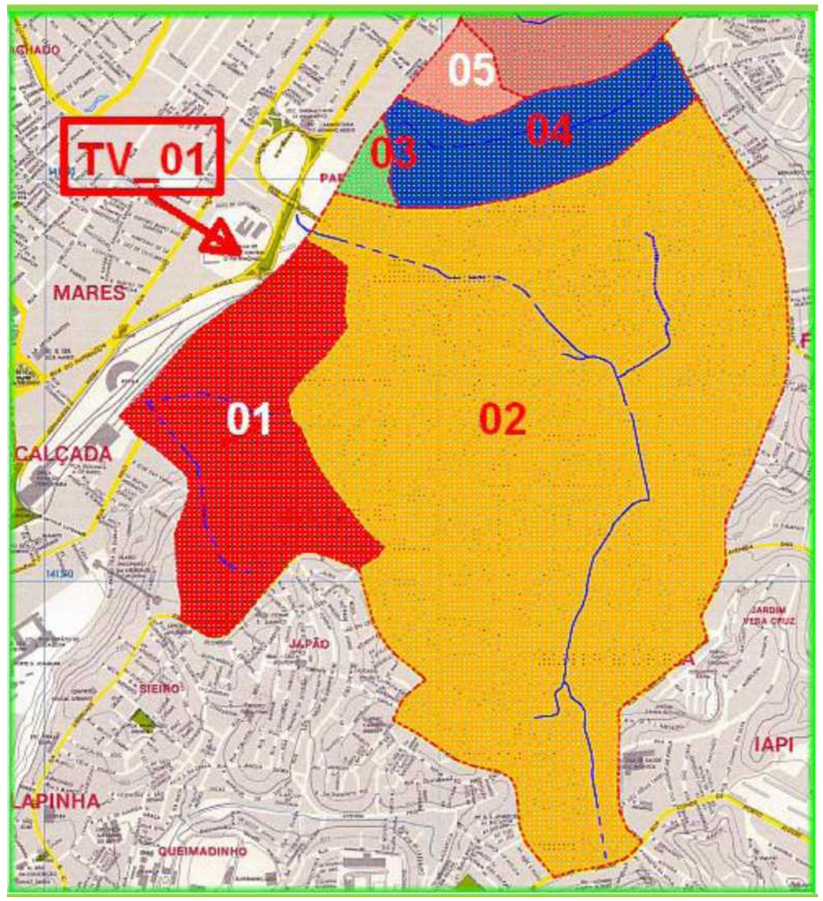
On the occasion of preparation of the Basic Design, an assessment of their functional and structural conditions should be made, in order to check their ability and decide either for structural and functional recovery or expansion, in order to meet the flow rate sections. Their load and unload ditches should be geometrized to meet the required flow section. Its release ditch should be geometrized and clean.

It is planned the release of a deep drain at the right side

Block 2_07 - Paripe Basin

Capped Gully Holes – Cartogram



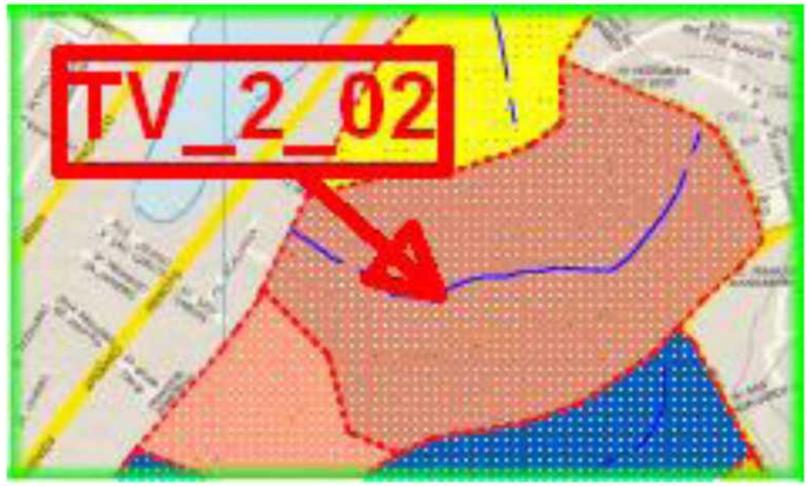


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_01	0.20%	34.86	242.22	269.67	36,055.99	2.75	11.00	1.20	1.19

Baixa do Fiscal Crossing - This is the largest contribution basin all the way and this thalweg crossing point, five basins with codes BH_01, BH_02, BH_03 and BH_04 and BH_05 converge on it.

This is the most critical point of the whole route presenting floods every critical rain, affecting most of the time the stoppage of the train. The downstream release channel needs to be unblocked and cleaning and the existing gully hole needs to be expanded in the flow section and release conditions are precarious regarding the very low heights in relation to sea level.

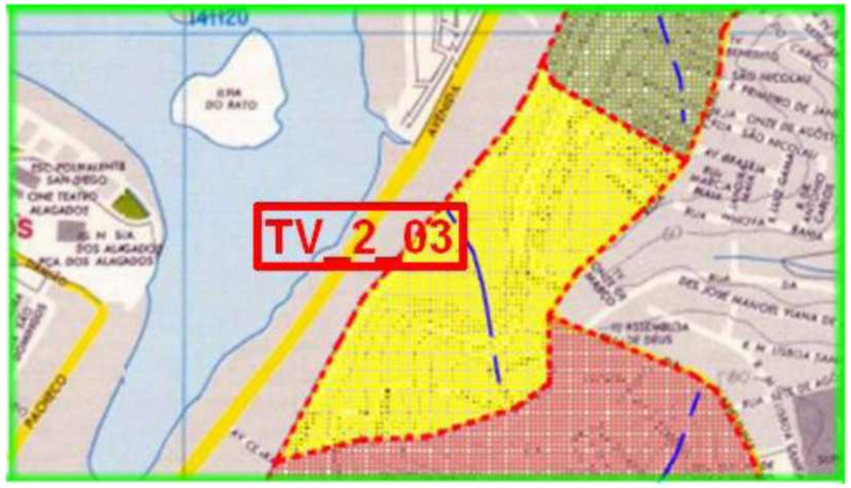


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_02	0.20%	10.27	362.01	22.18	6,423.48	1.99	3.50	1.00	0.92

It is the largest medium-size contribution basin with release near the sea, but completely blocked, requiring cleaning services.

The release conditions are very poor and on their course have an crossing under Av. Suburbana.

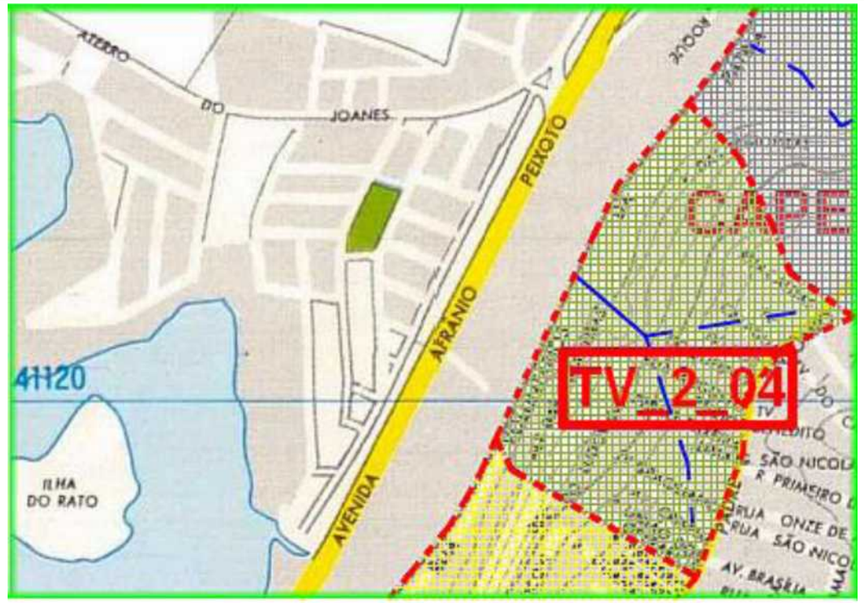


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_03	0.20%	7.72	383.40	11.13	3,413.78	1.72	2.50	1.00	0.79

It is the largest medium-size contribution basin with release near the sea, but completely blocked, requiring cleaning services.

The release conditions are very poor and on their course have an crossing under Av. Suburbana.

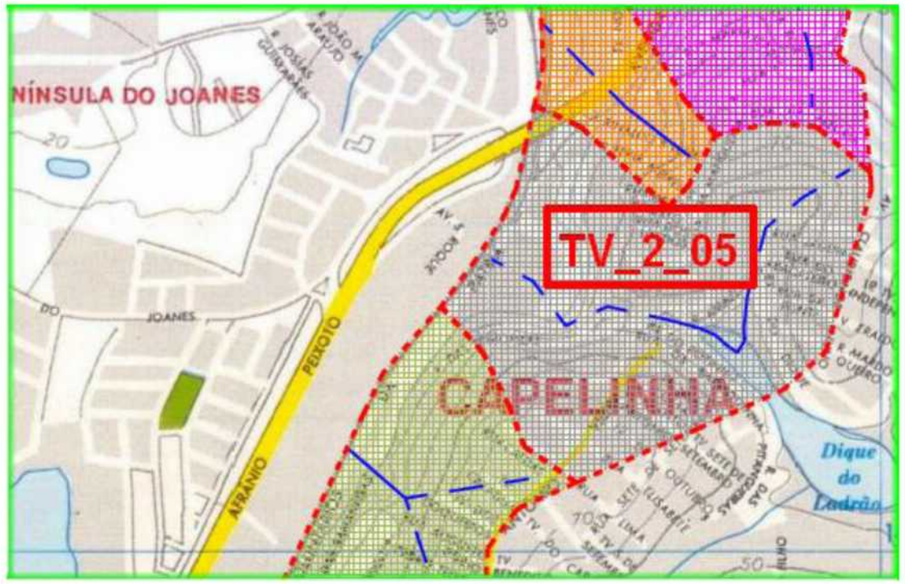


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_04	0.20%	5.00	409.84	7.15	2,344.29	1.58	1.50	1.00	0.99

It is a small-size contribution basin with release near the sea, but completely obstructed, requiring cleaning services.

The release conditions are very poor and on their course have an crossing under Av. Suburbana.

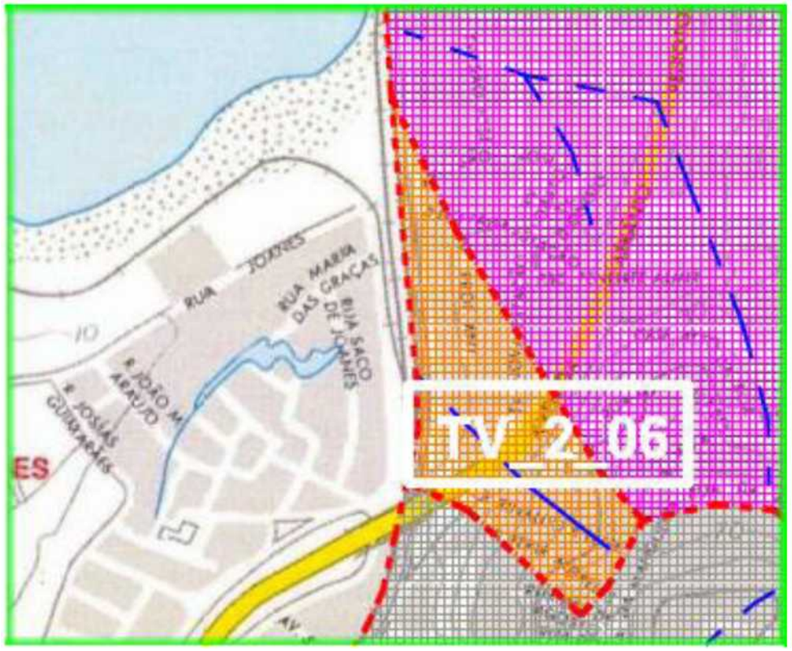


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_05	0.20%	5.00	409.84	13.15	4,311.54	1.84	2.50	1.00	0.94

It is a medium-size contribution basin, with release close to the sea, but completely obstructed, requiring cleaning services.

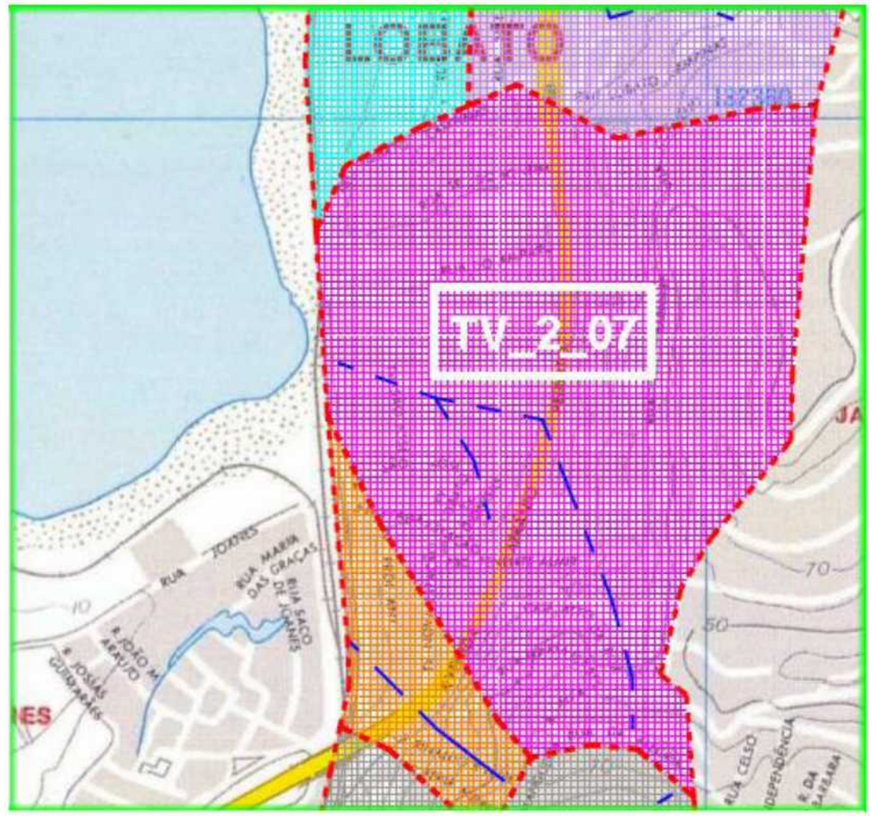
The release conditions are very poor and on their course have an crossing under Av. Suburbana.



Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_06	0.20%	6.10	398.66	3.71	1,183.23	1.31	1.00	1.00	0.90

This is a small-size contribution basin, with very long release section to the sea and with very poor unload conditions, with completely obstructed course, requiring cleaning services.

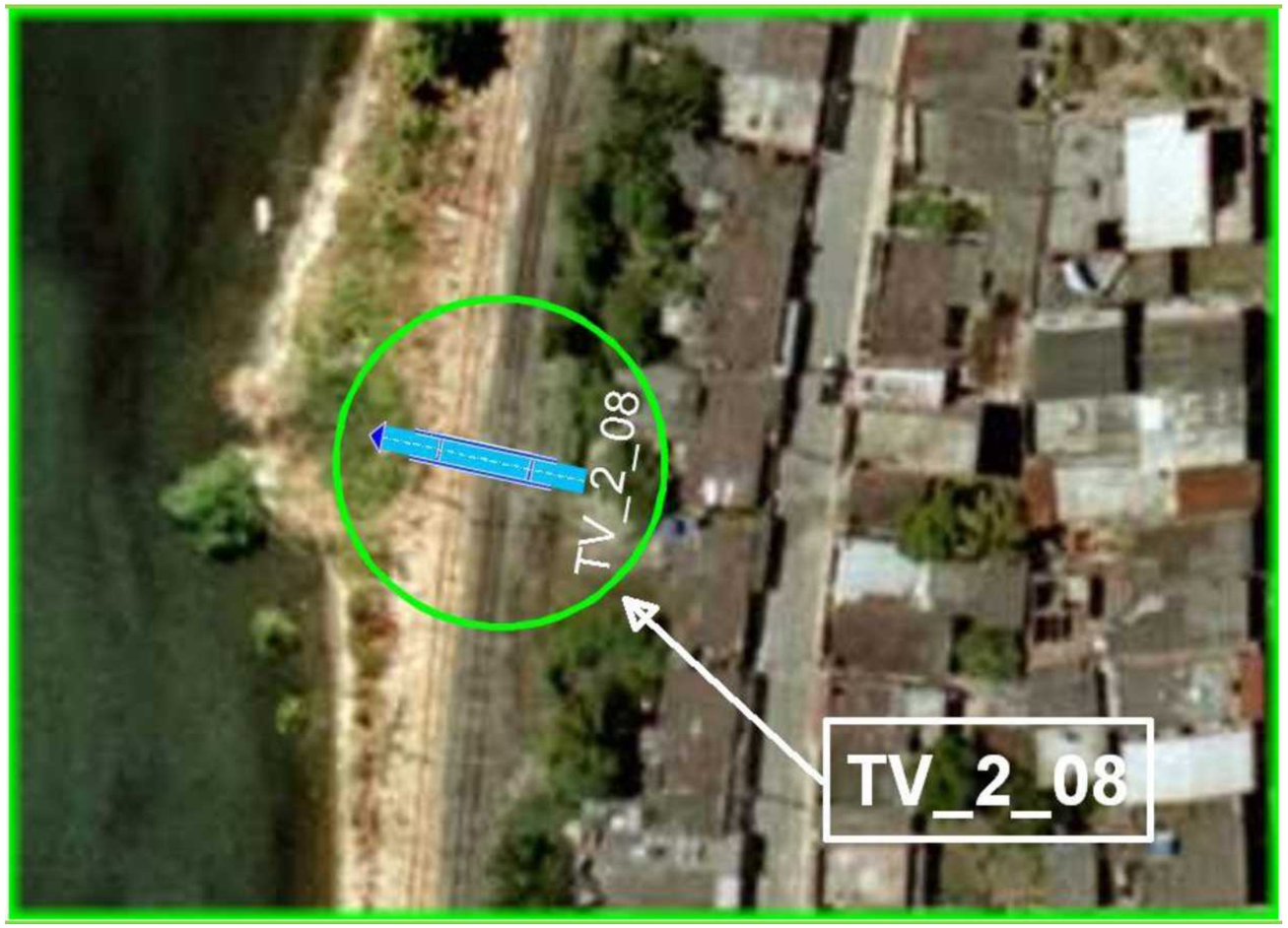


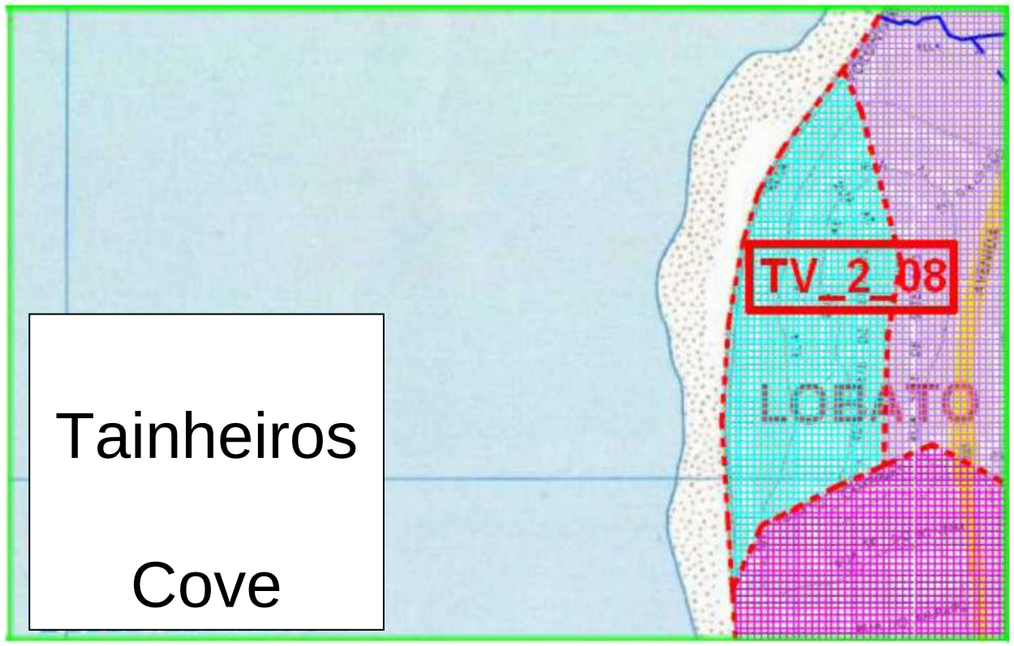
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_07	0.20%	5.00	409.84	27.85	9,131.27	2.14	4.50	1.00	0.35

It is a large-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is too short, the thalweg line has sharp slope and the combination of these factors with the medium index favors the occurrence of accentuated flood peaks.



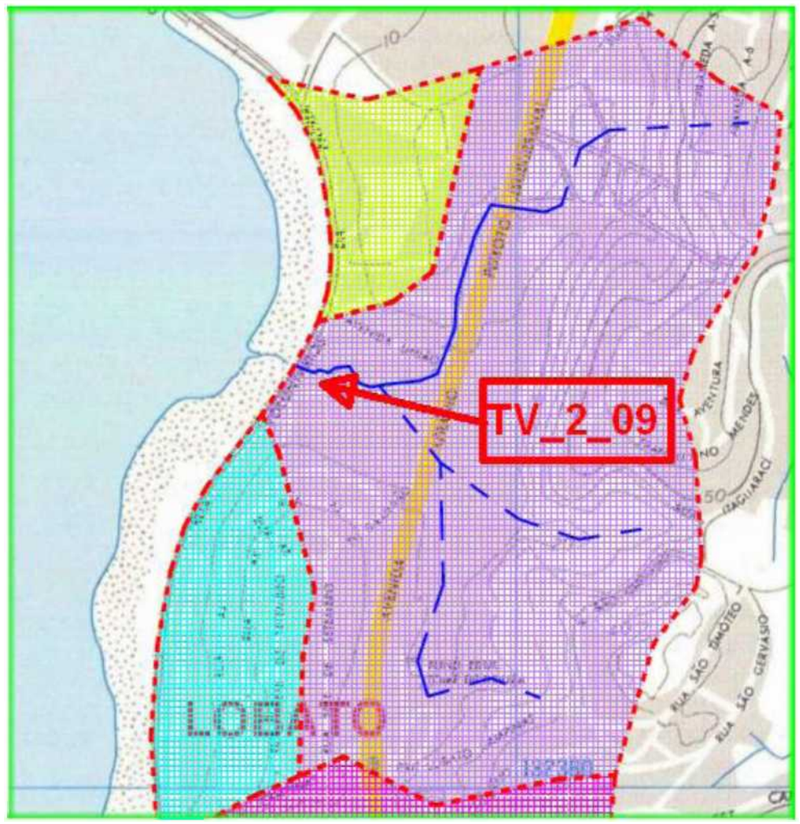


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_08	0.20%	6.26	397.08	6.82	2,166.48	1.55	1.50	1.00	0.93

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line does not have a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

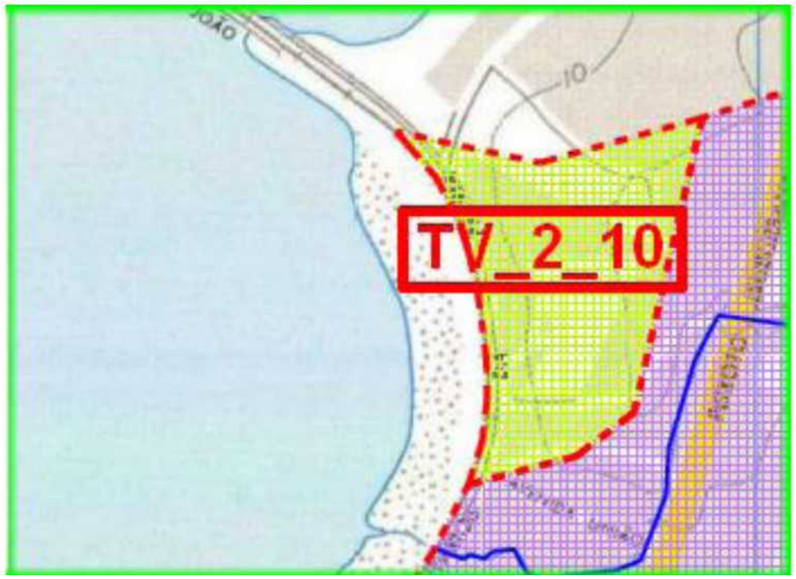


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_09	0.20%	5.00	409.84	36.50	11,967.38	2.24	5.50	1.00	0.97

It is a large-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is too short, the thalweg line has sharp slope and the combination of these factors favors the occurrence of accentuated flood peaks.

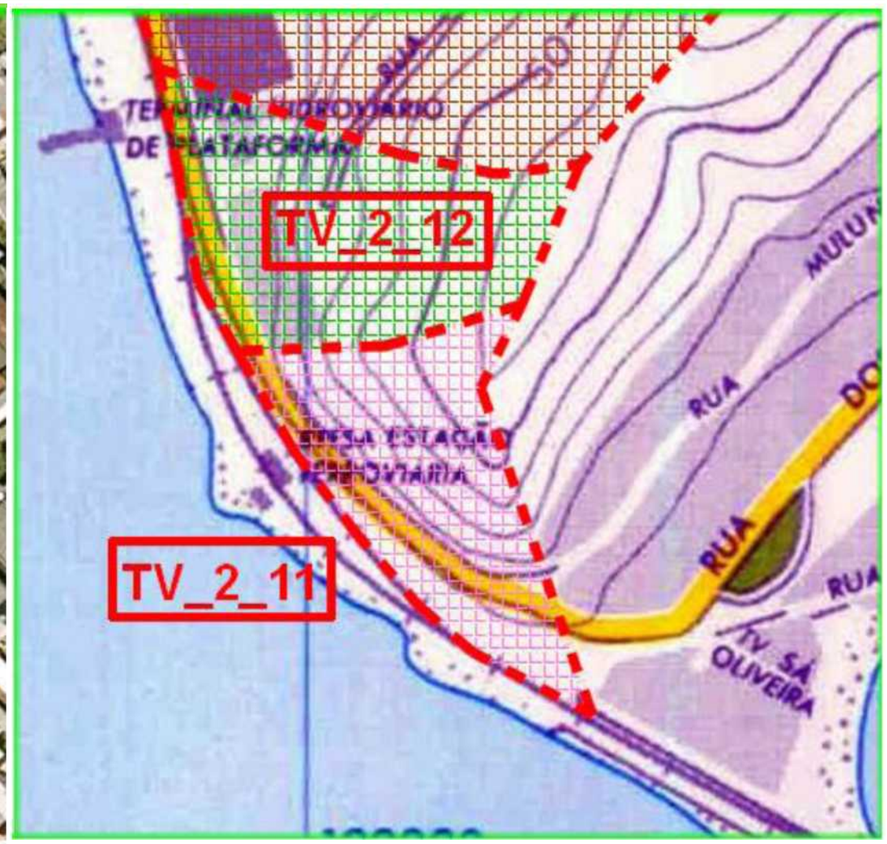


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_10	0.20%	8.26	378.69	4.06	1,230.00	1.32	1.00	1.00	0.93

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line does not have a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



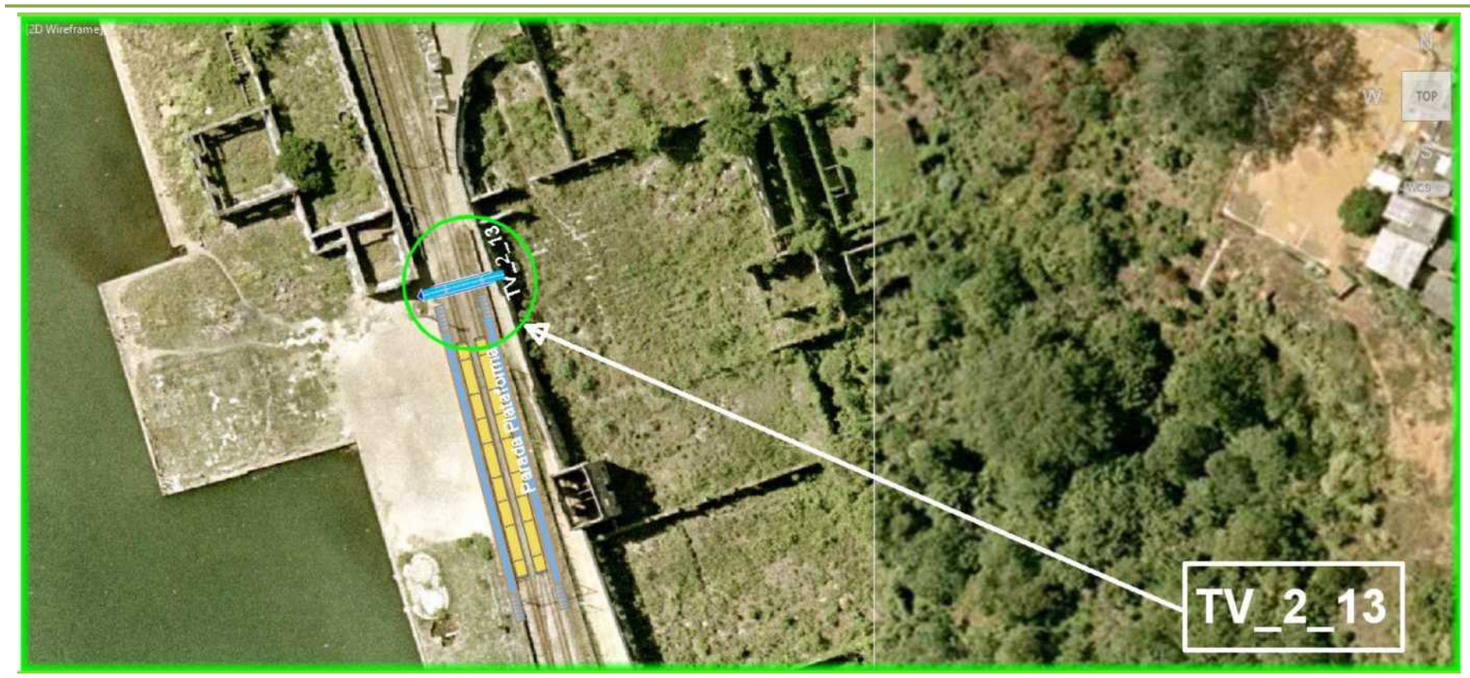
Capped Gully Holes – Sizing

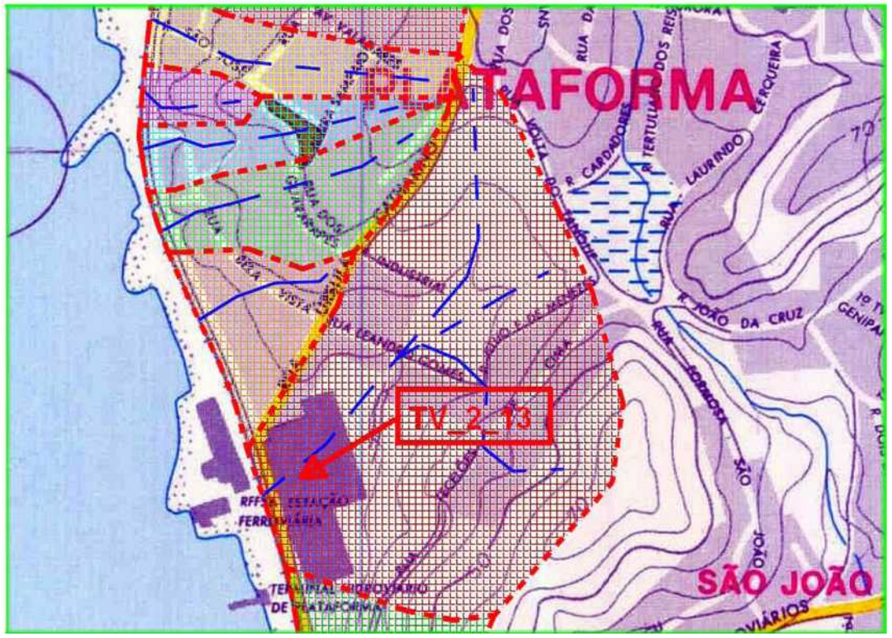
Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_11	0.20%	5.00	409.84	1.60	524.60	1.09	1.00	1.00	0.48
TV_2_12	0.20%	5.00	409.84	1.88	616.40	1.14	1.00	1.00	0.54

They are two small-size contribution basins, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

The hydraulic gradient resulting from the morphological conditions of the contribution area, conditioned the indication of deep drains along the bed of the railroad.





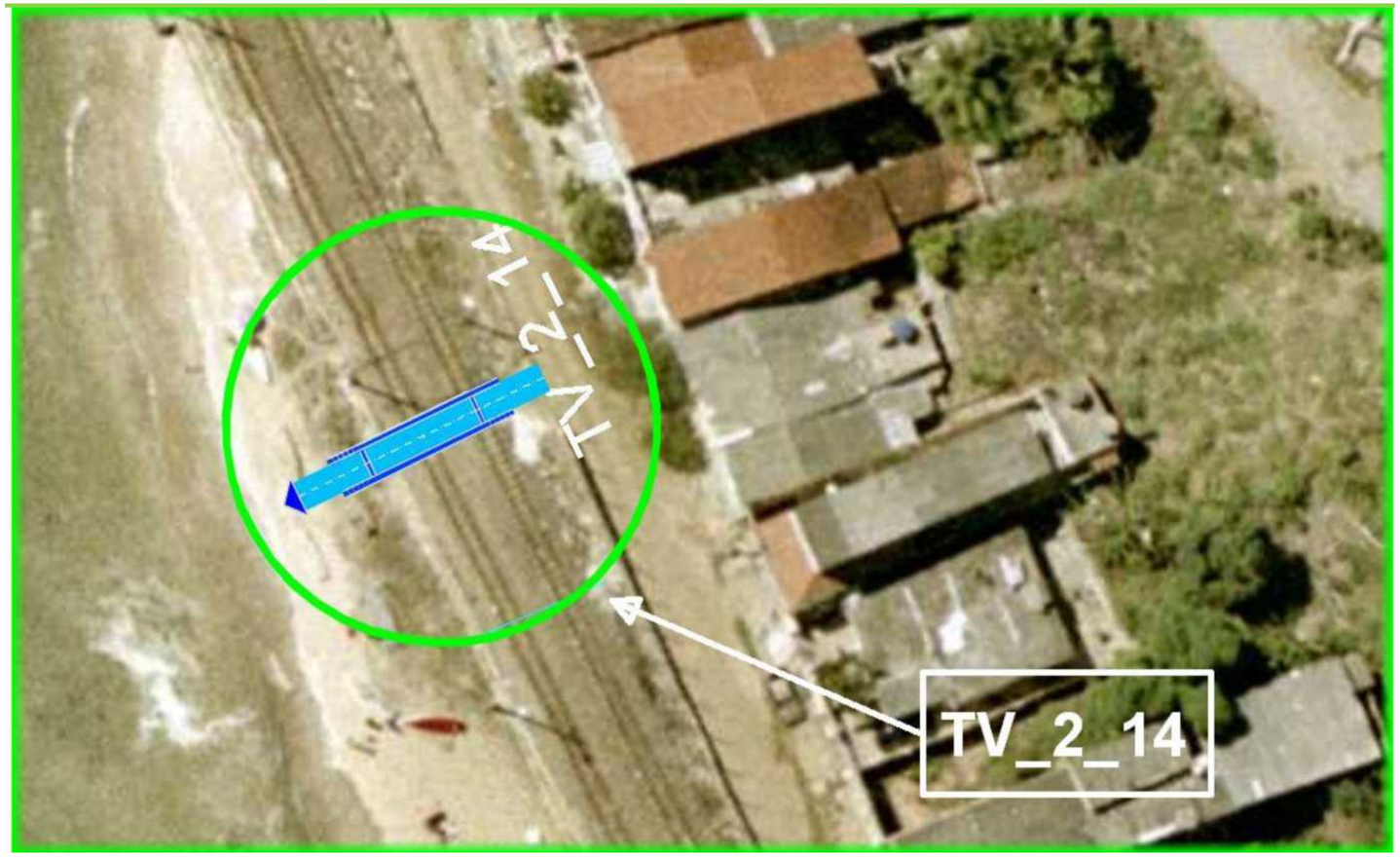
Capped Gully Holes – Sizing

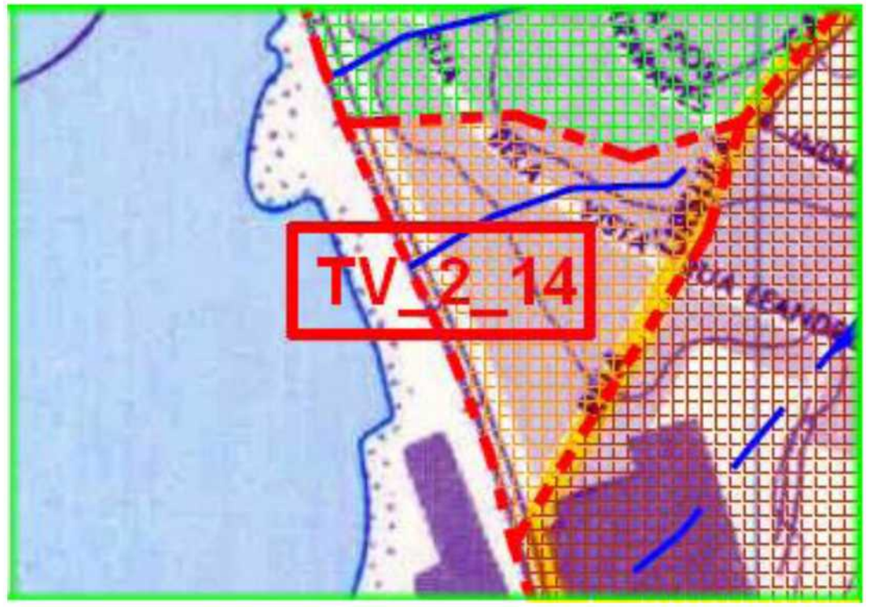
Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_13	0.20%	5.00	409.84	13.53	4,436.13	1.86	2.50	1.00	0.96

It is a medium-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

The hydraulic gradient resulting from the morphological conditions of the contribution area, conditioned the indication of deep drains along the bed of the railroad.



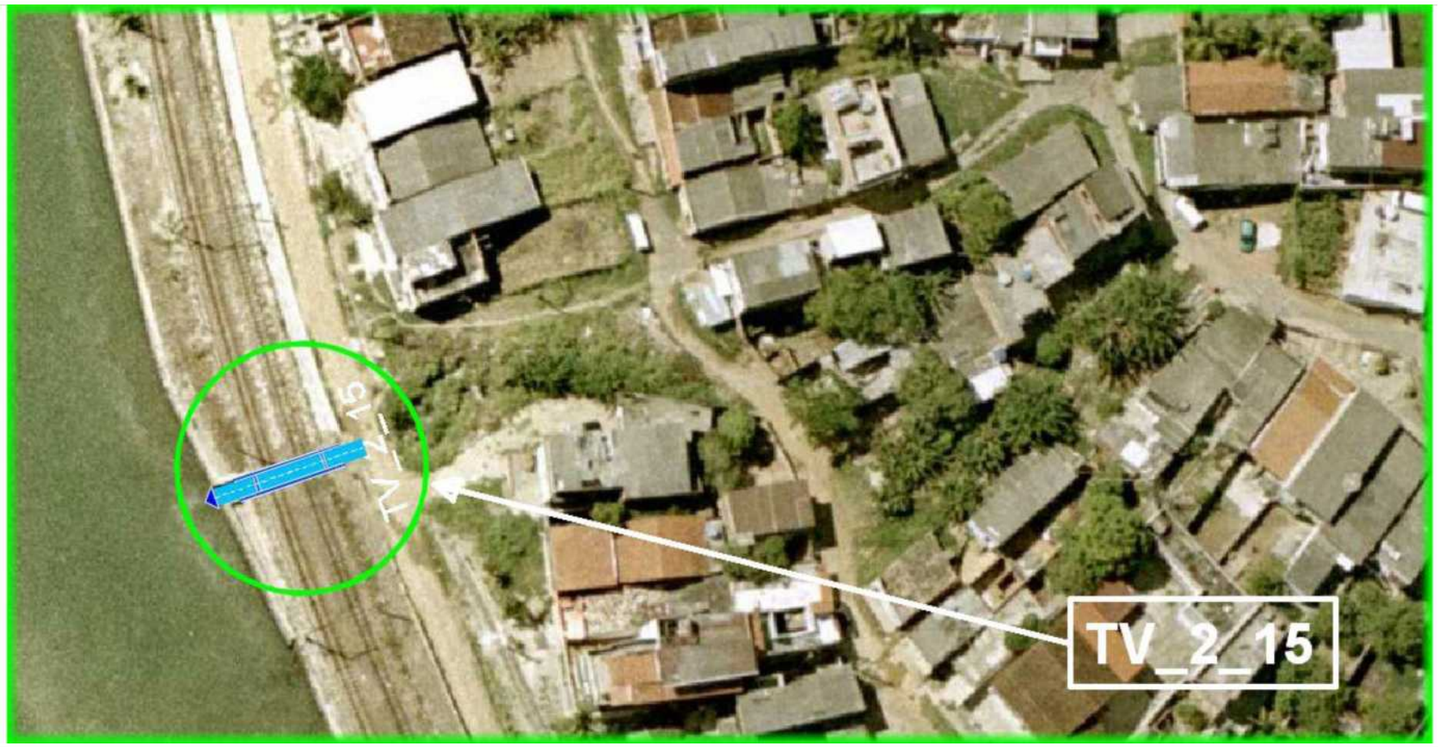


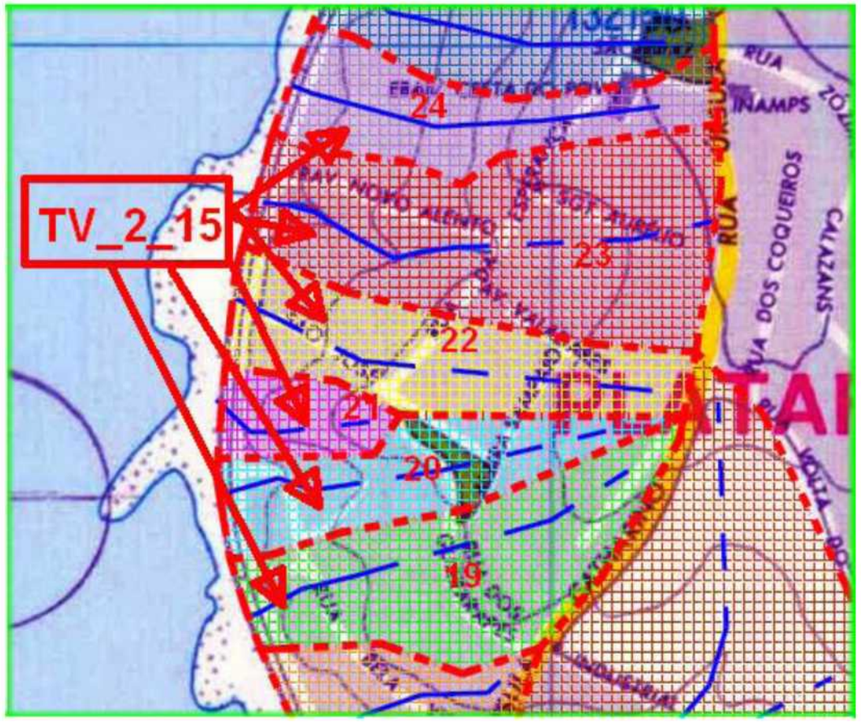
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_14	0.20%	5.00	409.84	1.95	639.35	1.15	1.00	1.00	0.56

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



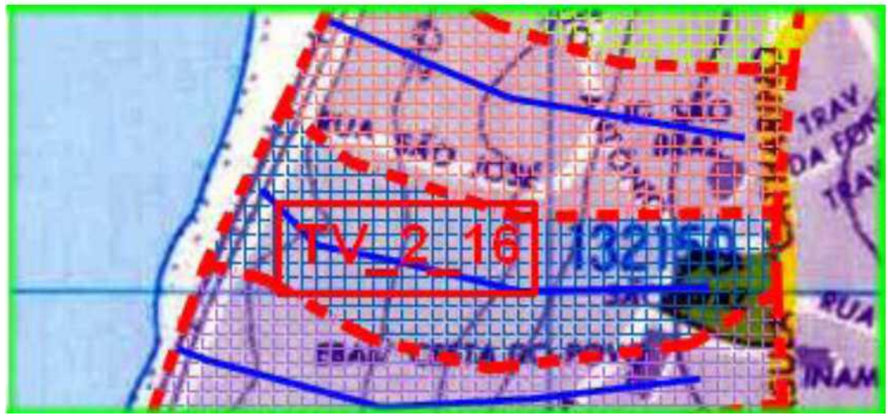


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_15	0.20%	5.00	409.84	11.95	3,918.09	1.79	2.50	1.00	0.87

It is a small-size contribution basin, but added to the six basins, BH_219, BH2_20, BH_2_21, BH_2_22, BH_2_23 and BH_2_24, with release near to the sea, in need of cleaning.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

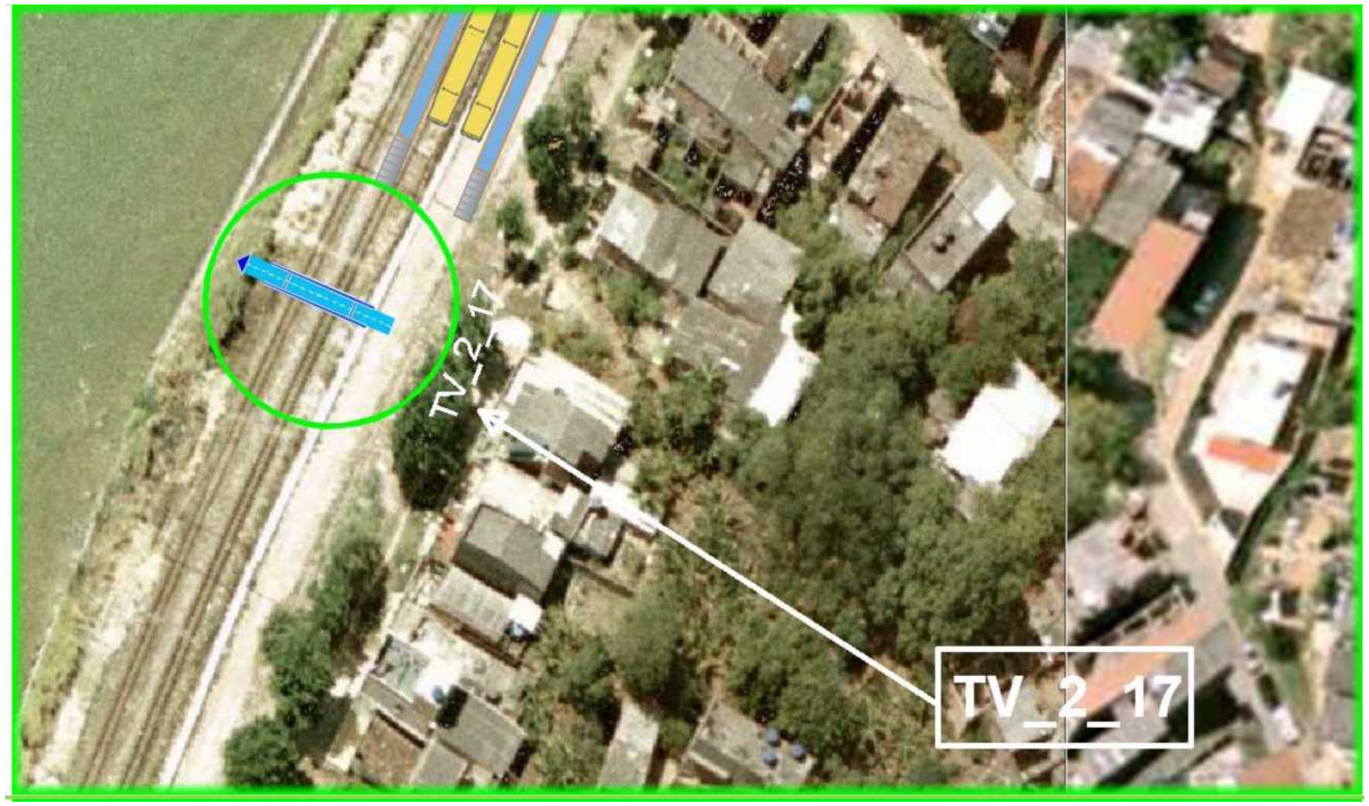


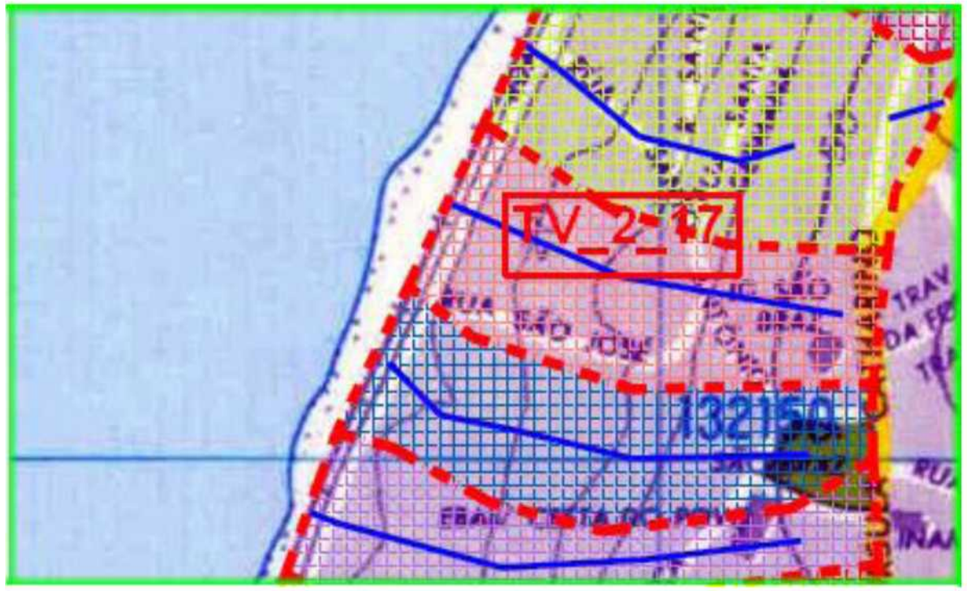
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_16	0.20%	5.00	409.84	1.87	613.12	1.14	1.00	1.00	0.54

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



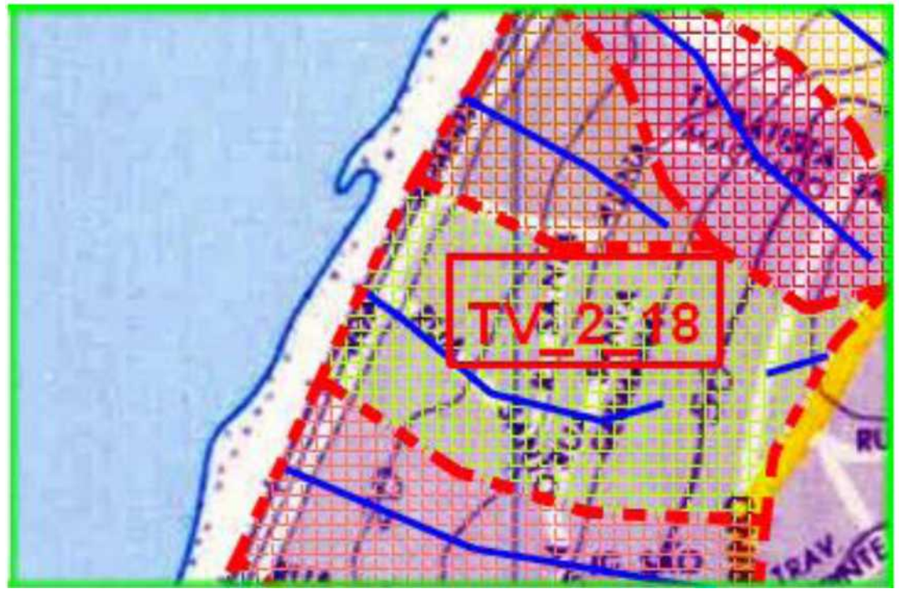


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_17	0.20%	5.00	409.84	1.96	642.63	1.15	1.00	1.00	0.56

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

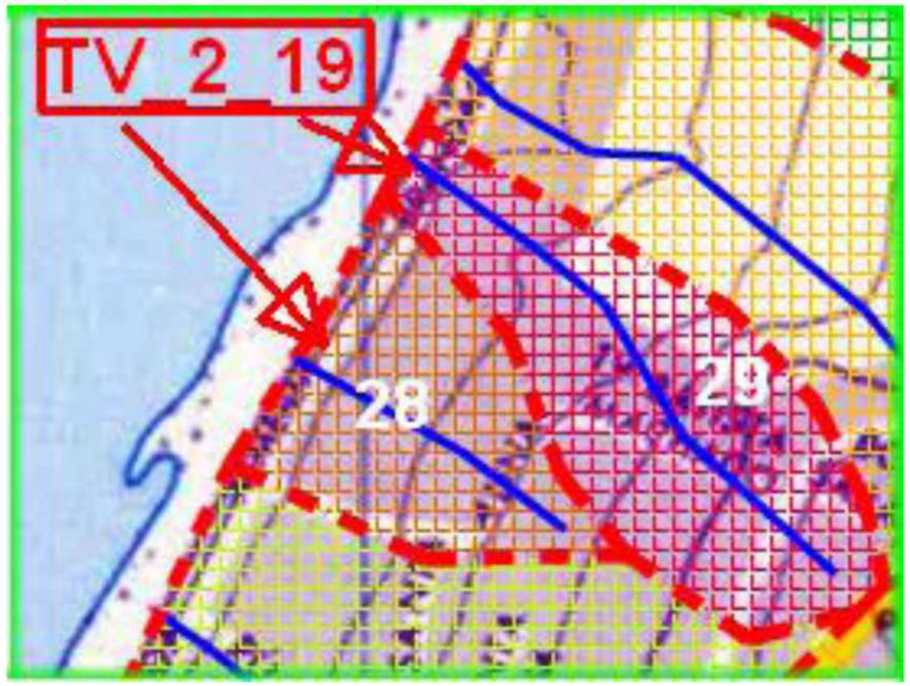


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_18	0.20%	5.00	409.84	2.52	826.24	1.22	1.00	1.00	0.68

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

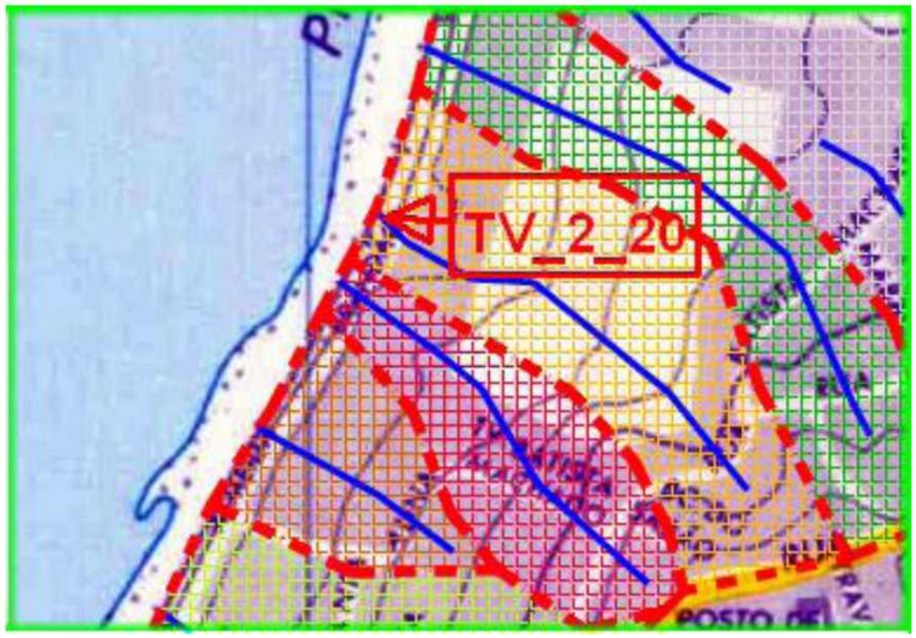


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_19	0.20%	5.00	409.84	2.27	744.27	1.19	1.00	1.00	0.63

They are two small-size contribution basins, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

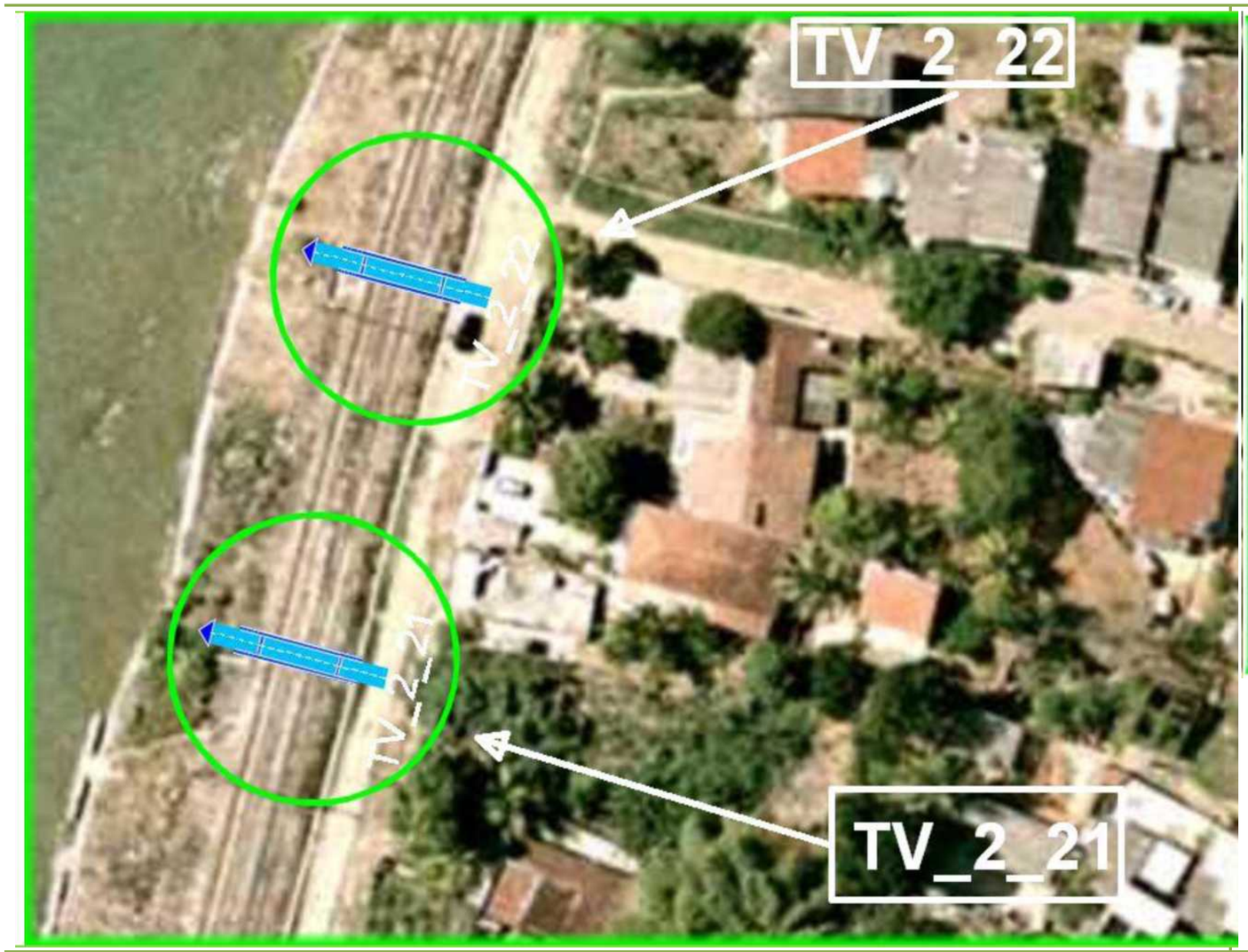


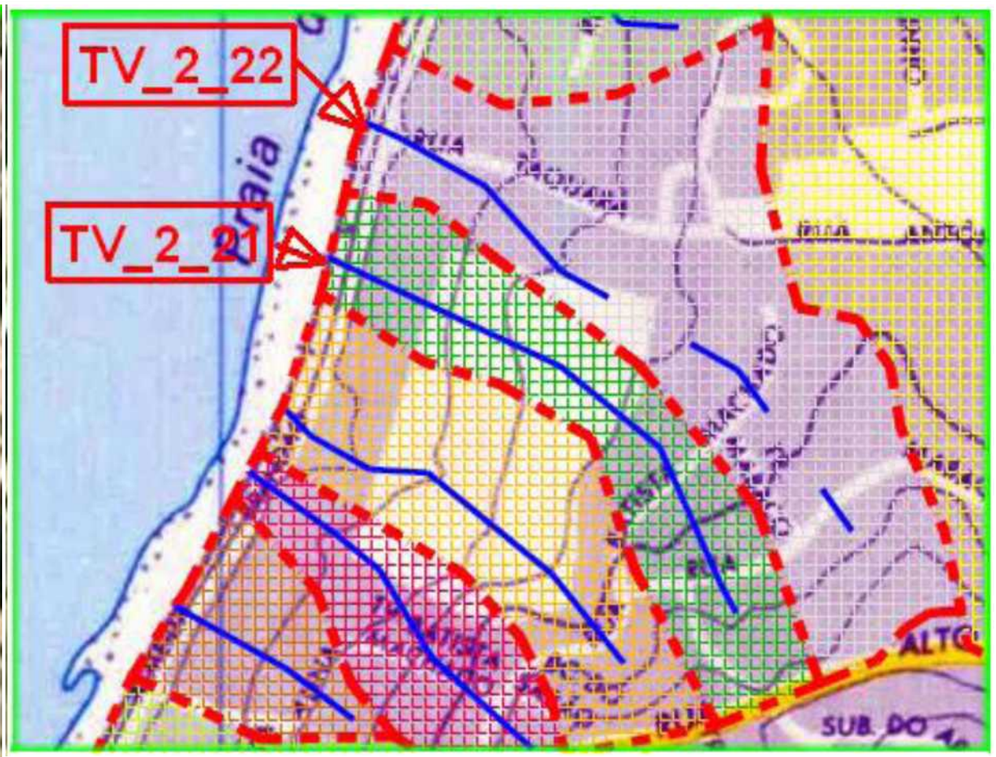
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_20	0.20%	5.00	409.84	2.42	793.45	1.21	1.00	1.00	0.66

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



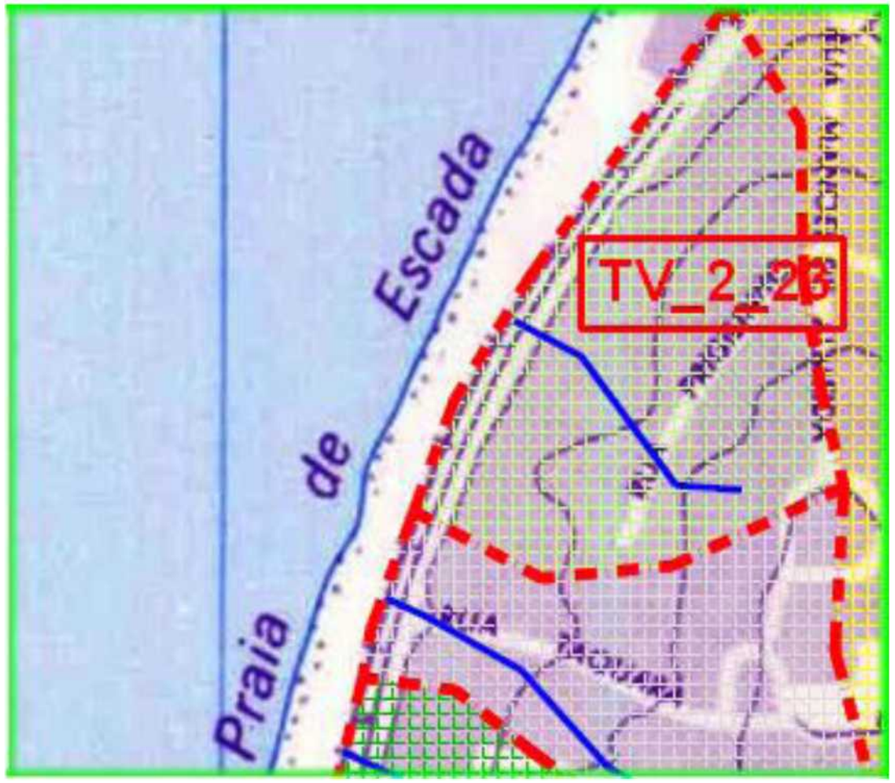


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_21	0.20%	5.00	409.84	2.17	711.49	1.18	1.00	1.00	0.60
TV_2_22	0.20%	5.00	409.84	4.31	1,413.13	1.39	1.20	1.00	0.85

They are two small-size contribution basins, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

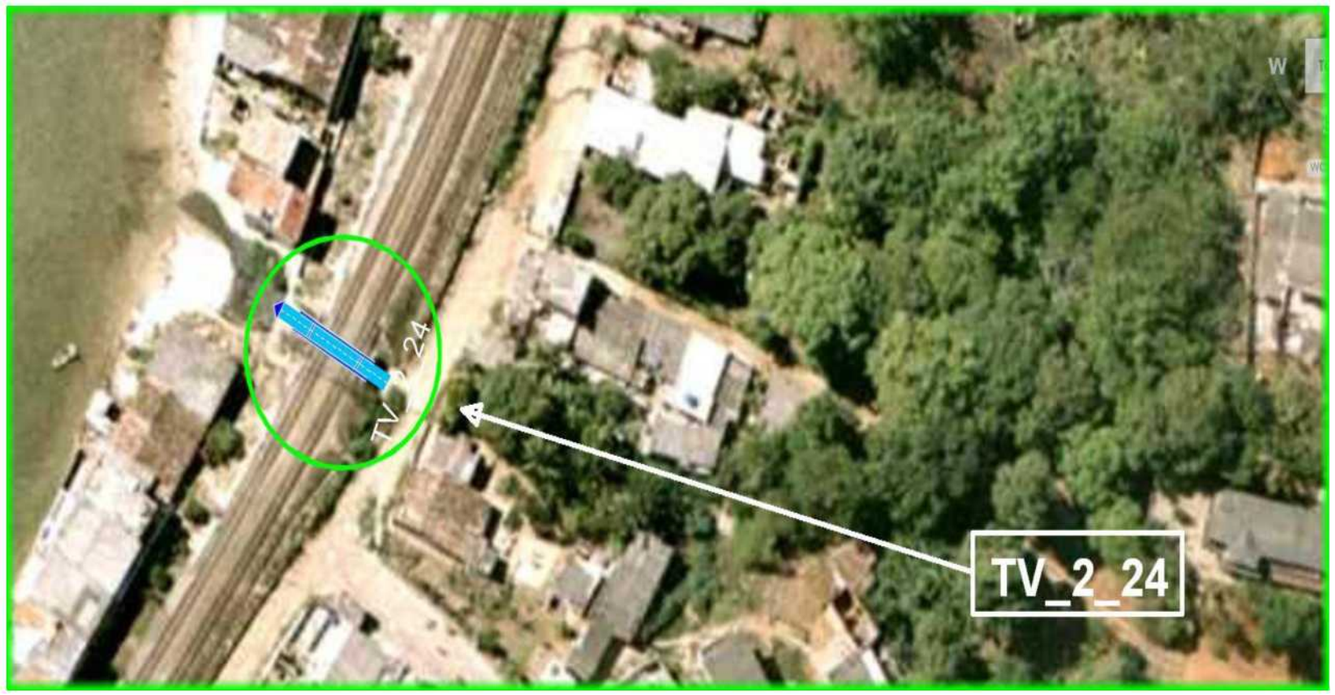


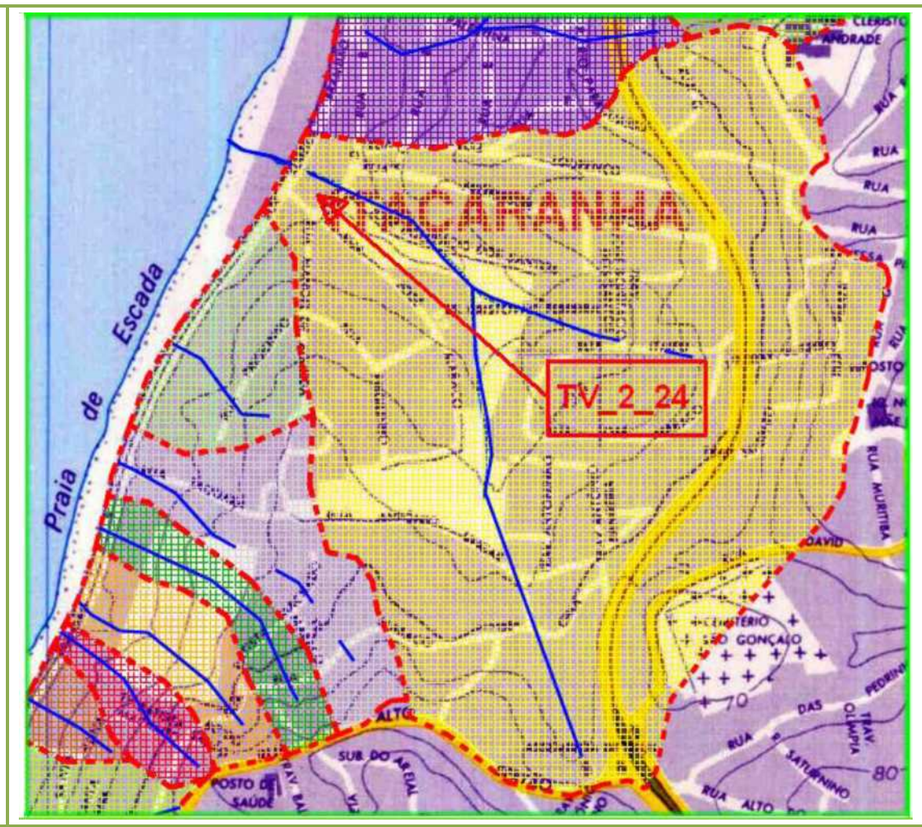
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_23	0.20%	5.00	409.84	3.15	1,032.80	1.28	1.00	1.00	0.81

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



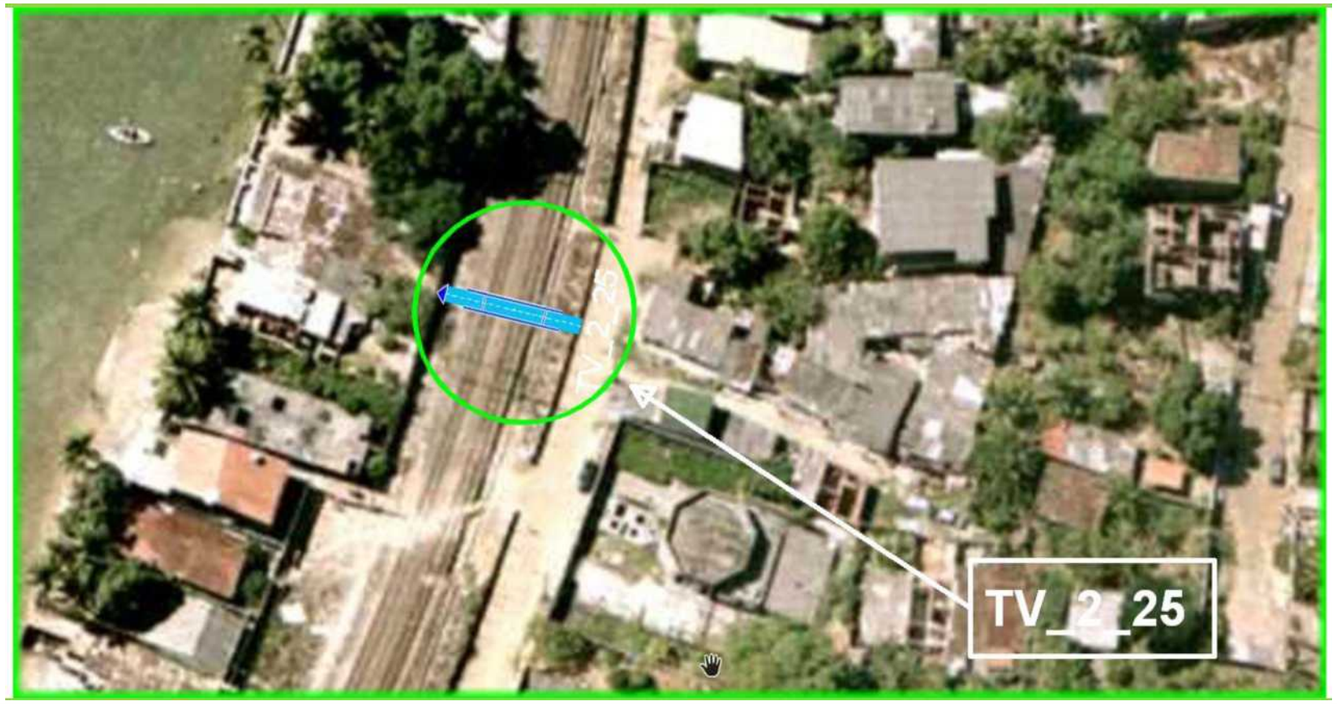


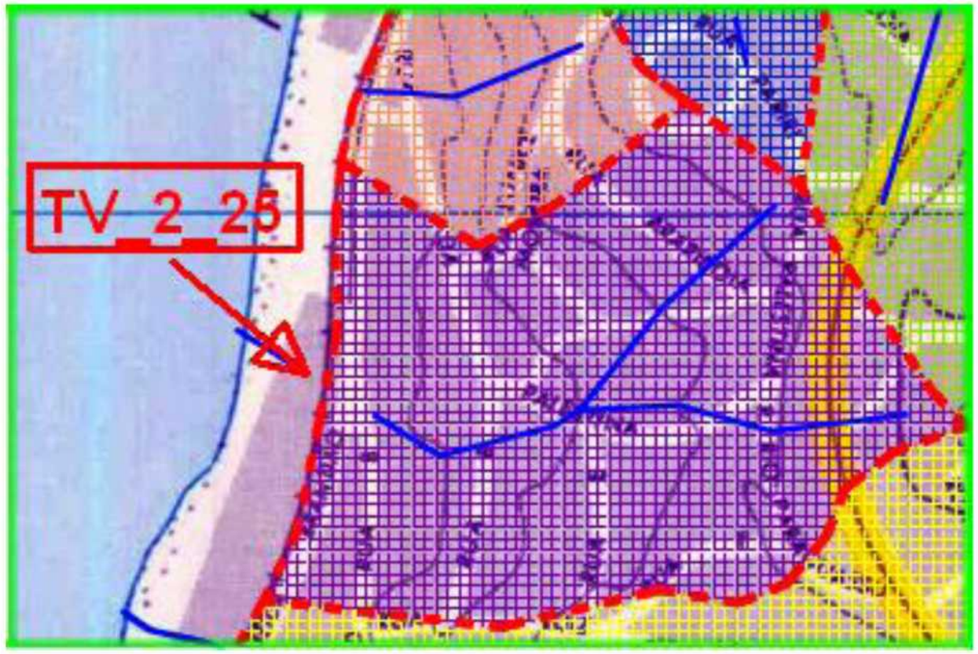
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_24	0.20%	8.72	374.69	38.26	11,468.62	2.17	6.00	1.00	0.88

It is a large-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



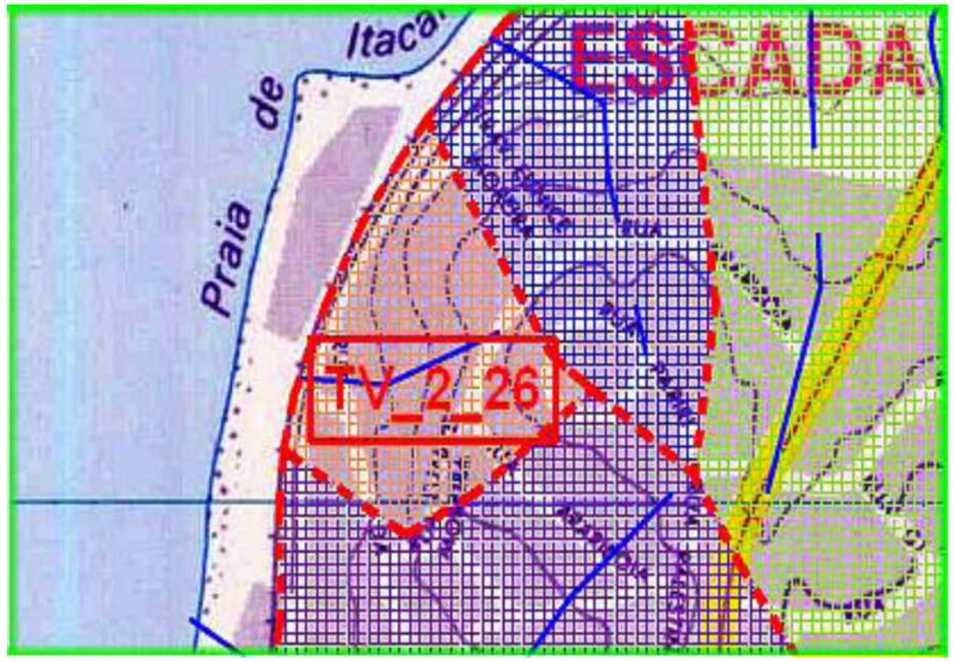


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_25	0.20%	5.00	409.84	8.54	2,800.04	1.66	1.80	1.00	0.94

It is a medium-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

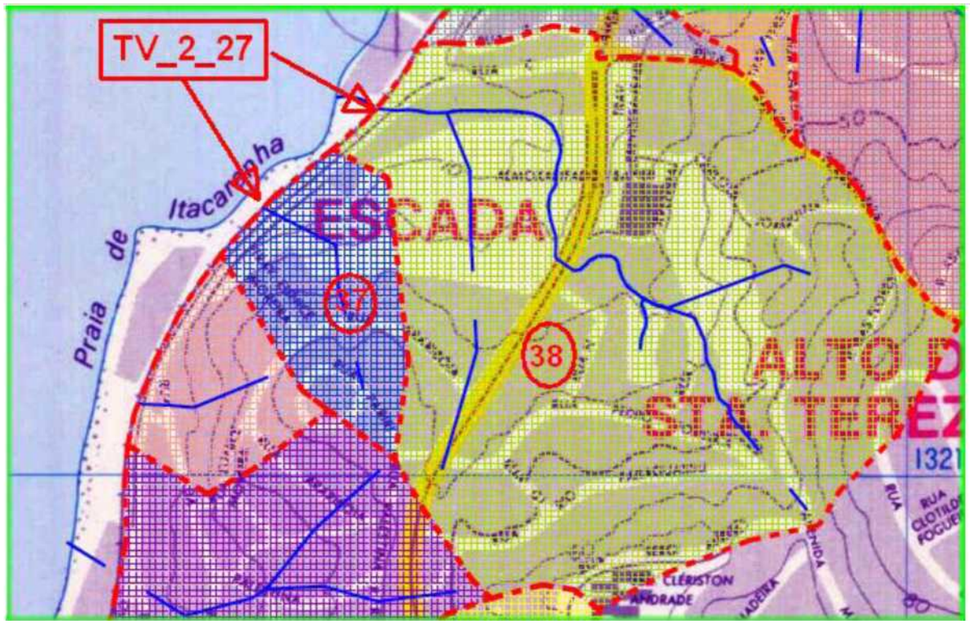


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_26	0.20%	5.00	409.84	2.71	888.54	1.24	1.00	1.00	0.72

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

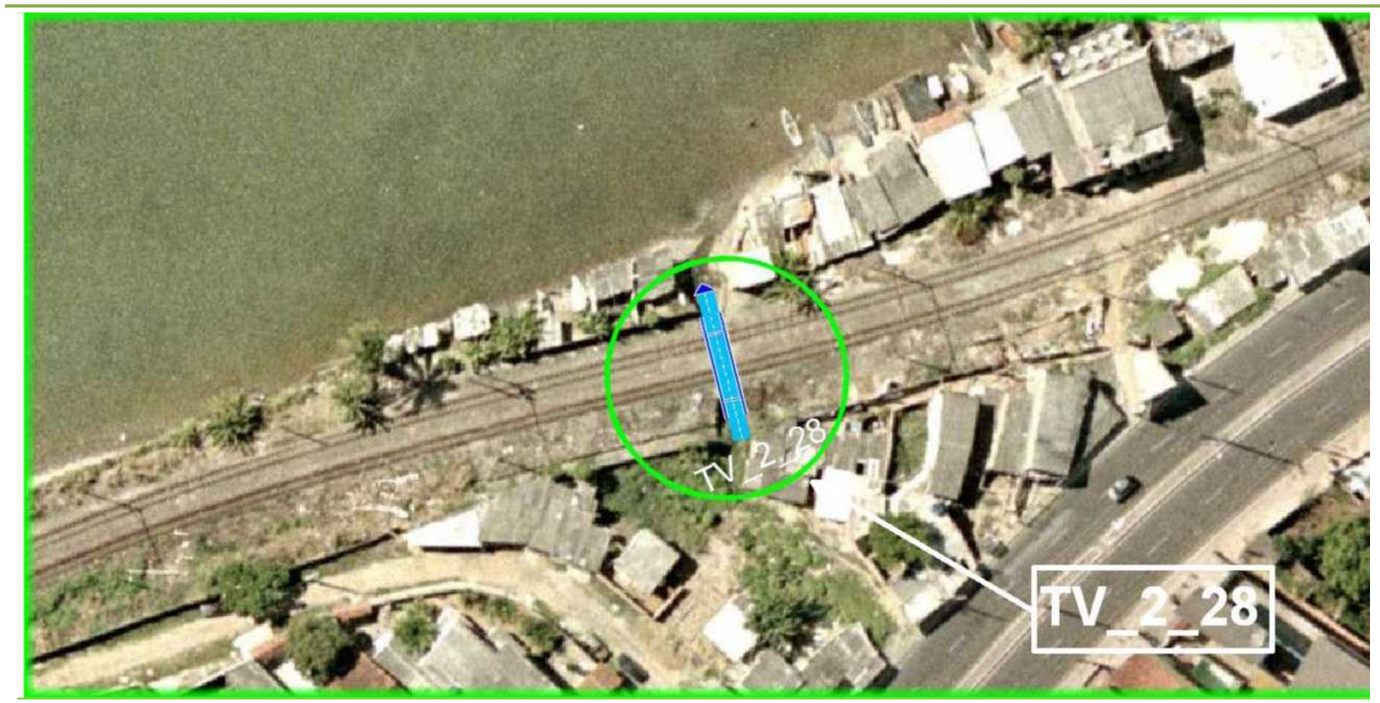


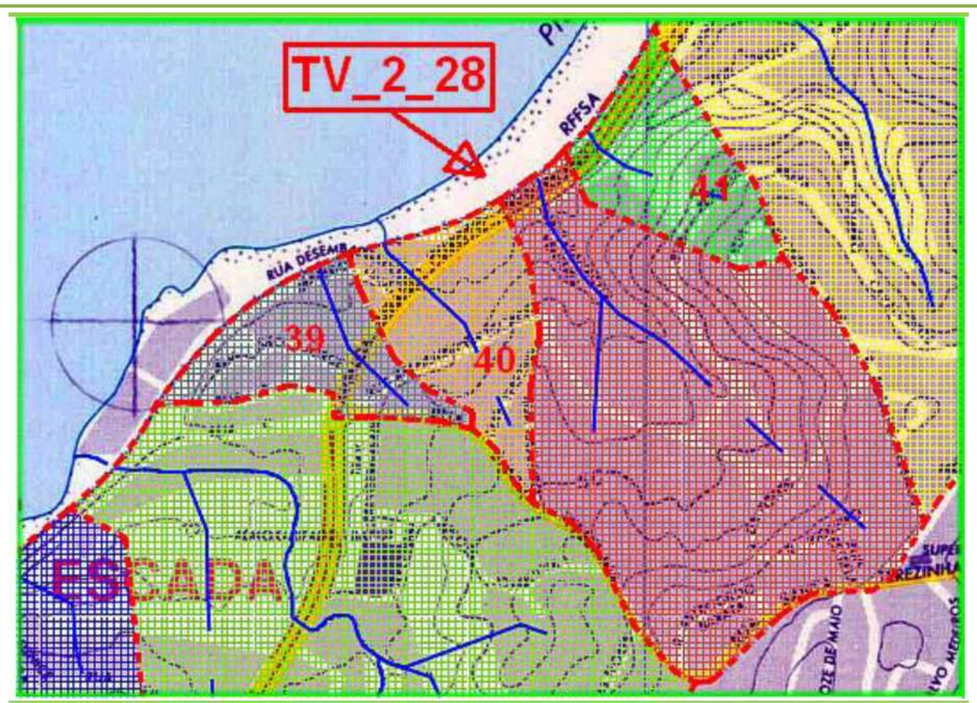
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_27	0.20%	8.46	376.88	29.94	9,027.01	2.13	4.50	1.00	0.94

These are two contribution basins, one of small-size and another of large-size, with release near the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



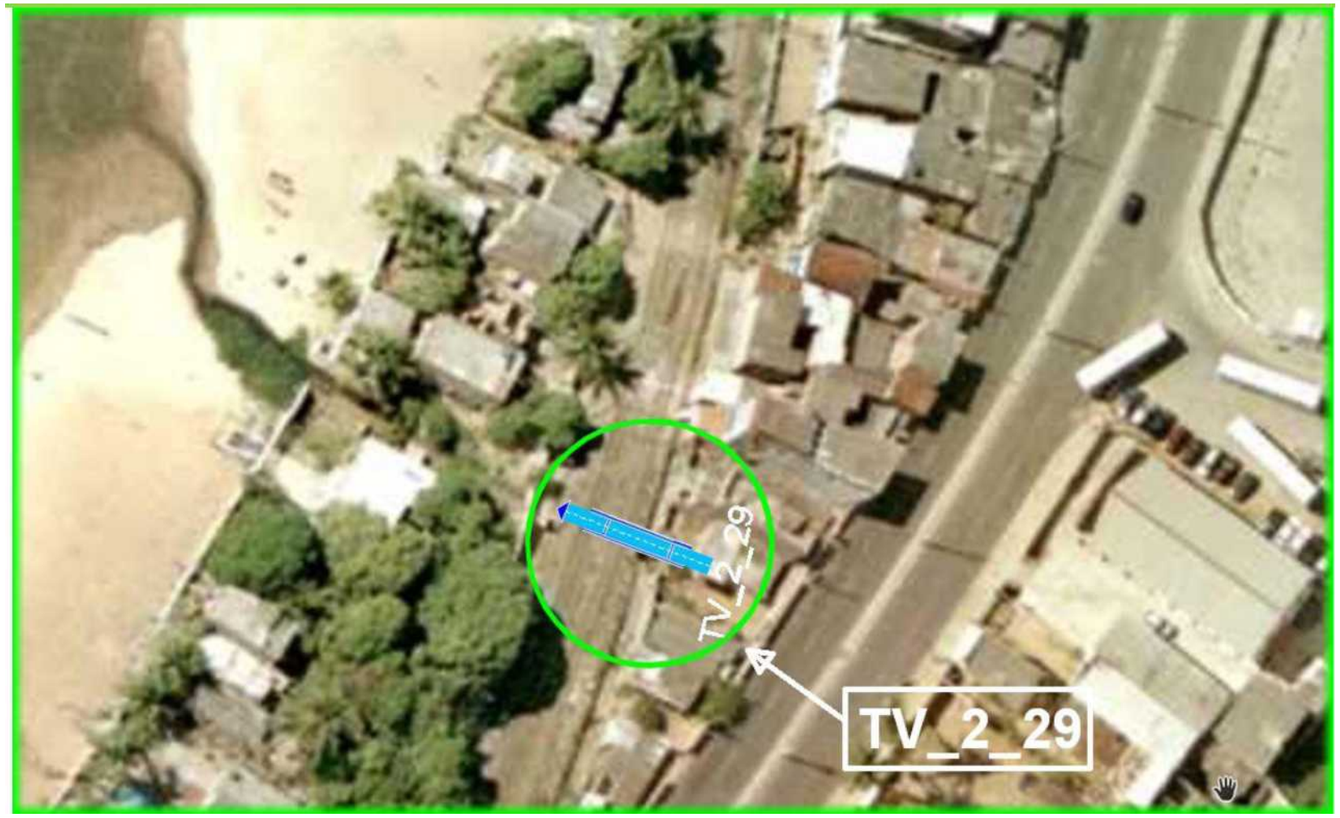


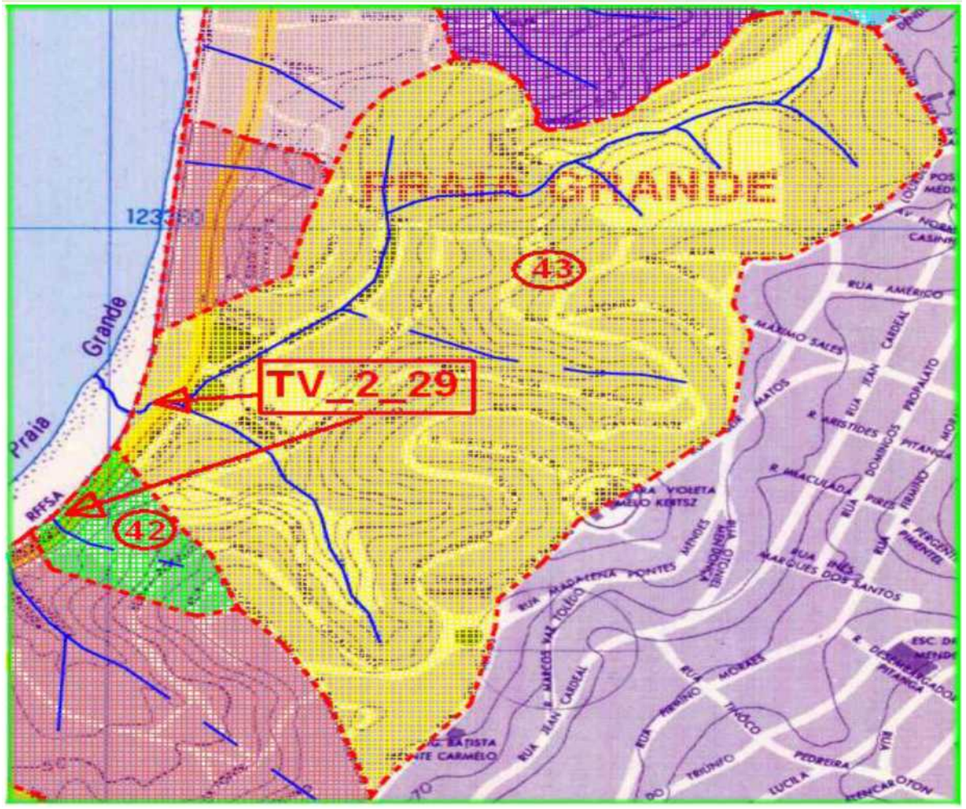
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_28	0.20%	5.00	400.84	19.86	6,544.35	2.01	3.50	1.00	0.93

These are three contribution basins, two of small-size and another of large-size, with release near the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



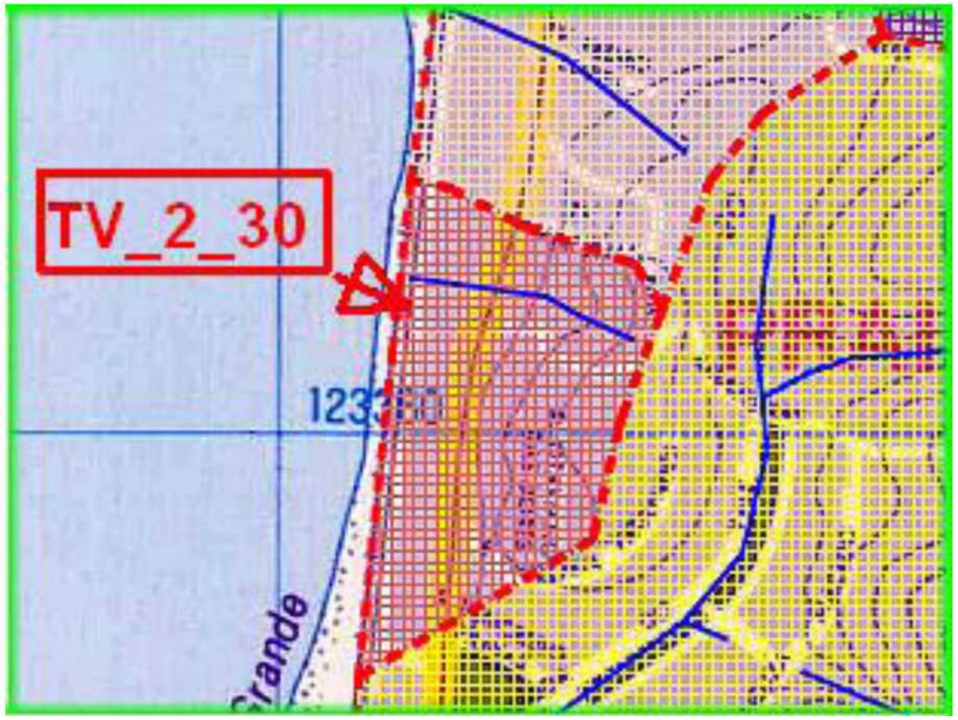


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_29	0.20%	11.89	349.84	51.98	14,547.86	2.39	5.50	1.20	1.11

These are two contribution basins, one of small-size and another of large-size, with release near the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

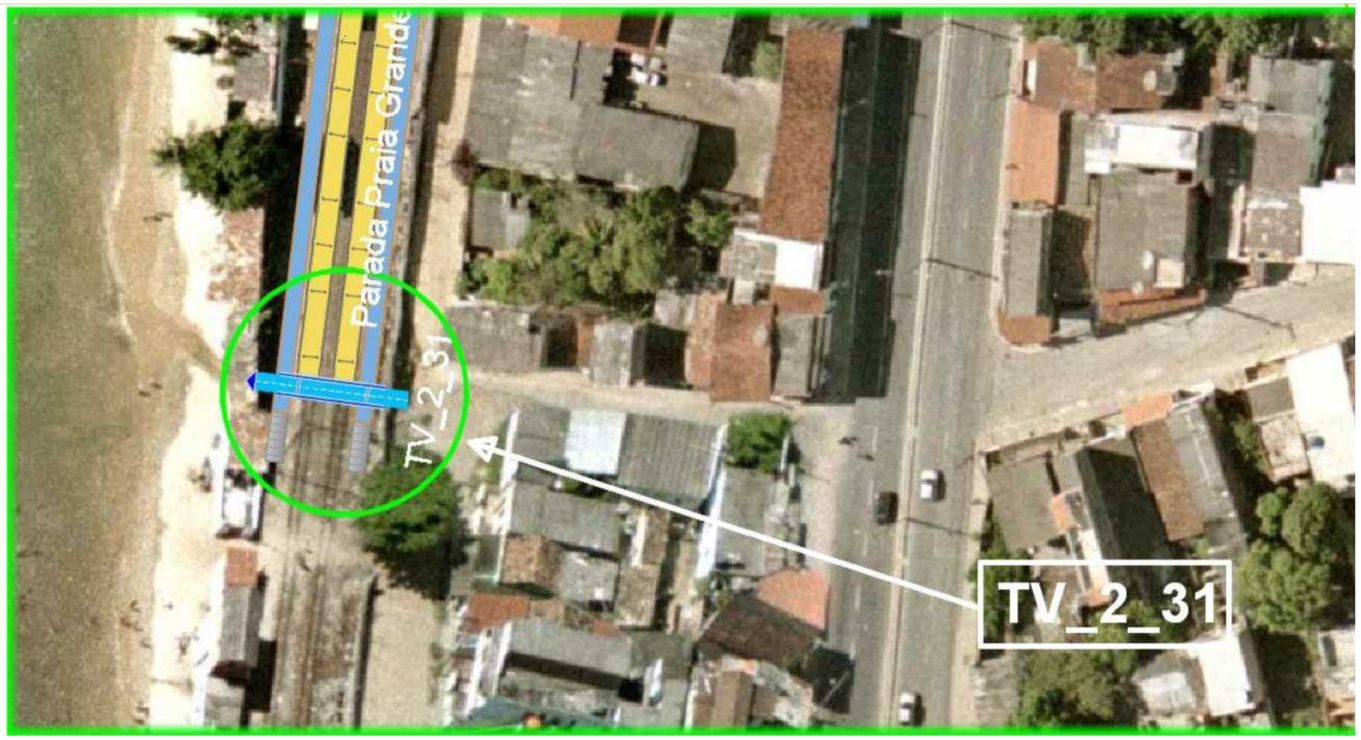


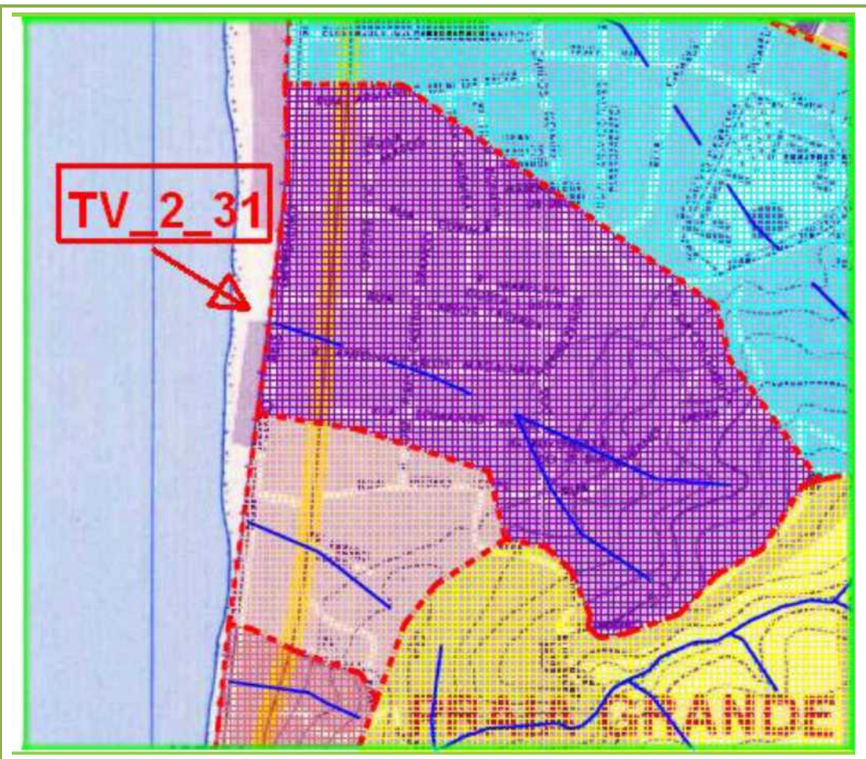
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_30	0.20%	5.00	409.84	3.63	1,190.18	1.31	1.00	1.00	0.91

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



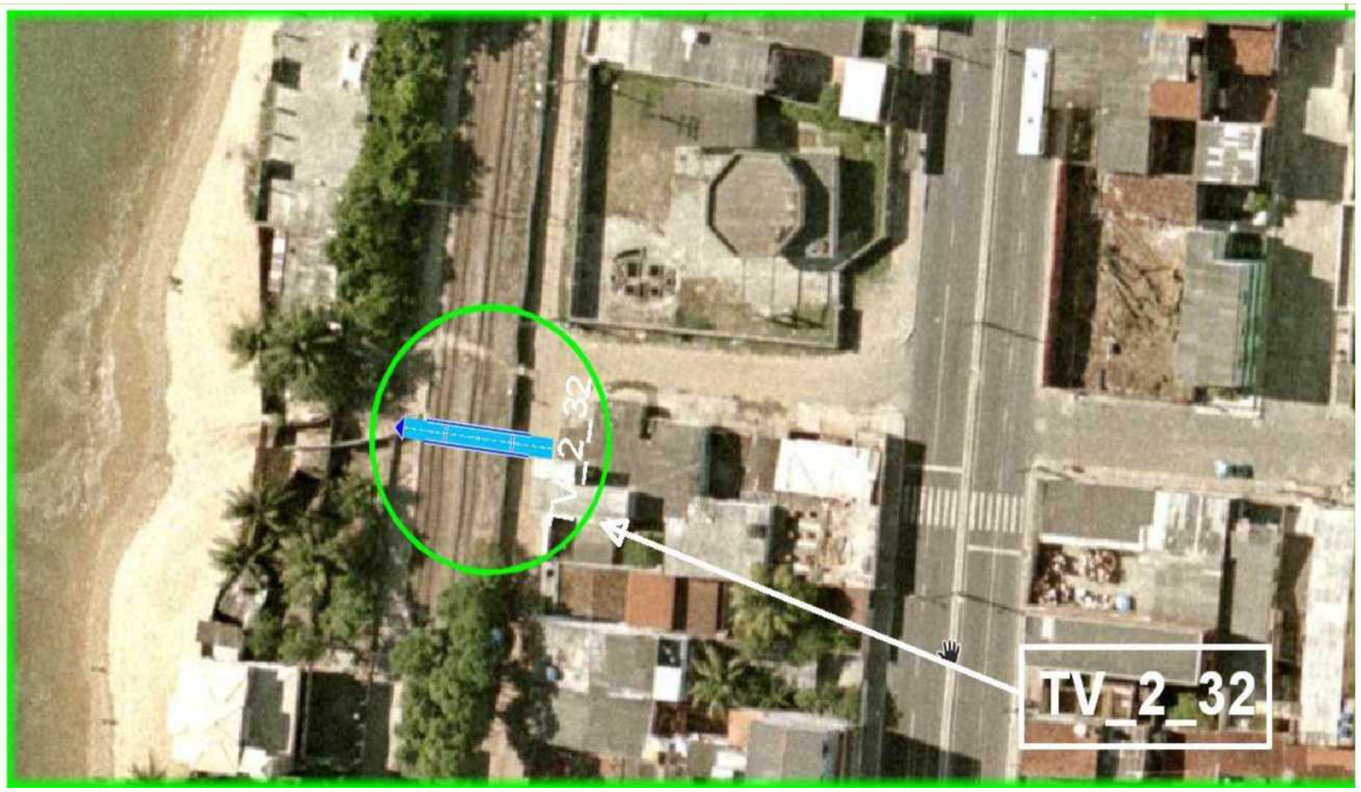


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_31	0.20%	5.00	409.84	5.60	1,836.09	1.48	1.30	1.00	0.95

It is a small-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

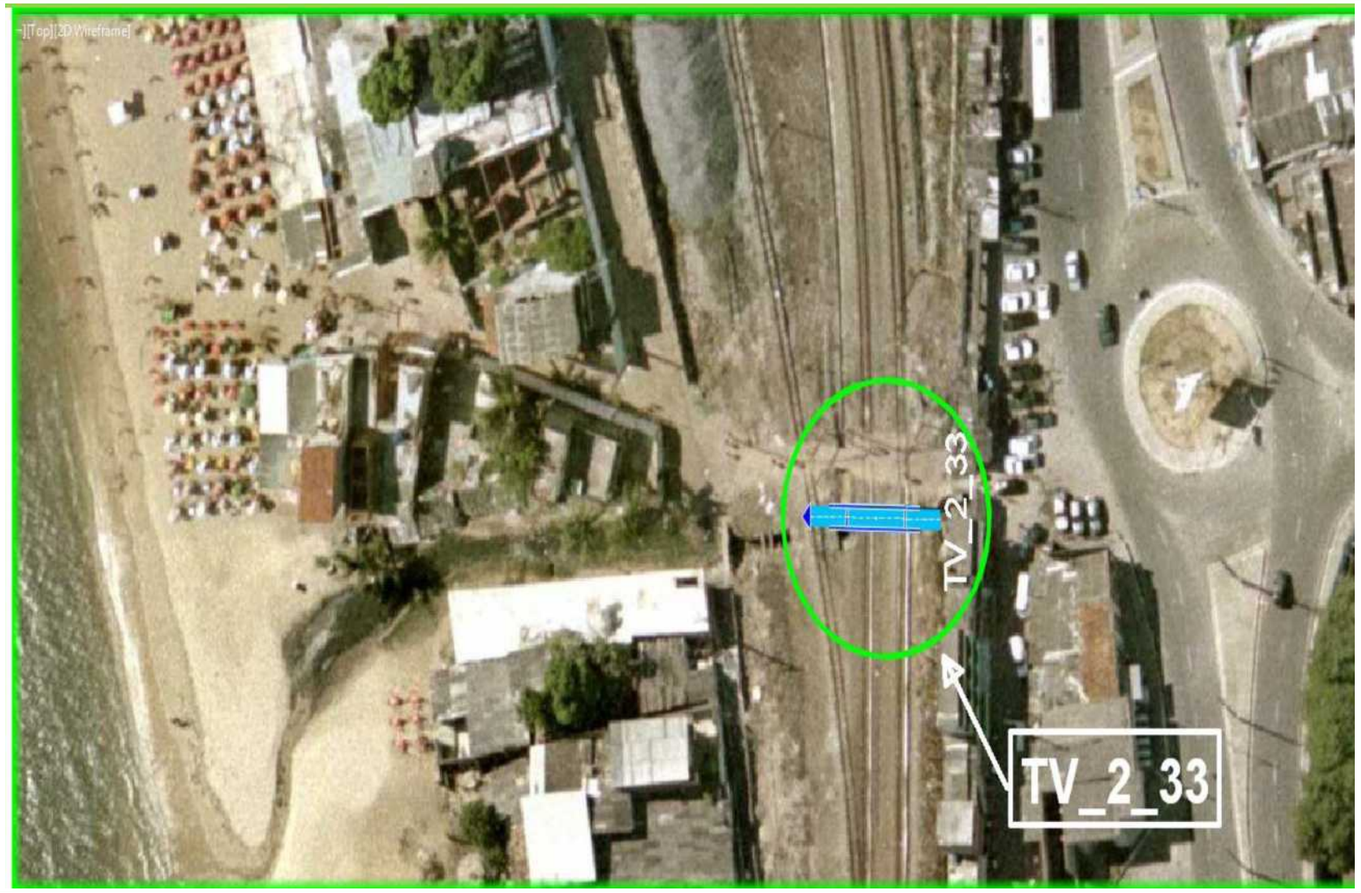


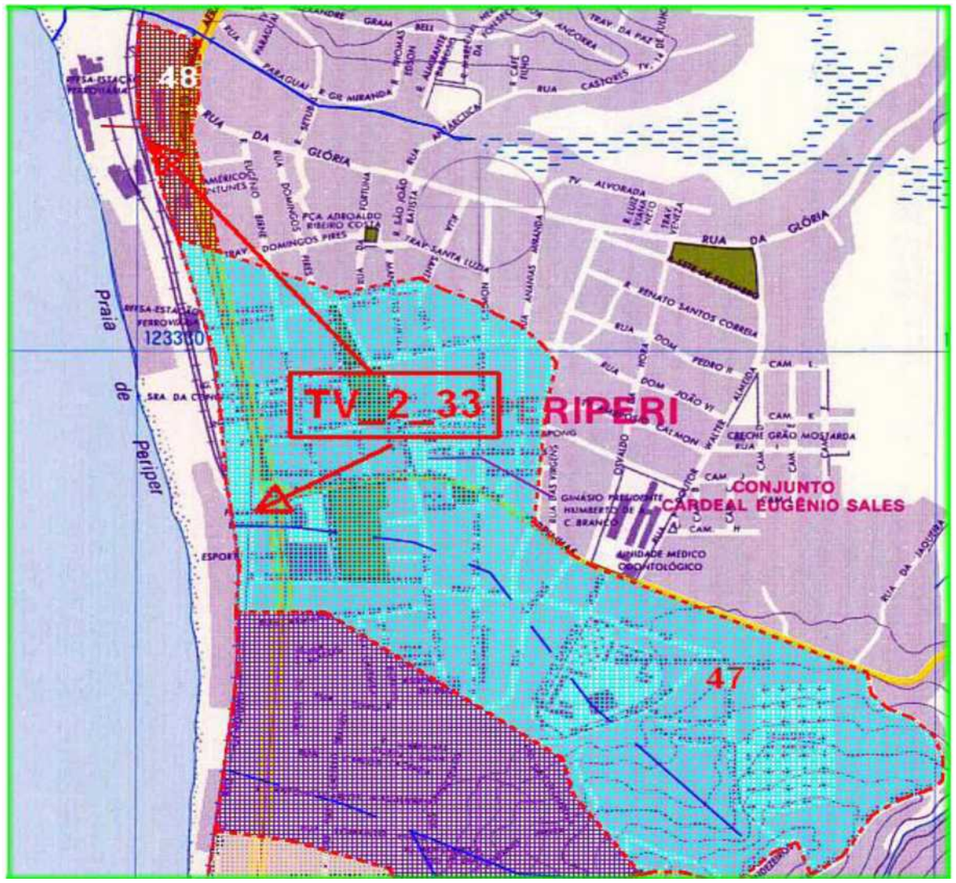
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_32	0.20%	6.16	398.05	19.43	6,187.28	2.01	3.00	1.00	1.03

It is a medium- to large-size contribution basin, with release close to the sea, requiring cleaning services.

The concentration time is a little longer, but the thalweg line has a marked slope and the combination of these factors leads to the occurrence of accentuated flood peaks.



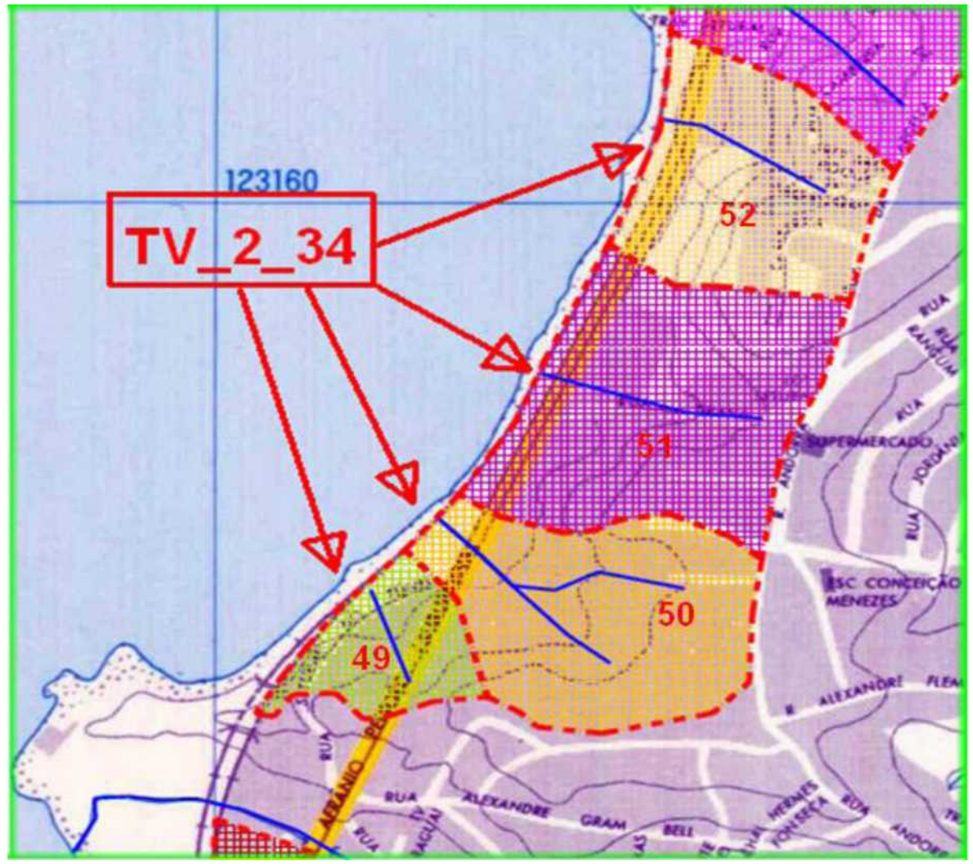


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_33	0.20%	9.94	364.62	49.32	14,386.61	2.40	5.20	1.20	1.15

These are two contribution basins, one of small-size and another of large-size, with release near the sea, requiring cleaning services.

The concentration time is a little longer, but the thalweg line has a marked slope and the combination of these factors leads to the occurrence of accentuated flood peaks.

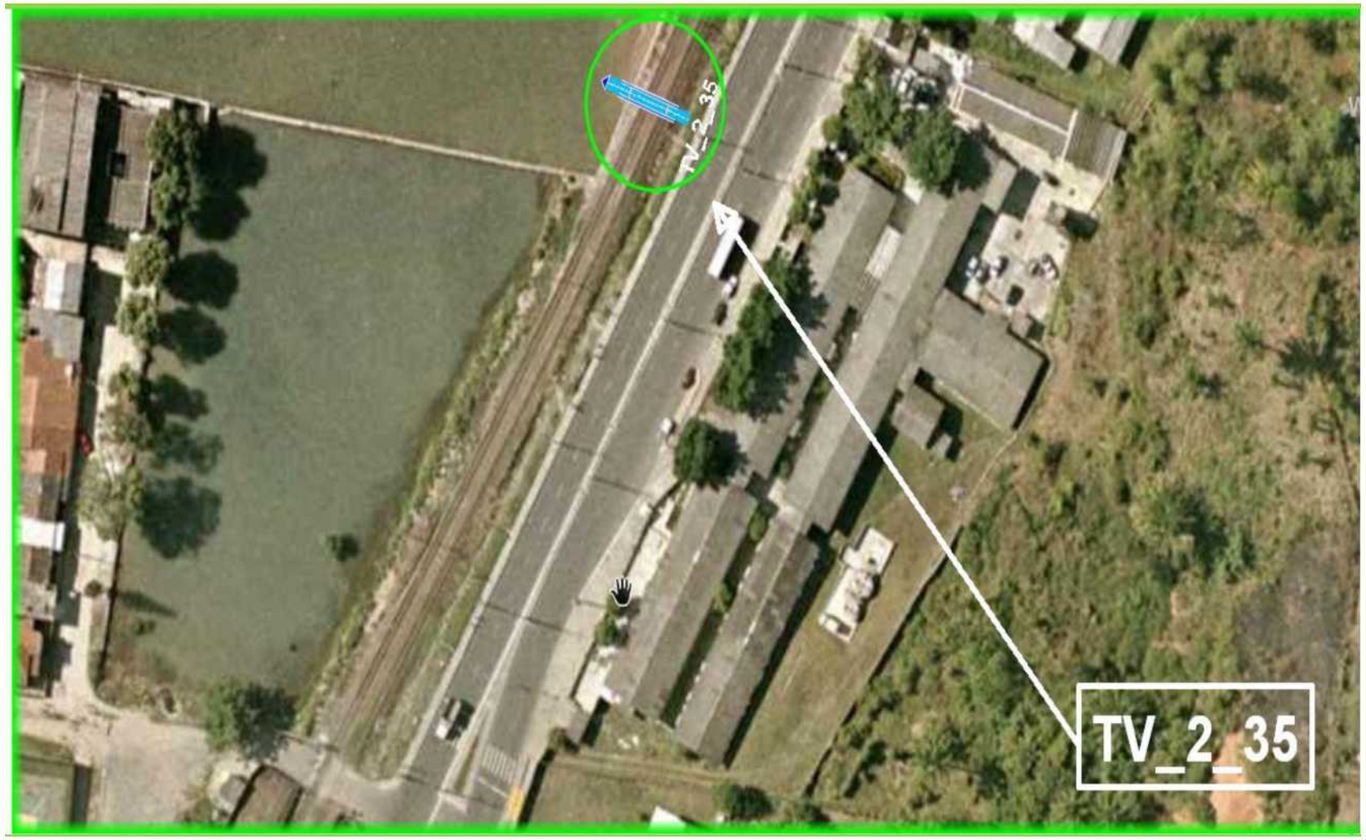


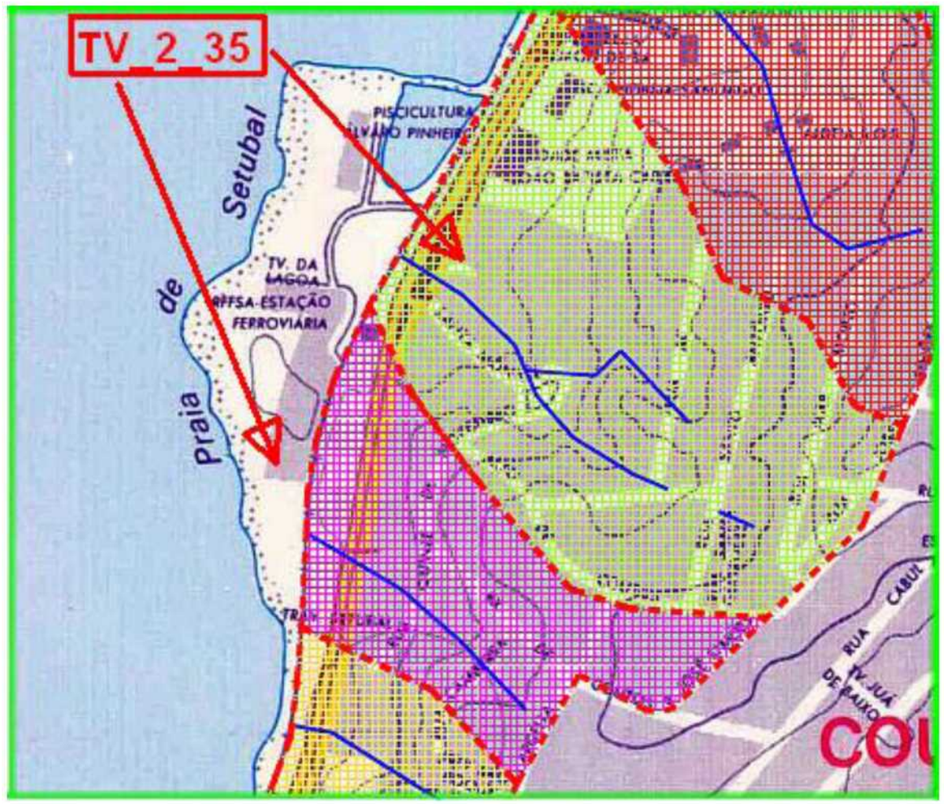
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_34	0.20%	5.00	409.84	17.61	5,773.85	1.93	3.50	1.00	0.85

They are four small-size basins, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



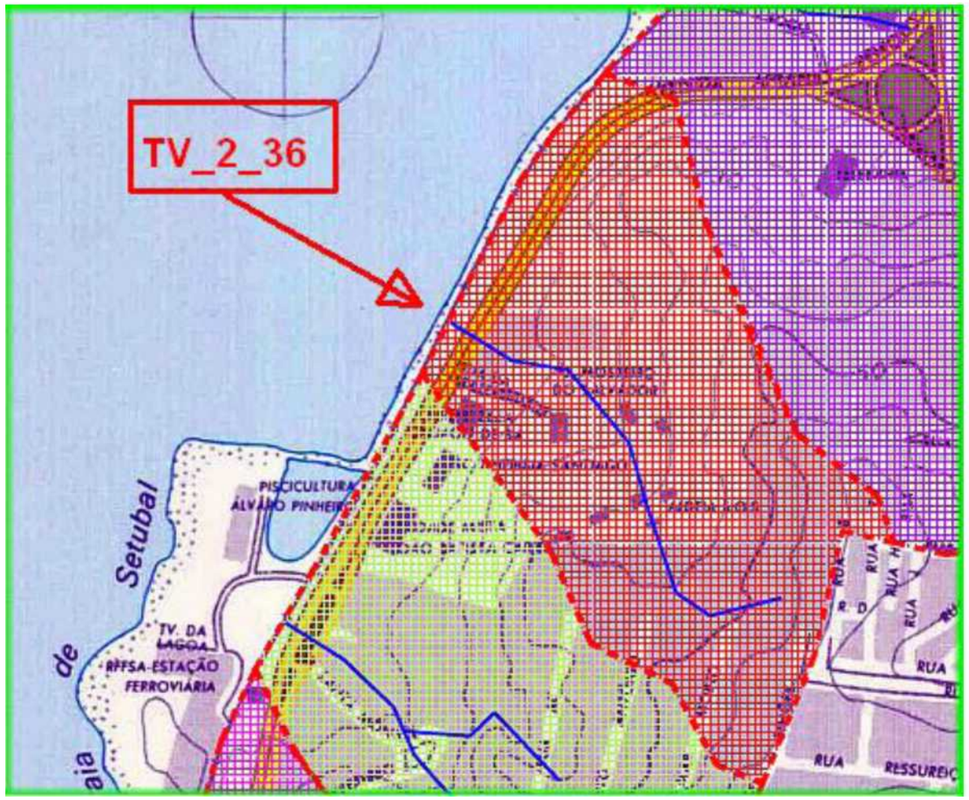


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_35	0.20%	5.00	409.84	21.26	6,970.59	2.04	3.50	1.00	0.97

They are two medium-size added basins, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.

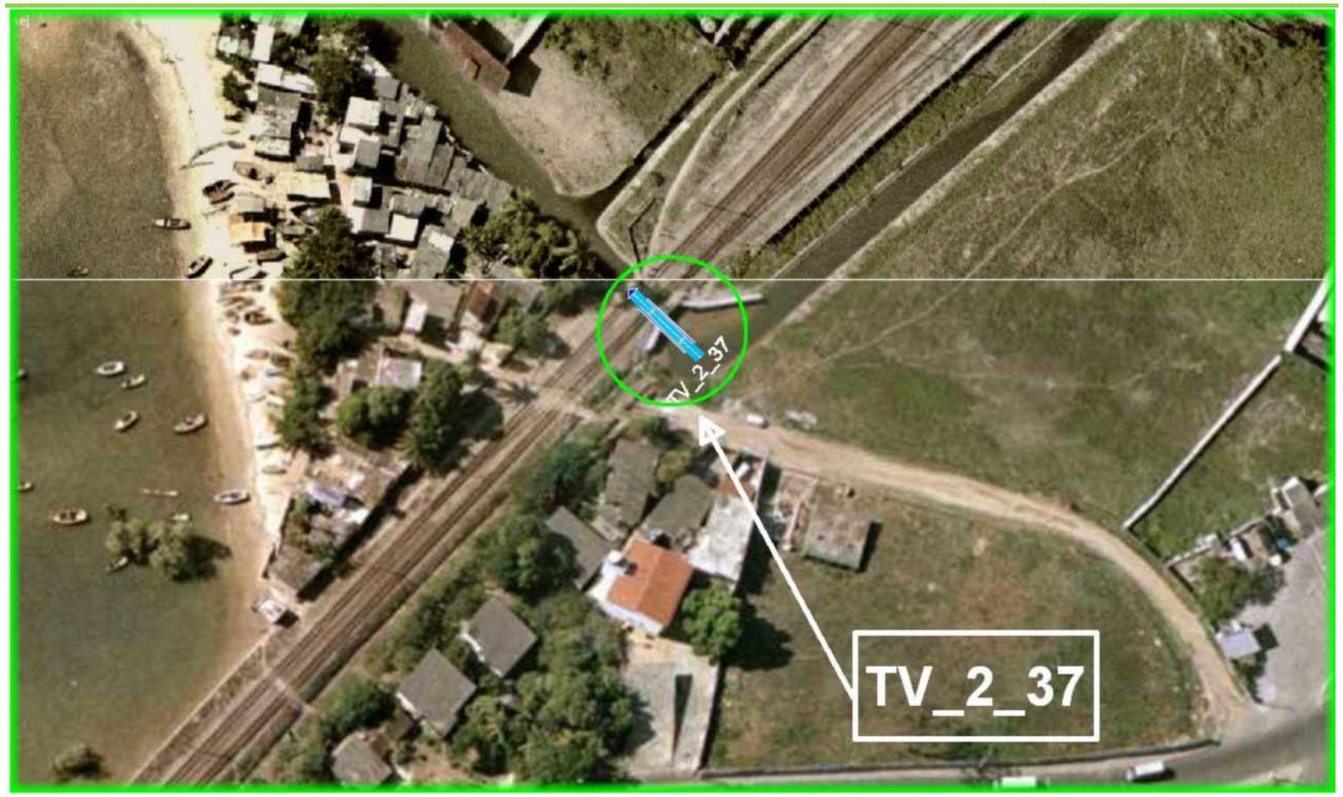


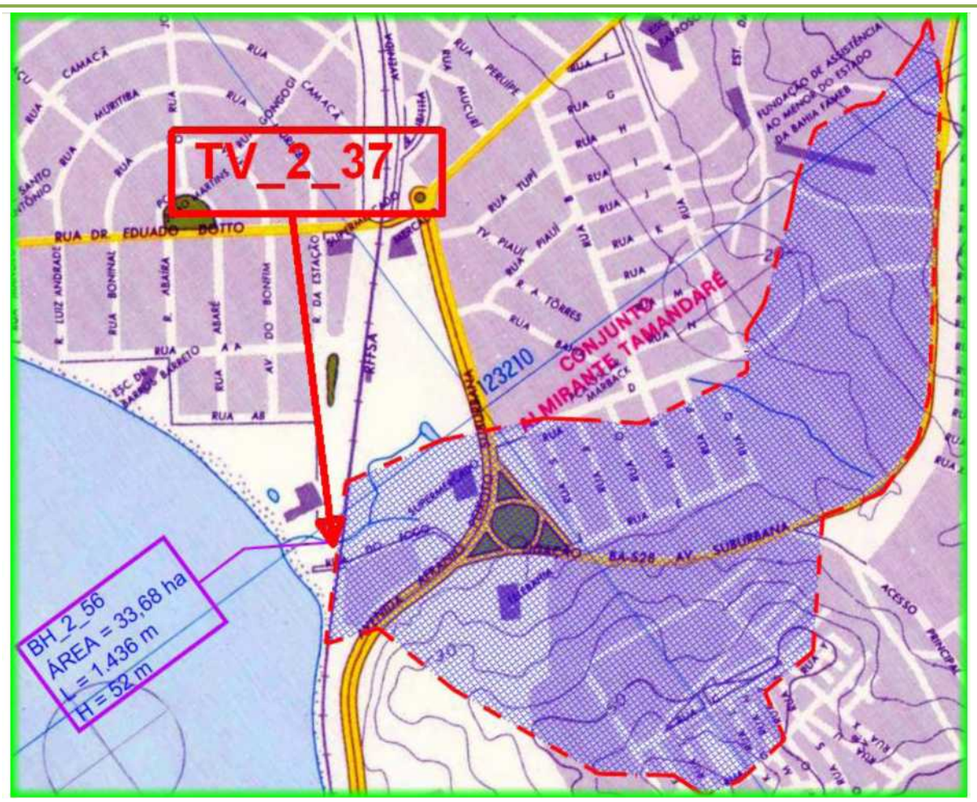
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
T_V 2_36	0.20%	5.20	407.76	14.76	4,814.79	1.89	2.60	1.00	0.98

It is a medium- to large-size basin, with release close to the sea, requiring cleaning services.

The concentration time is very short, the thalweg line has a marked slope, but the combination of these factors leads to the occurrence of accentuated flood peaks.



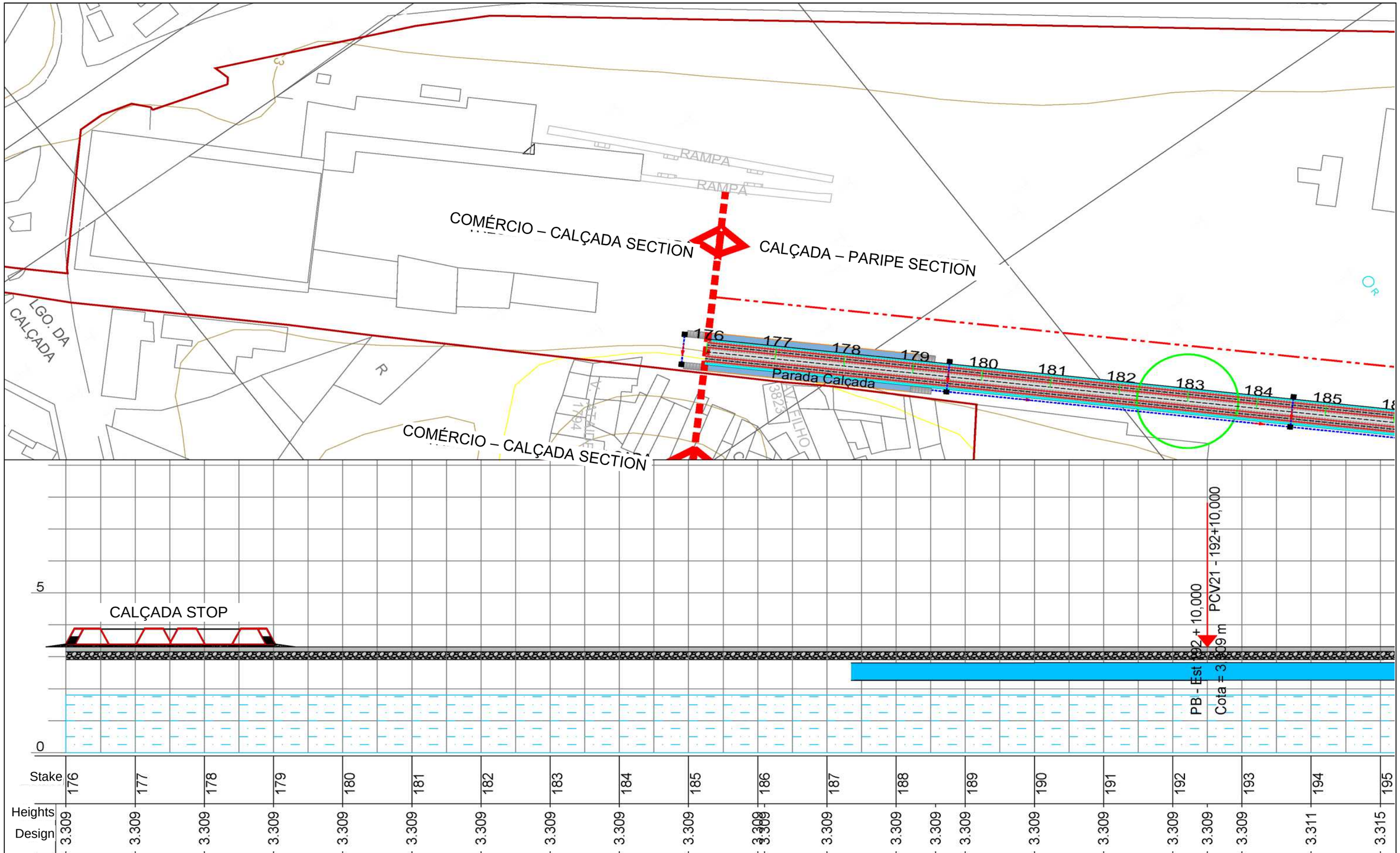


Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	slope	tc	int	Area	Q = C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_2_37	0.20%	19.13	305.19	33.68	8,222.99	2.07	4.50	1.00	0.88

It is a large-size basin with release near the sea, requiring cleaning services.

It has a long concentration time, the thalweg line has medium slope and the combination of these factors do not provide the occurrence of sharp flood peaks.



CAPTION

Axis
TR45 Rail
TR45 Rail
Permanent Track
Higher Point
Lower Point
Tubular gallery
Collecting or Passage Box
Deep Drain (Plant)
Deep Drain (Profile)
Right of way
Rectangular channel (Plant)
Regularization of the land
Rectangular channel (Profile)
Crossing - Capped gully hole (Profile)
Crossing - Capped gully hole (Plant)
Potential Crossing
Maximum tide = 1.80 m

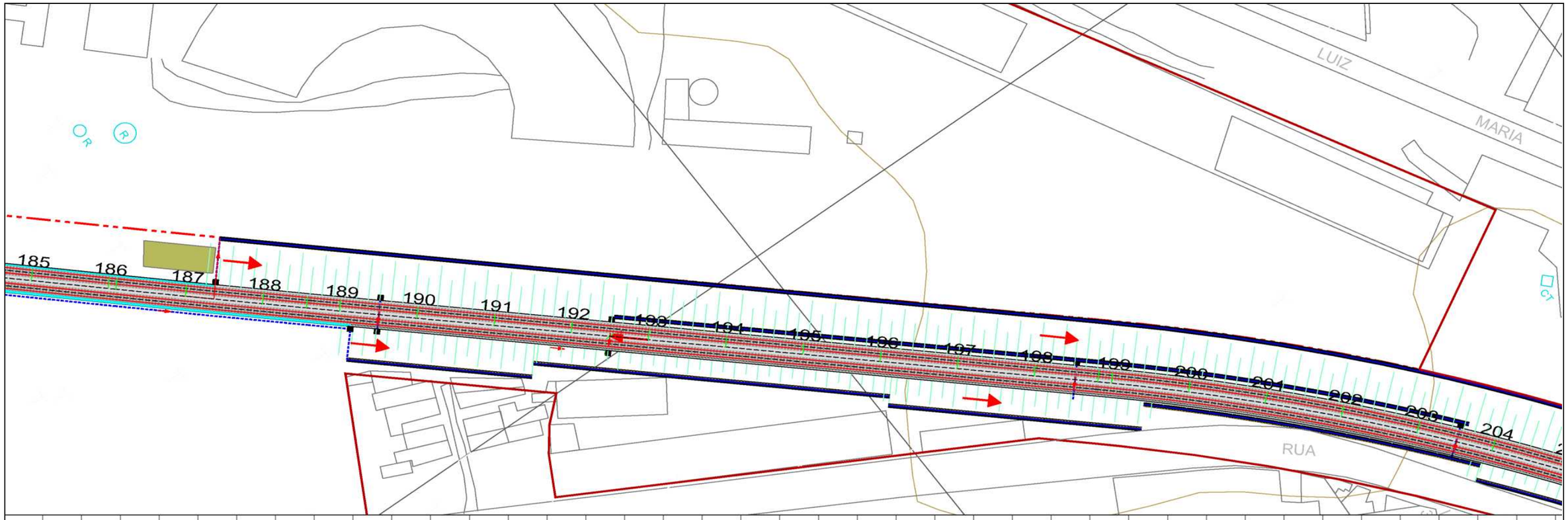
DRAWING		/ /	SHEET 01/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

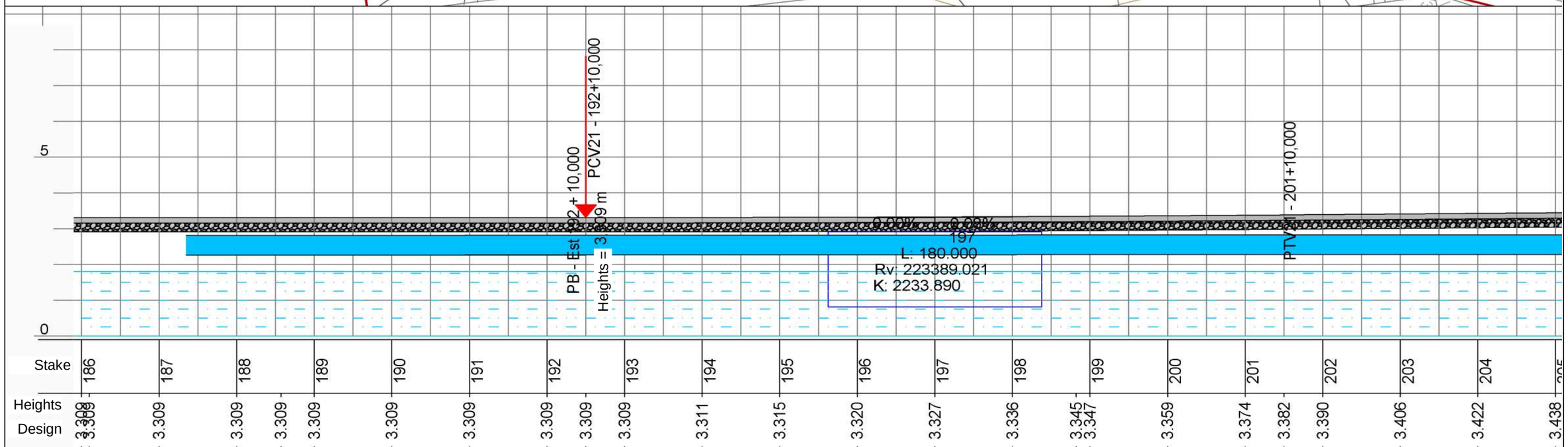
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 02/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

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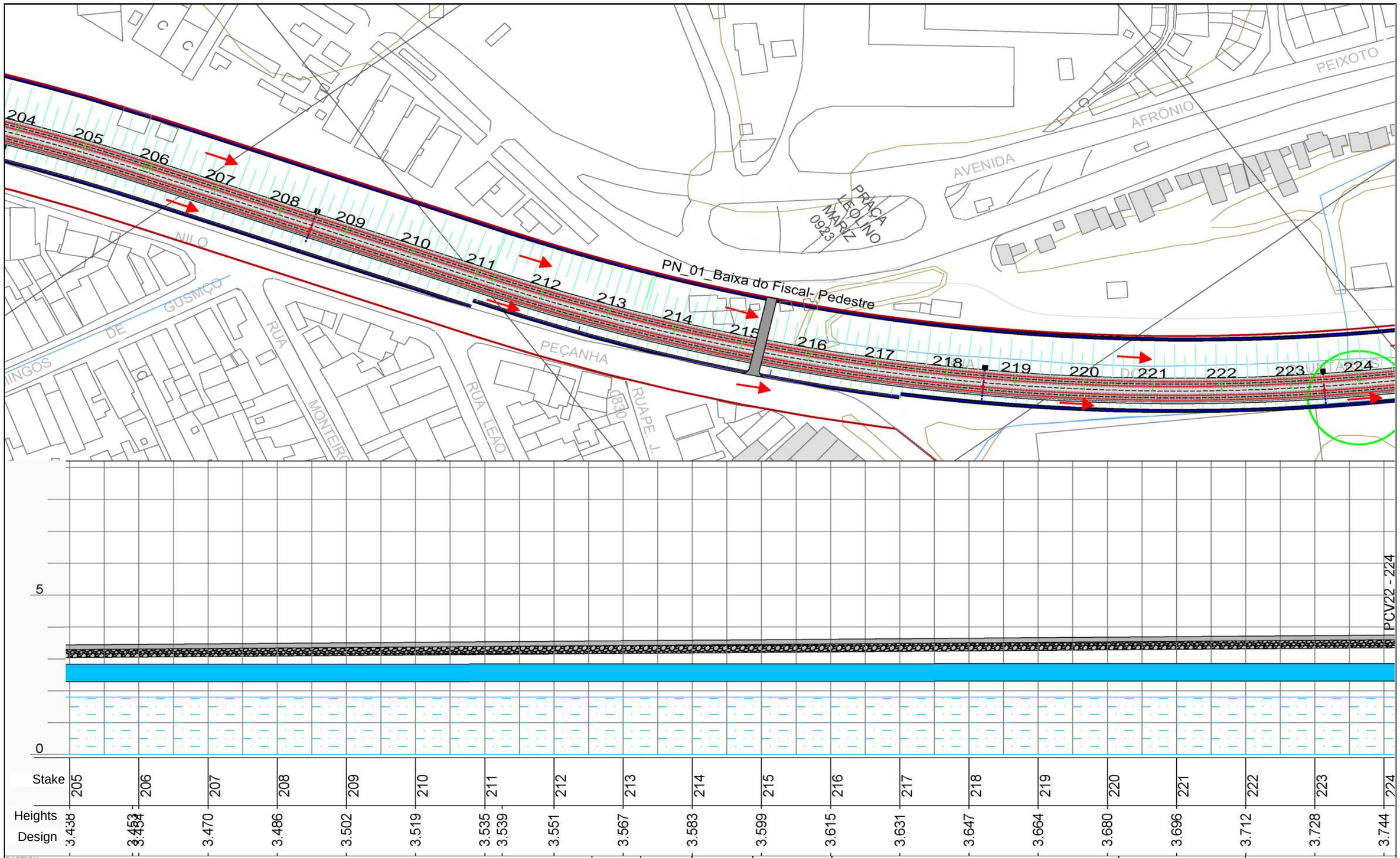
LIGHT-RAIL VEHICLE
LRV



CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 03/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY: SALVADOR

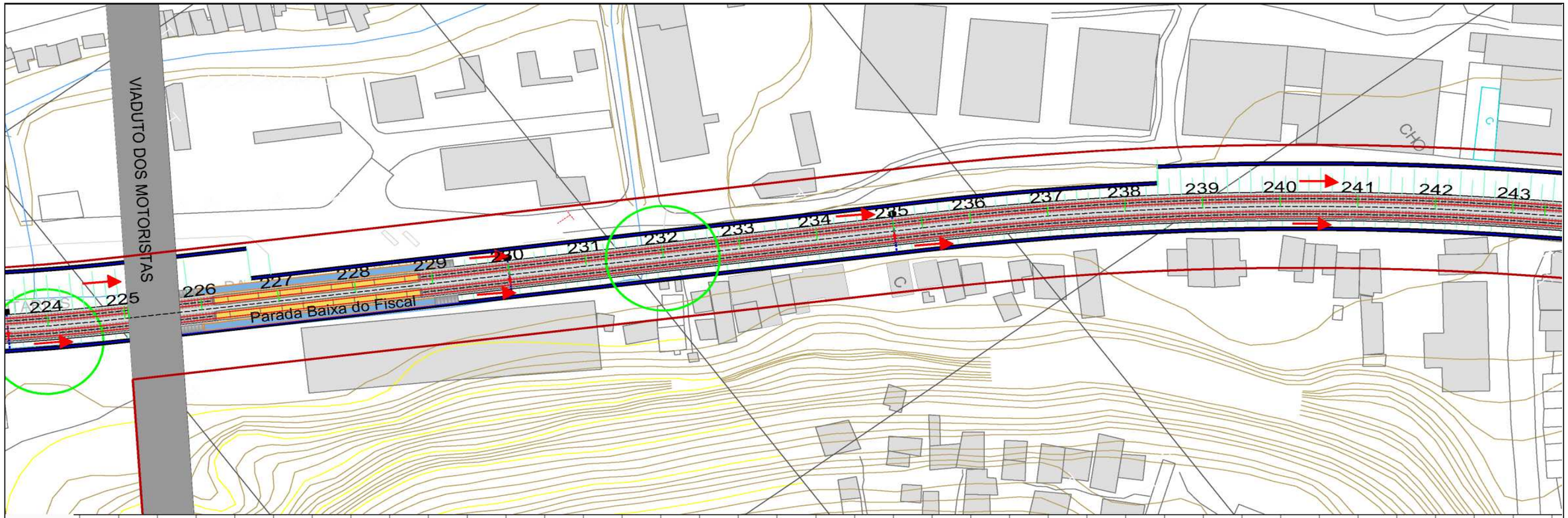
SUBJECT: DRAINAGE - FLOOR PLAN AND PROFILE

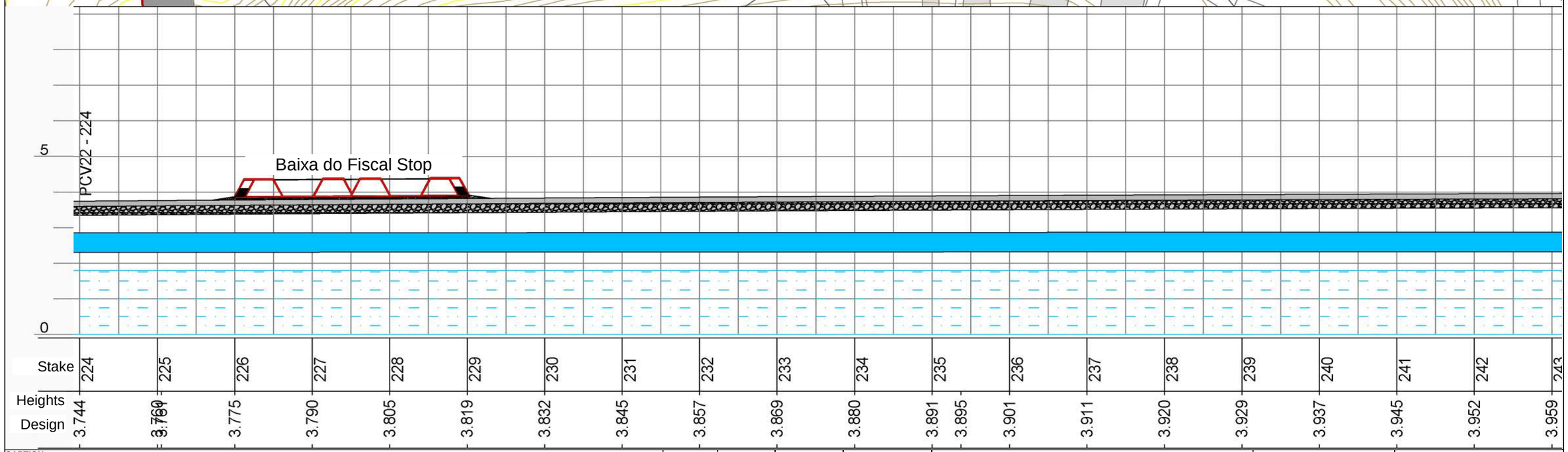
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 04/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

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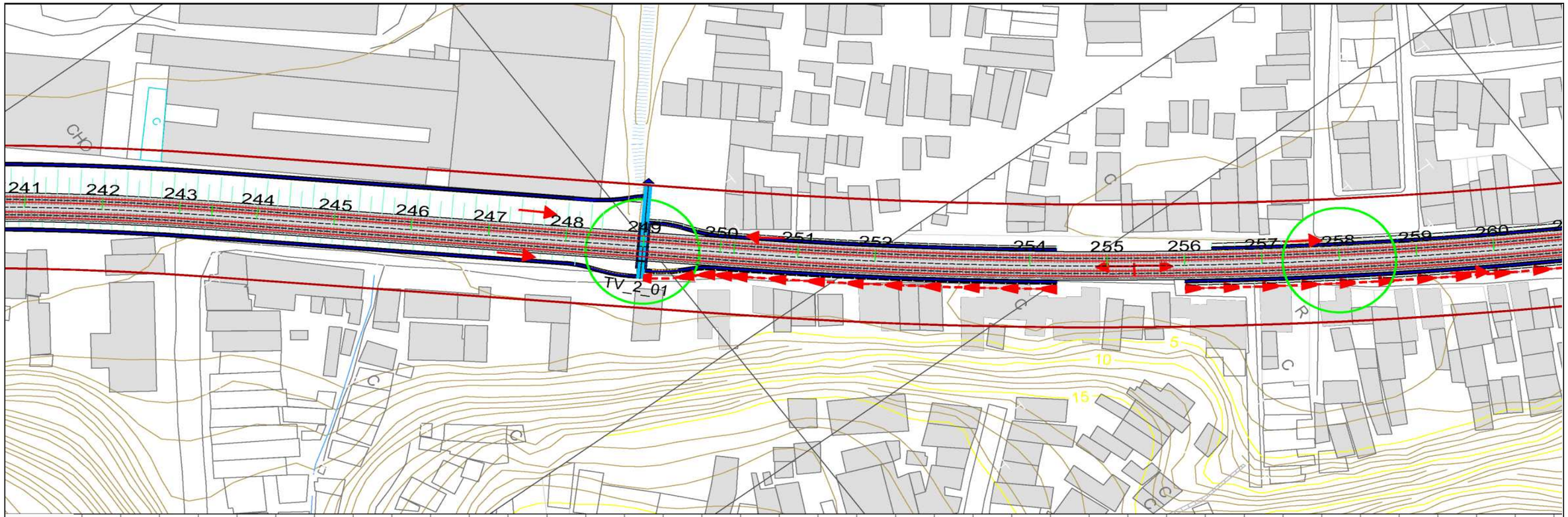
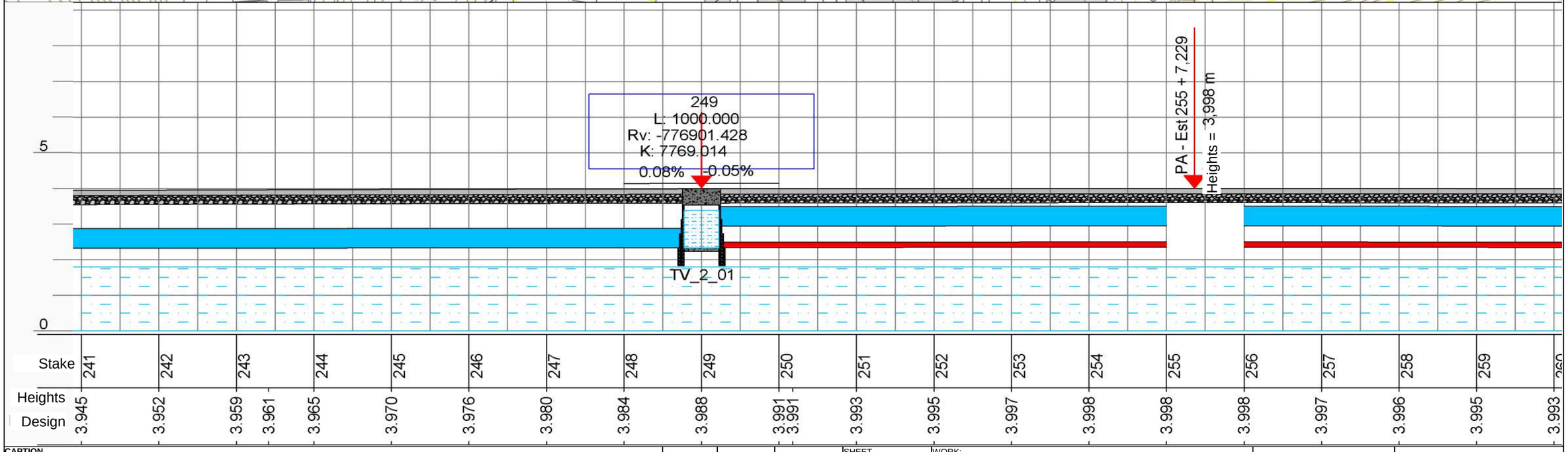
CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 05/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

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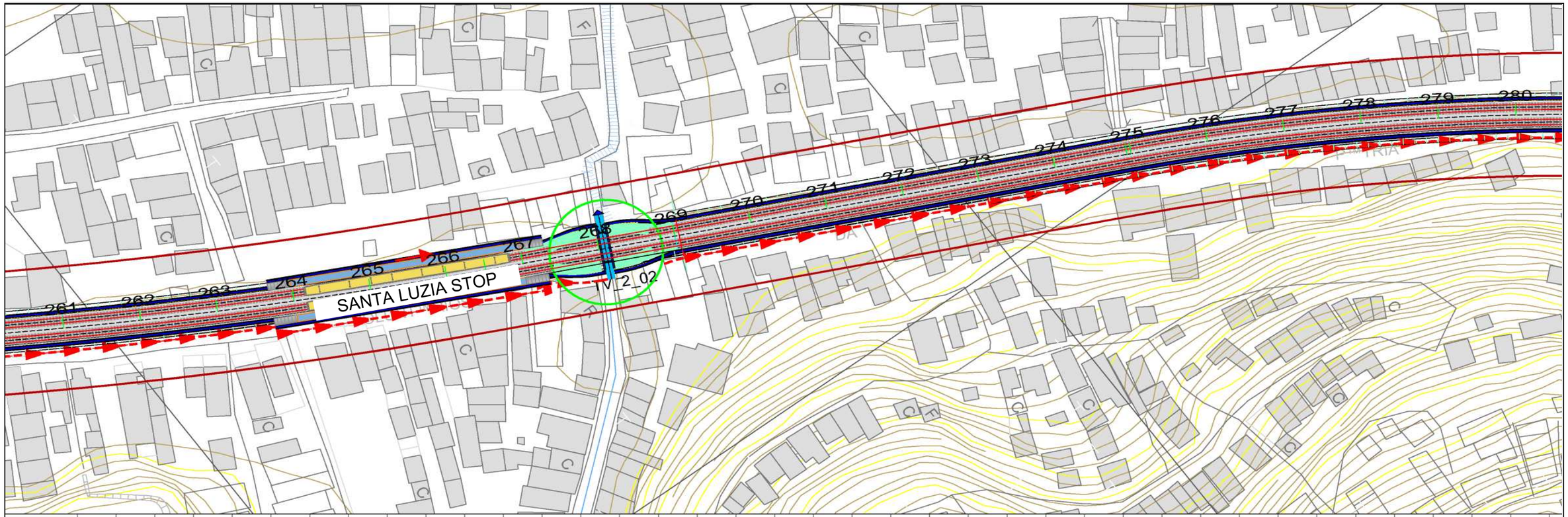
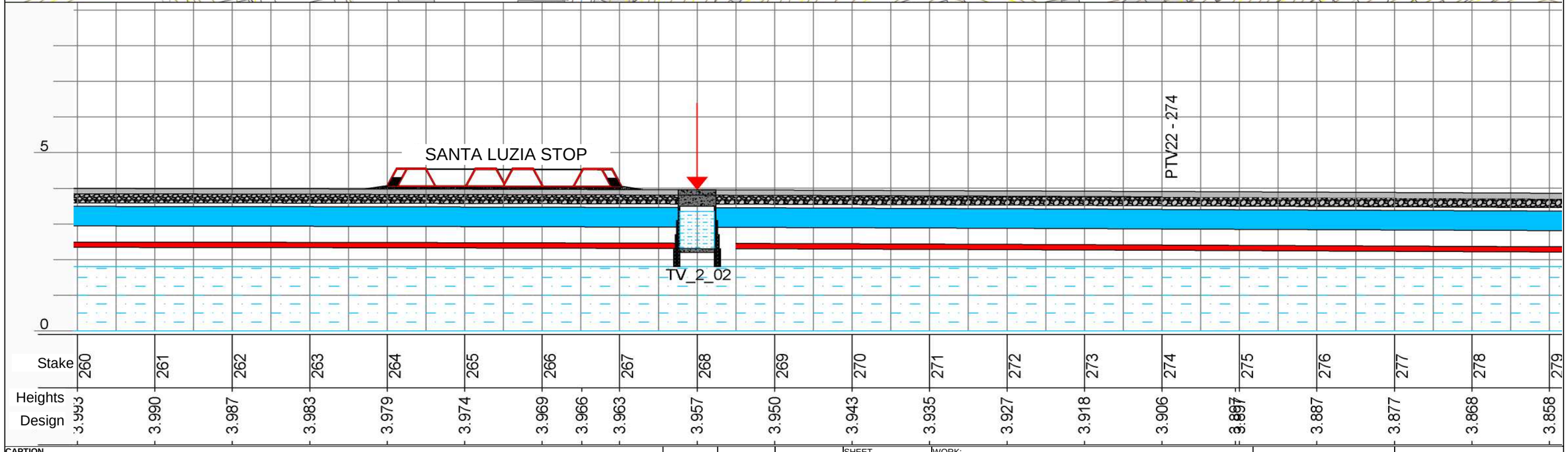
BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

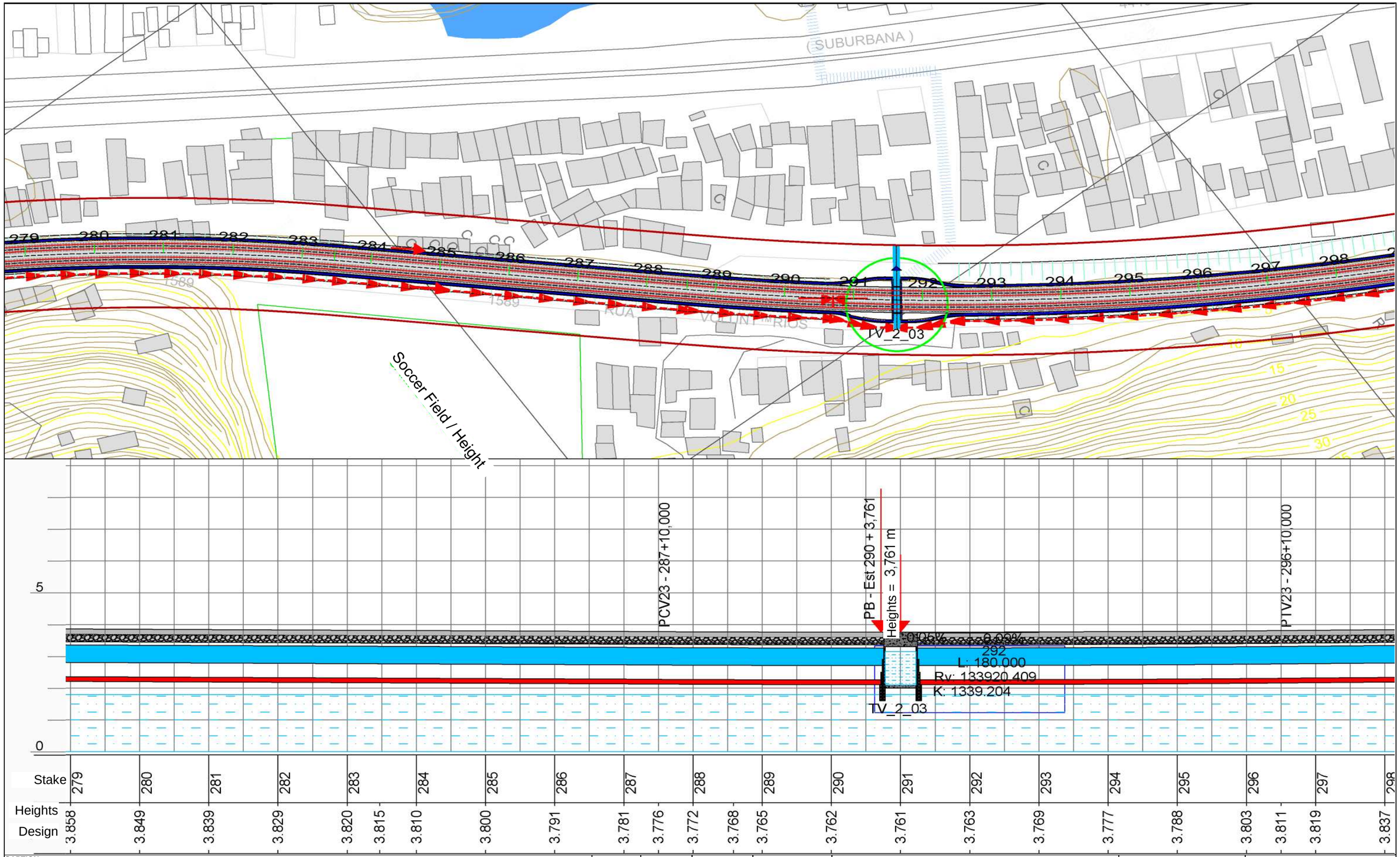
DRAWING		/ /	SHEET 06/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 07/36
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000
APPROVAL		/ /	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY: SALVADOR

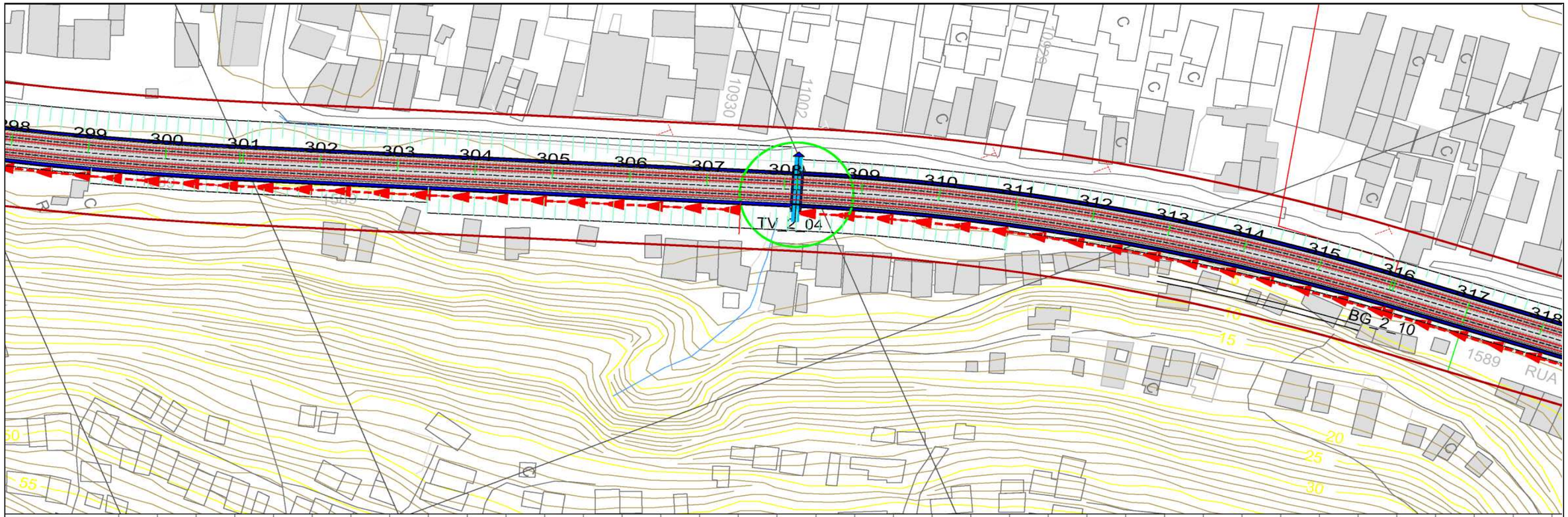
SUBJECT: DRAINAGE - FLOOR PLAN AND PROFILE

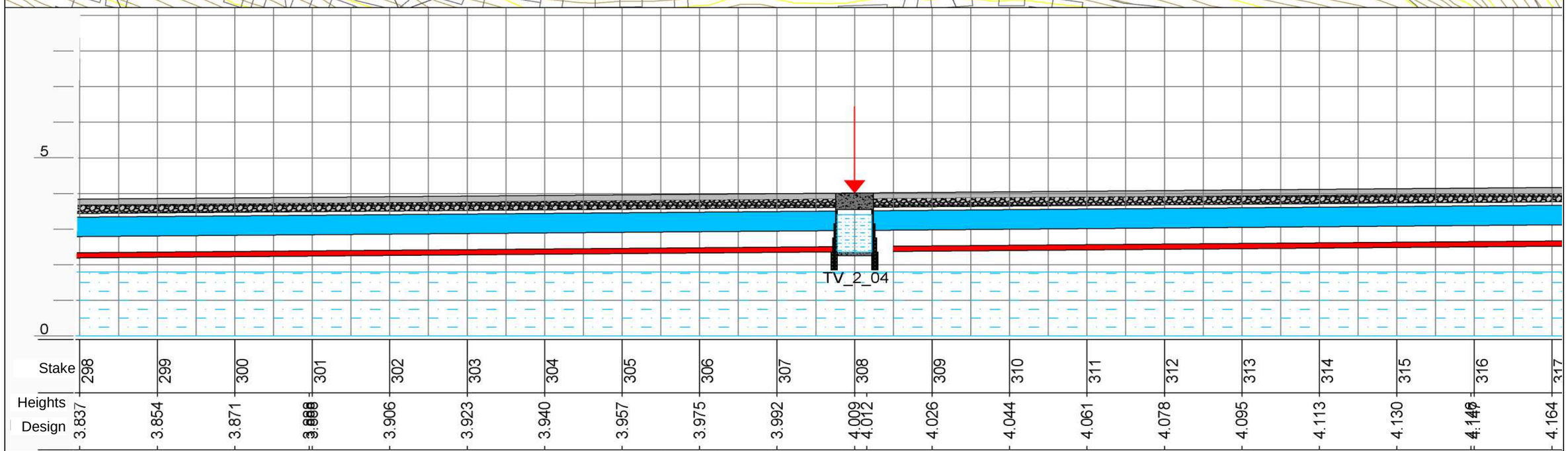
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

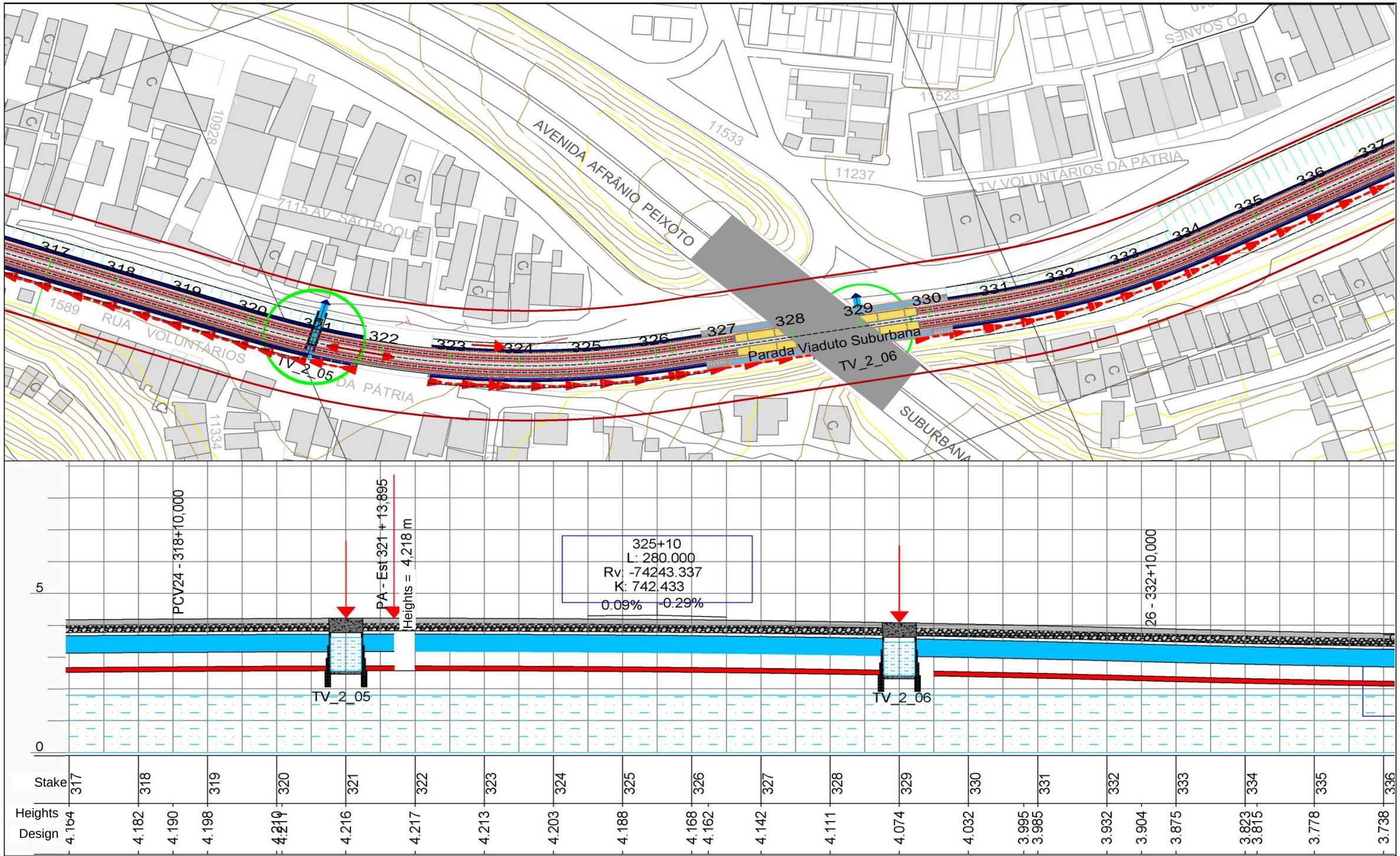
DRAWING		/ /	SHEET 08/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

Axis; TR45 Rail; TR45 Rail; Permanent Track; Higher Point; Lower Point; Tubular gallery; Collecting or Passage Box; Deep Drain (Plant); Deep Drain (Profile); Right of way; Rectangular channel (Plant); Regularization of the land; Rectangular channel (Profile); Crossing - Capped gully hole (Profile); Crossing - Capped gully hole (Plant); Potential Crossing; Maximum tide = 1.80 m

DRAWING		/ /	SHEET 09/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY: SALVADOR

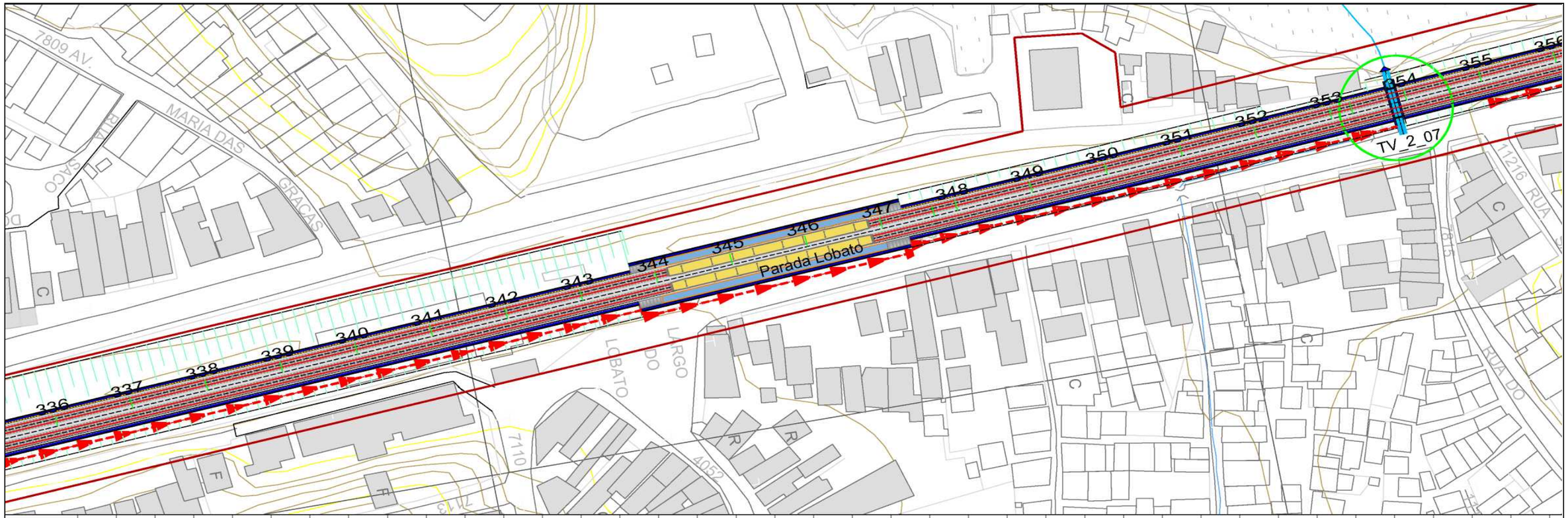
SUBJECT: DRAINAGE - FLOOR PLAN AND PROFILE

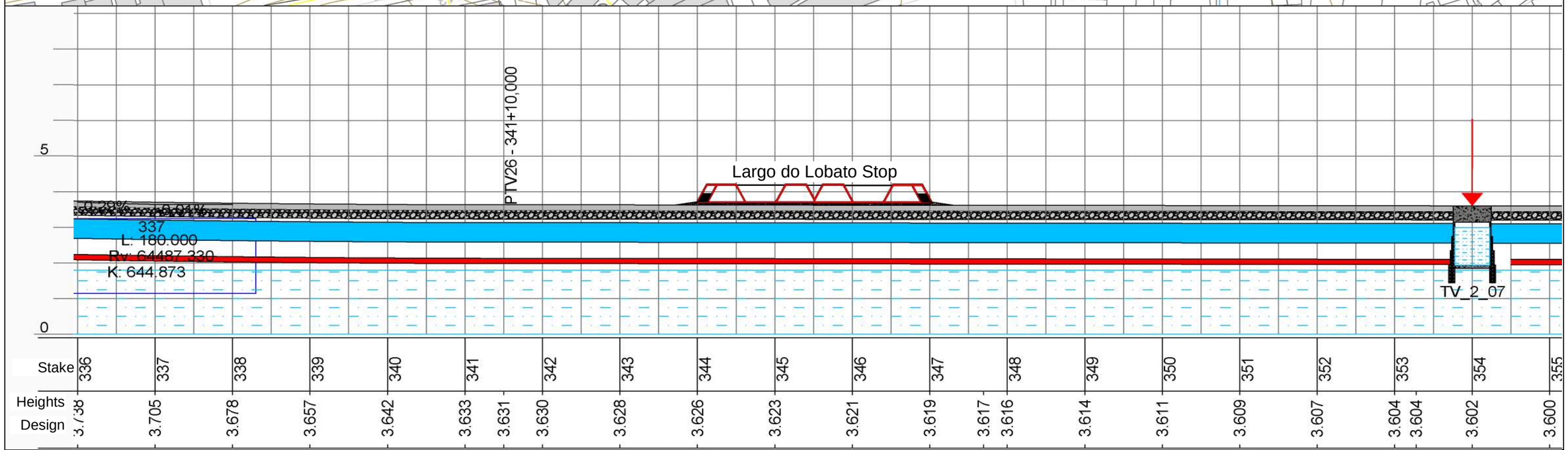
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

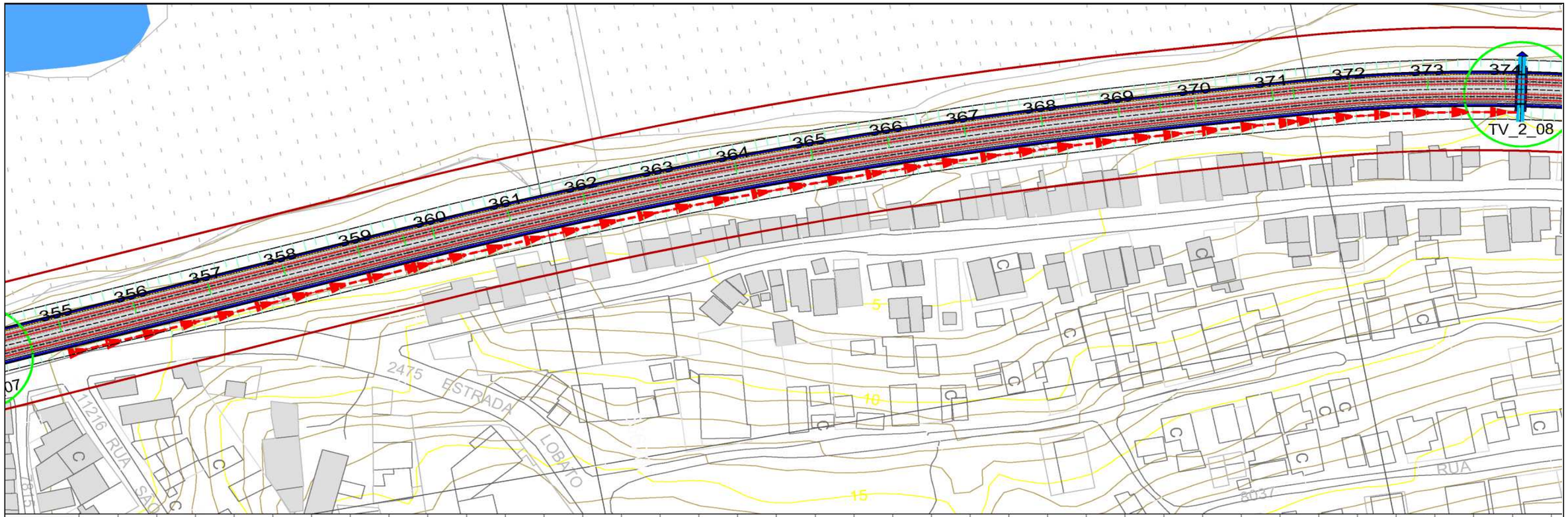
DRAWING		/ /	SHEET 10/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

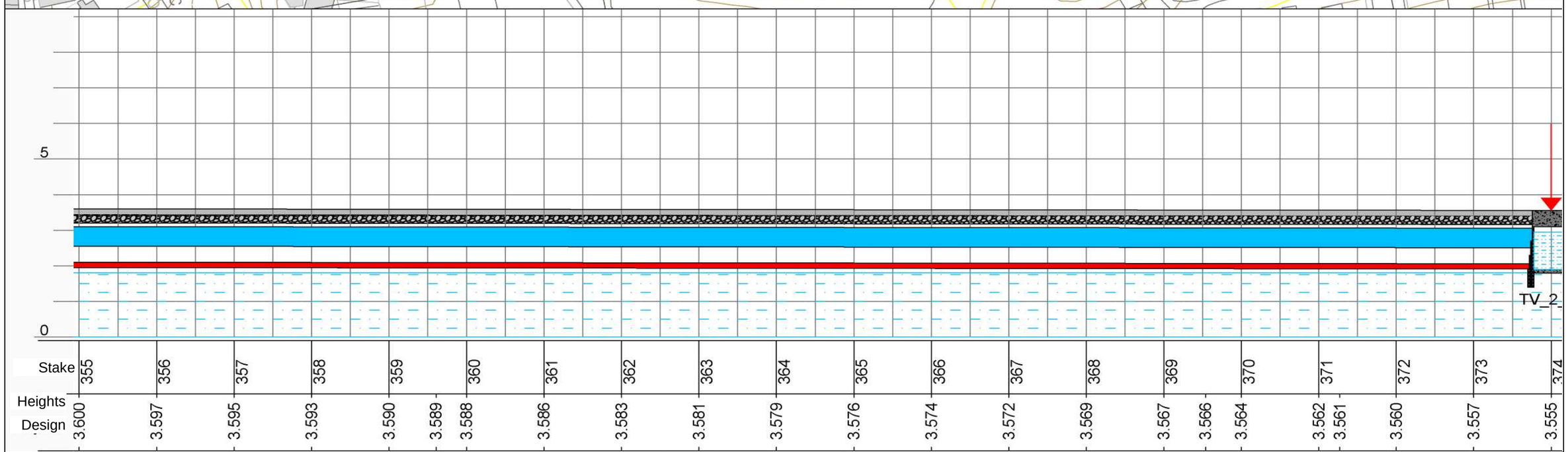
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 11/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY SALVADOR

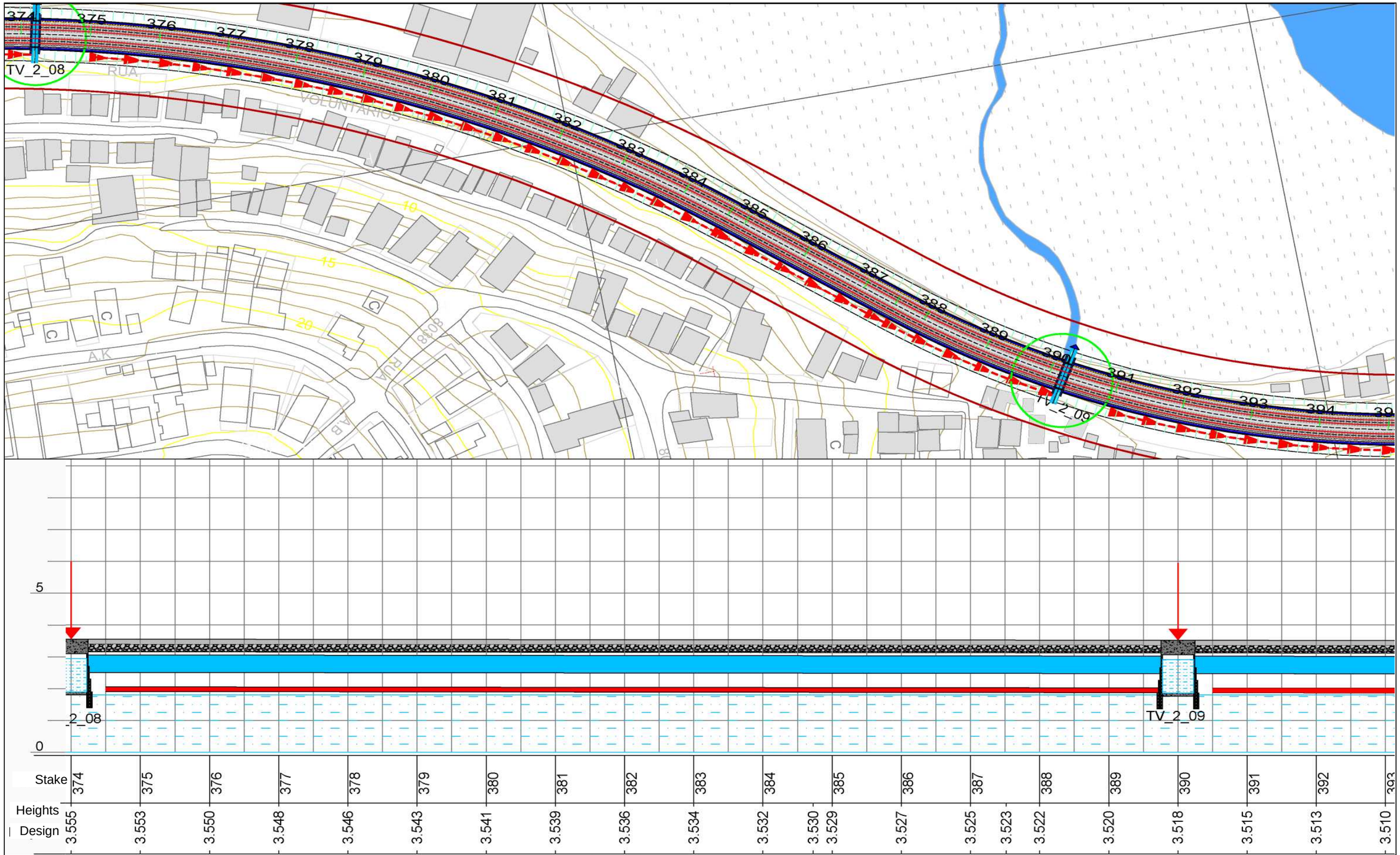
SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 12/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY SALVADOR

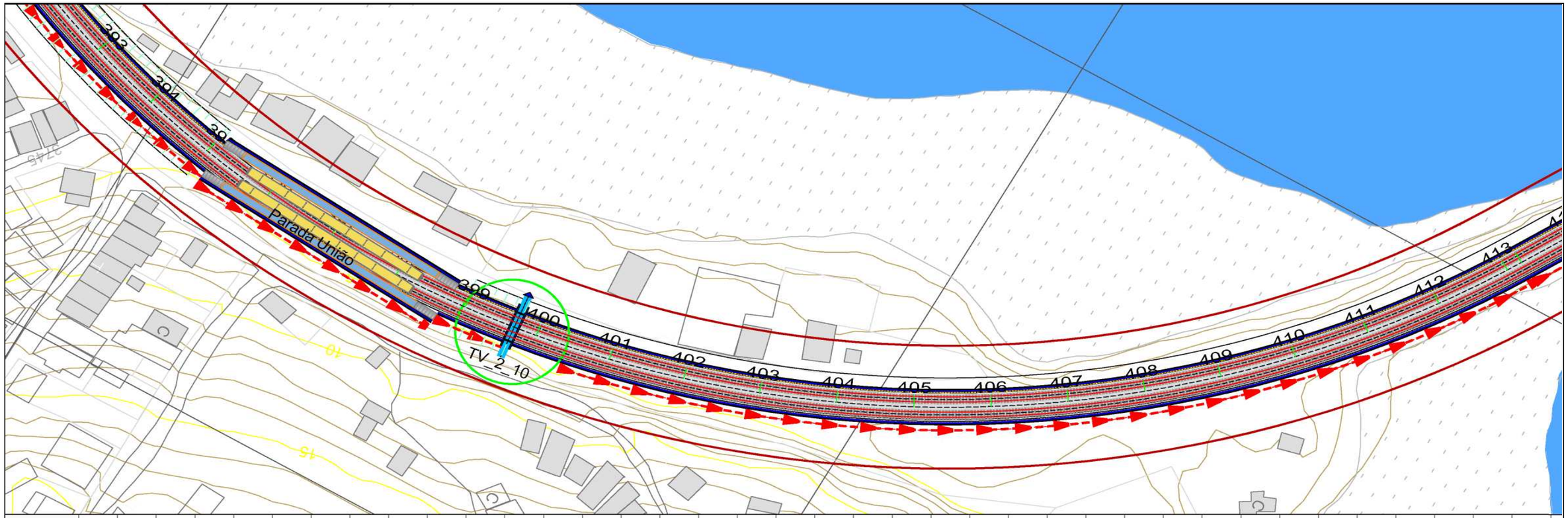
SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE

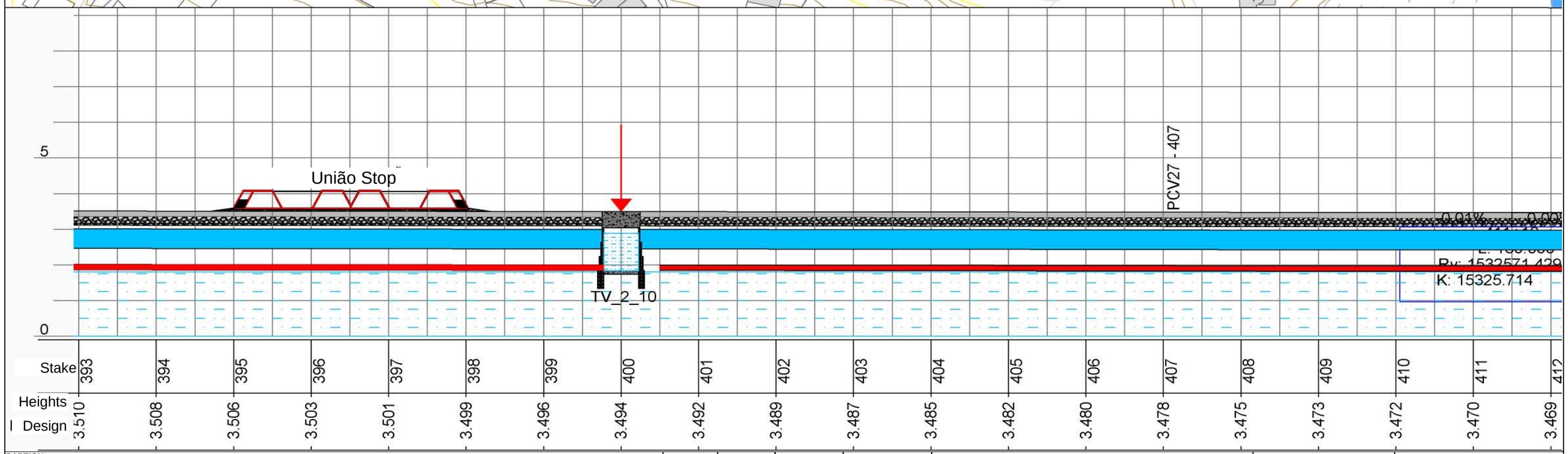
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

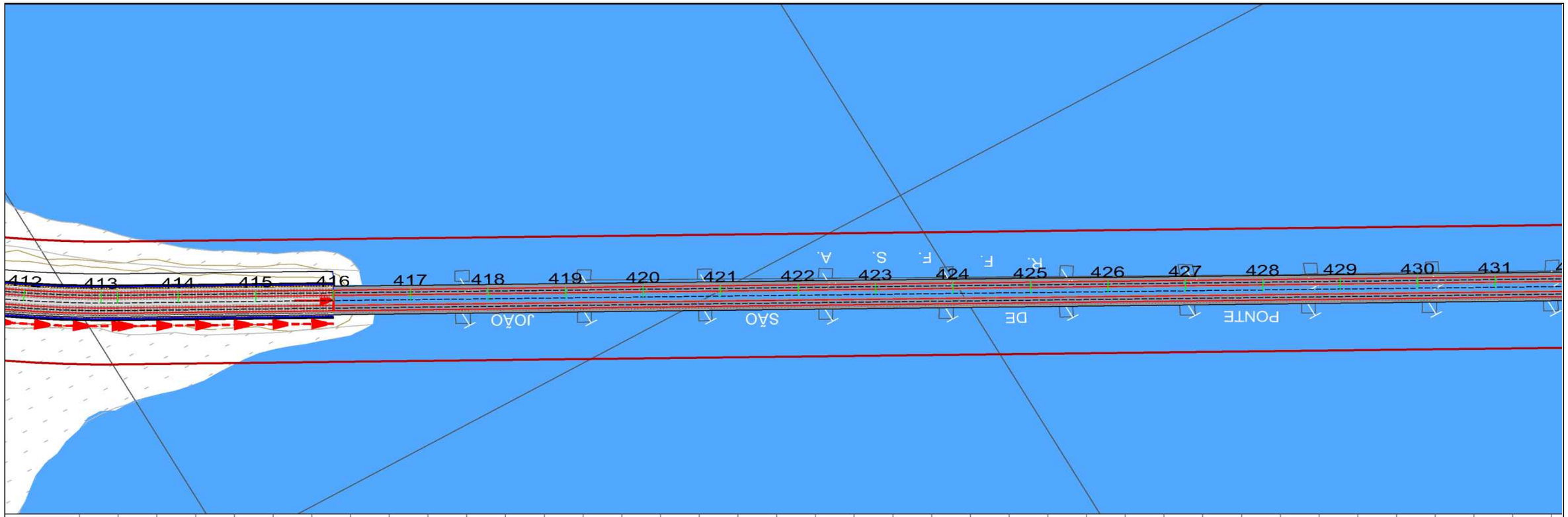
DRAWING		/ /	SHEET 13/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

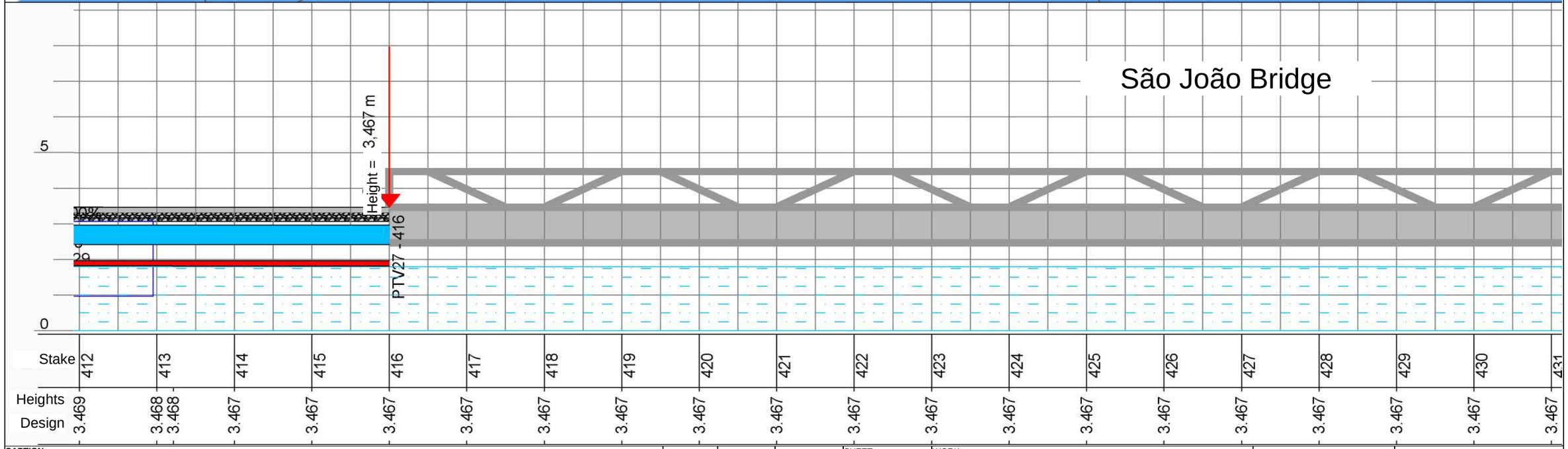
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 14/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY: SALVADOR

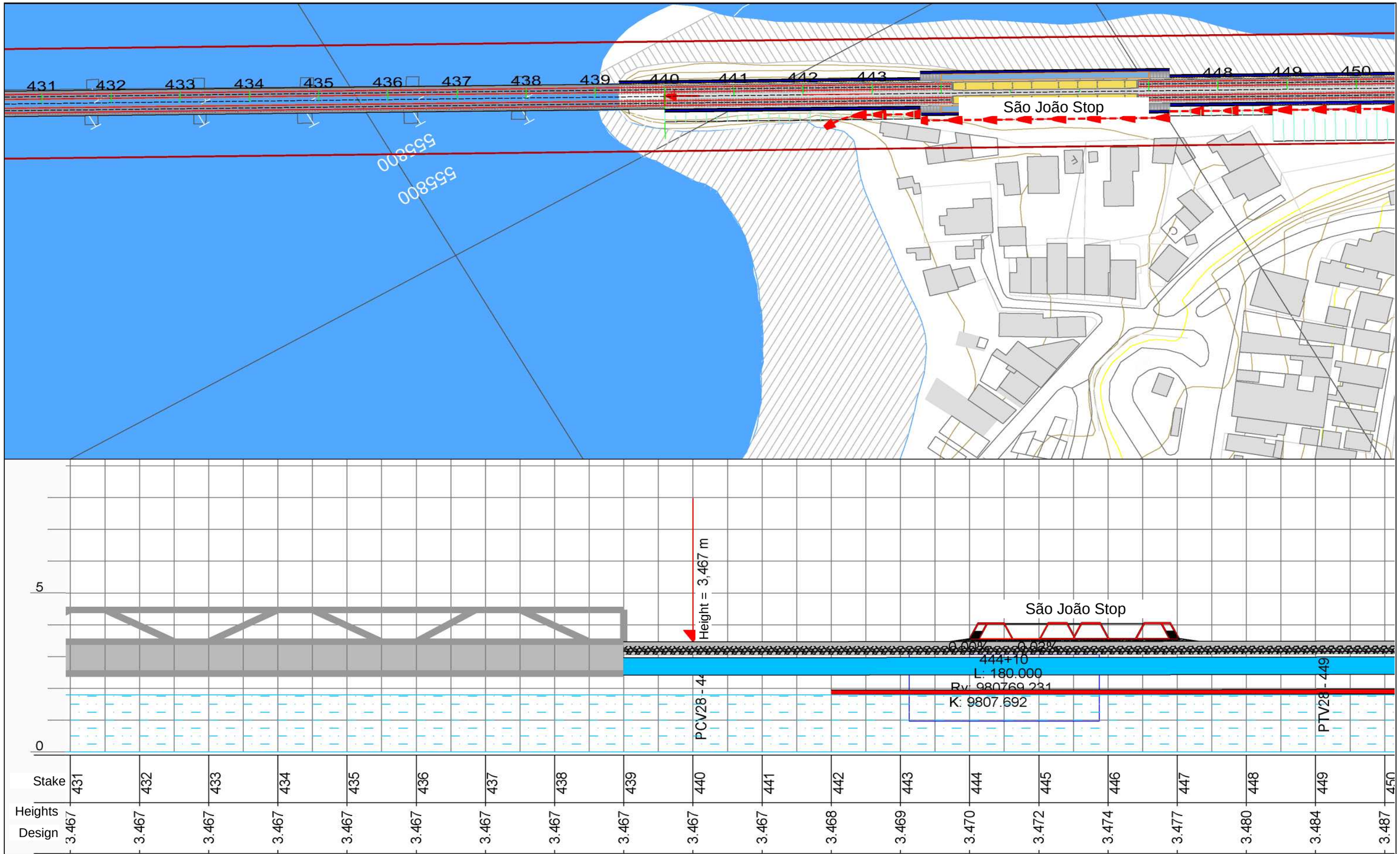
SUBJECT: DRAINAGE - FLOOR PLAN AND PROFILE

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

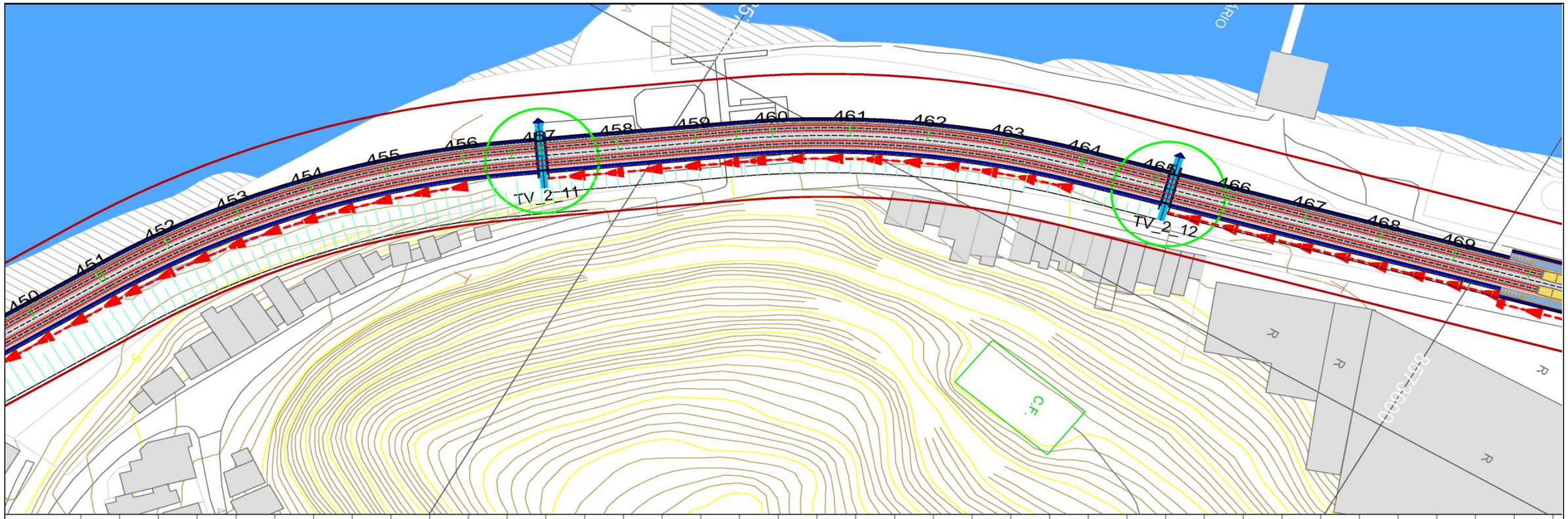
DRAWING		/ /	SHEET 15/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

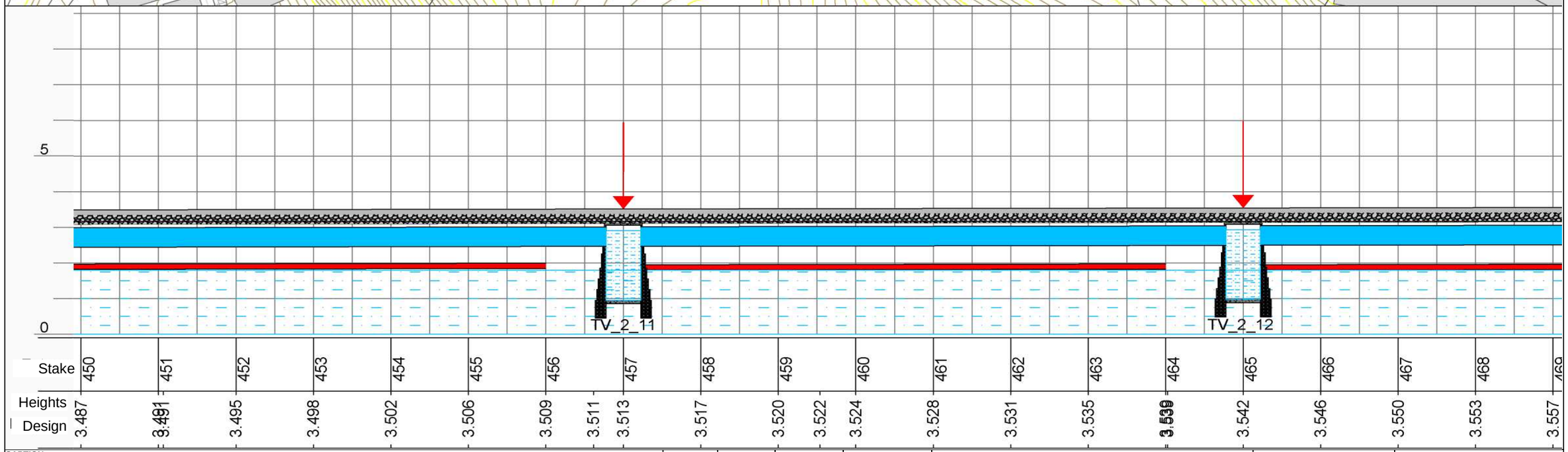
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

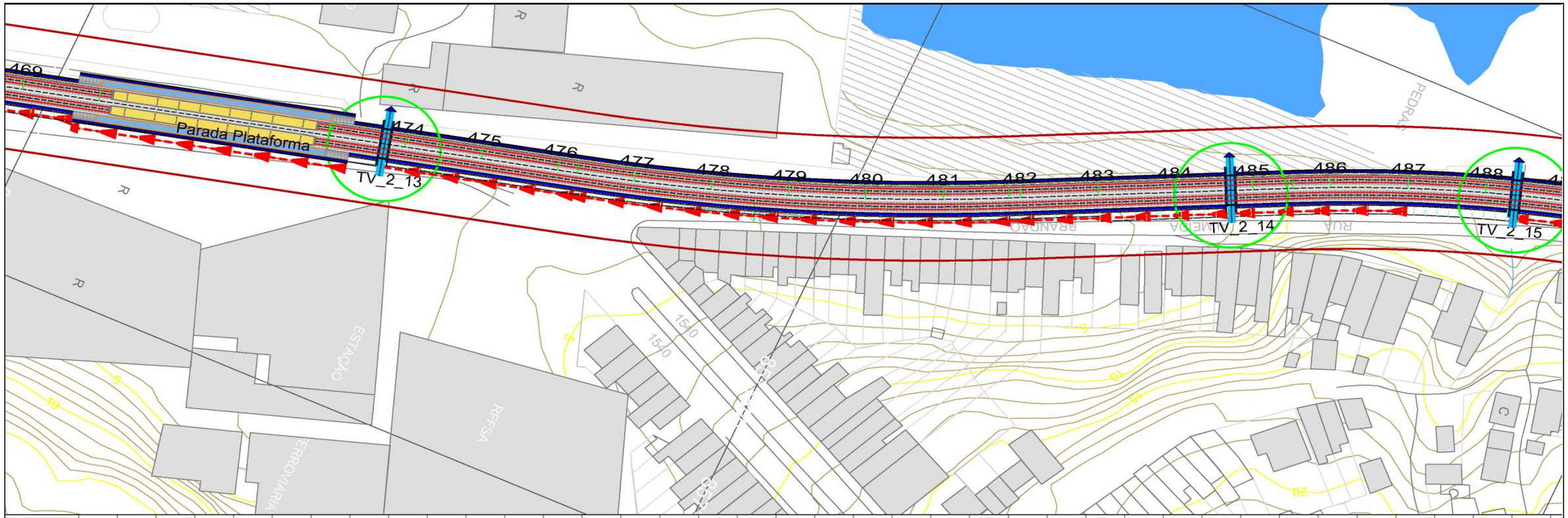
- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

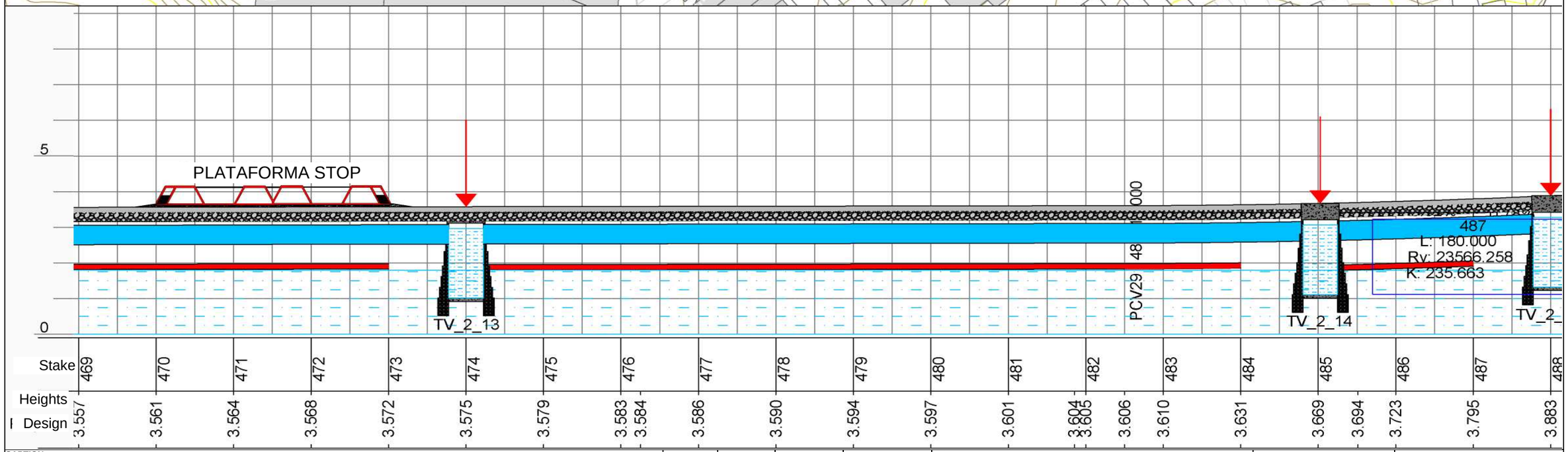
DRAWING		/ /	SHEET 16/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV





CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

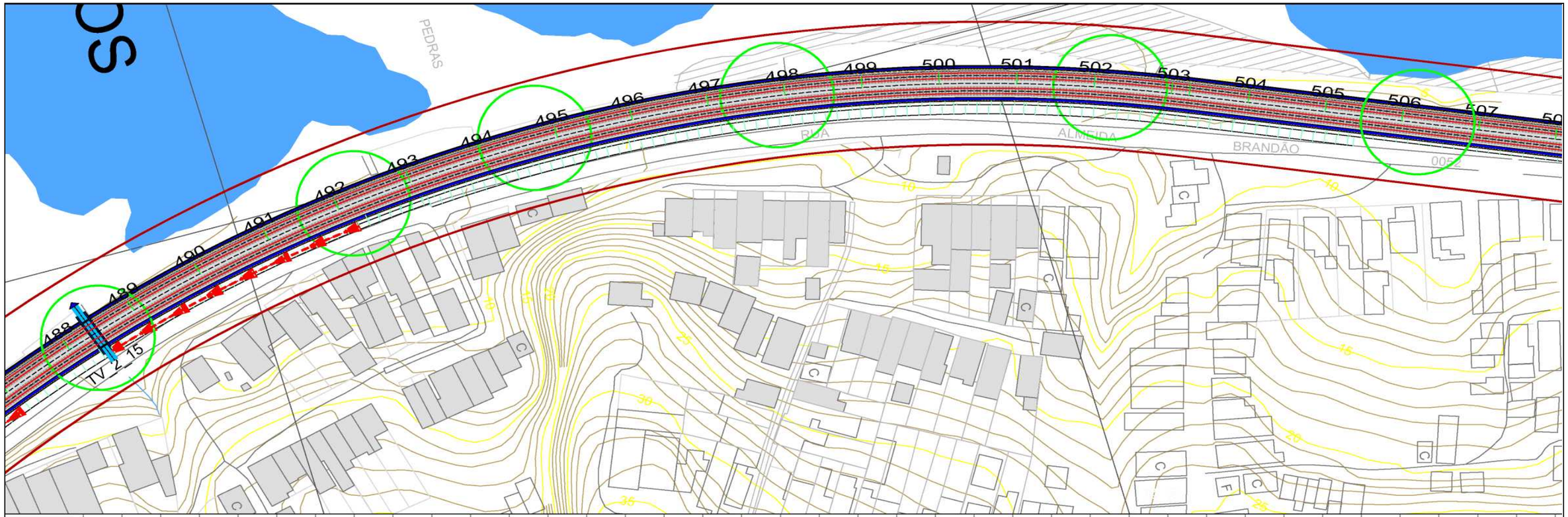
DRAWING		/ /	SHEET 17/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

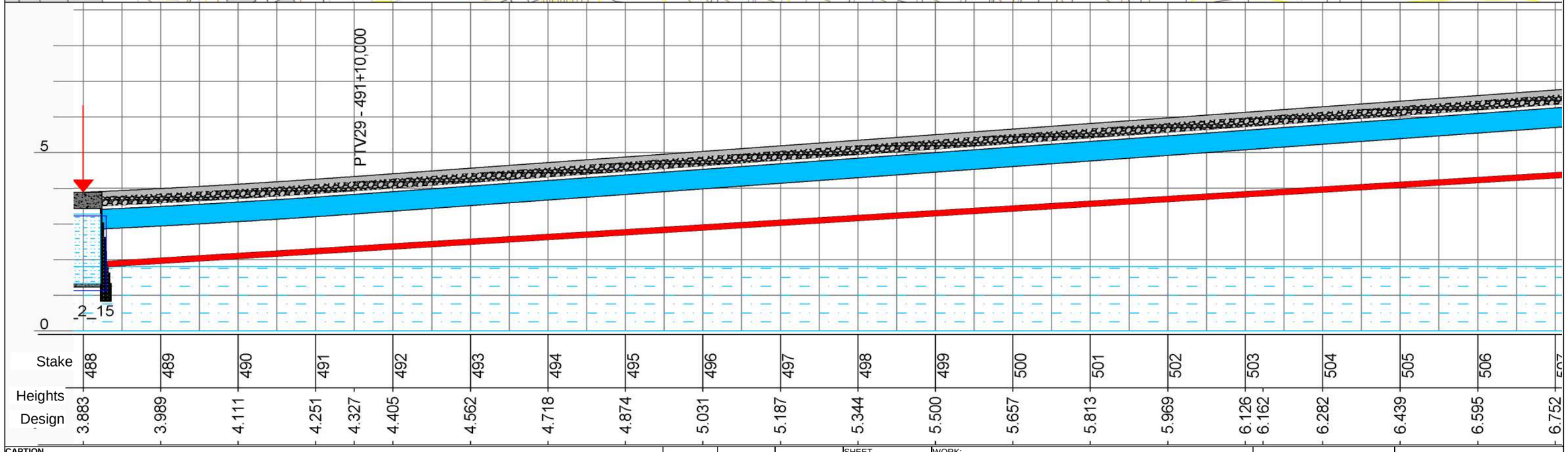
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

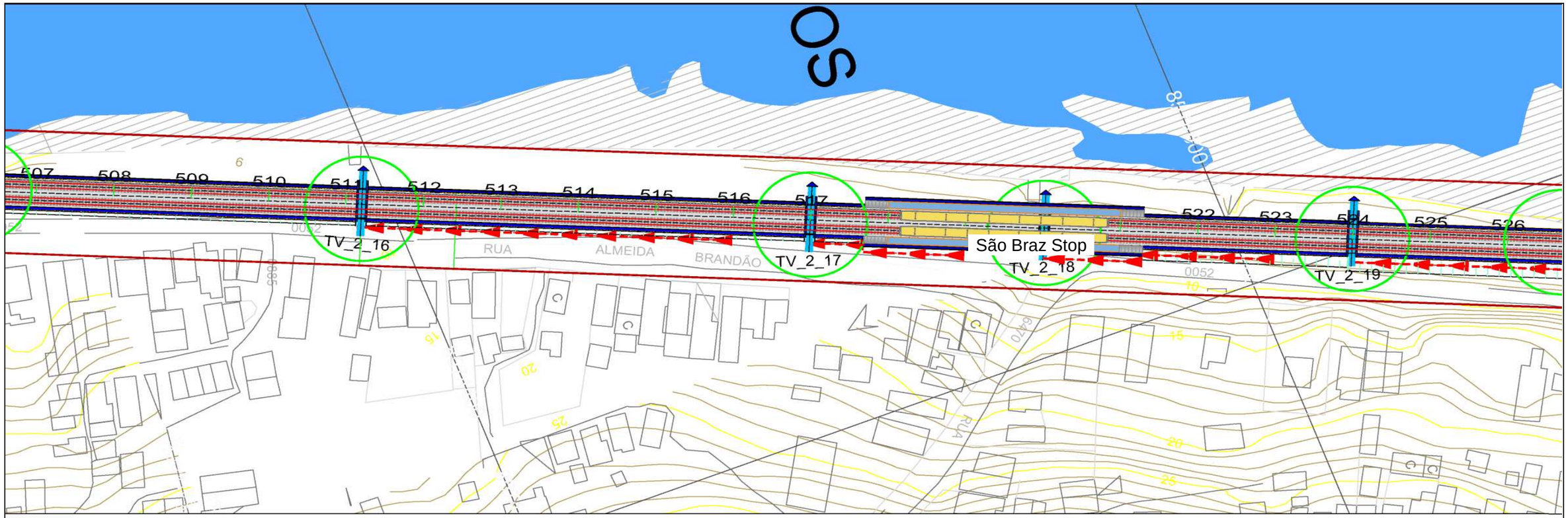
DRAWING		/ /	SHEET 18/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

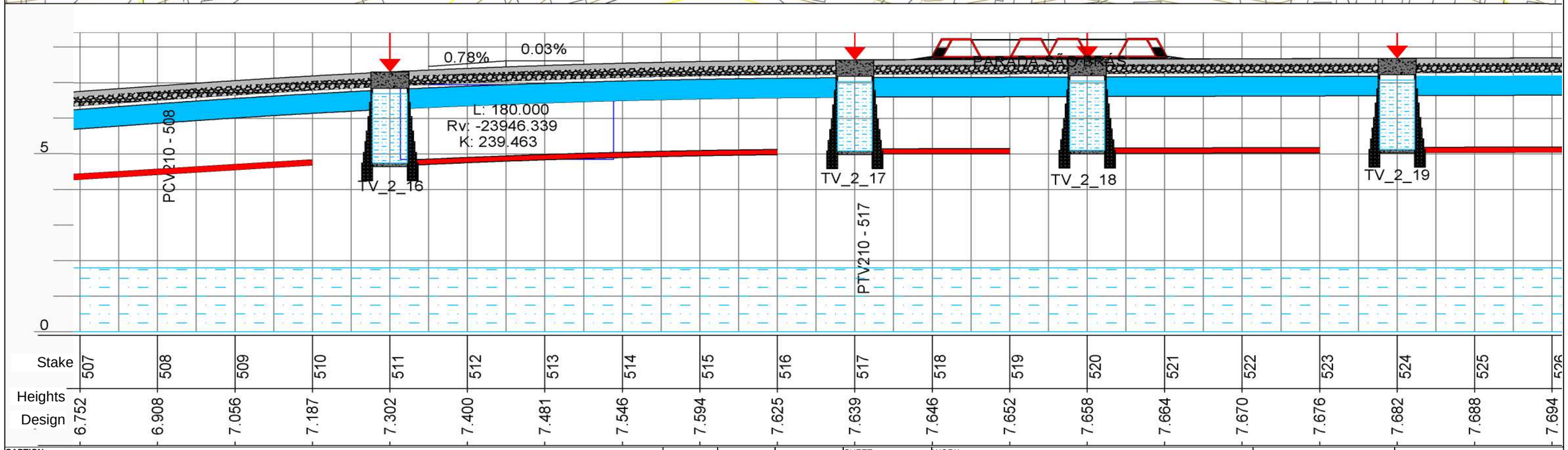
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 19/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY: SALVADOR

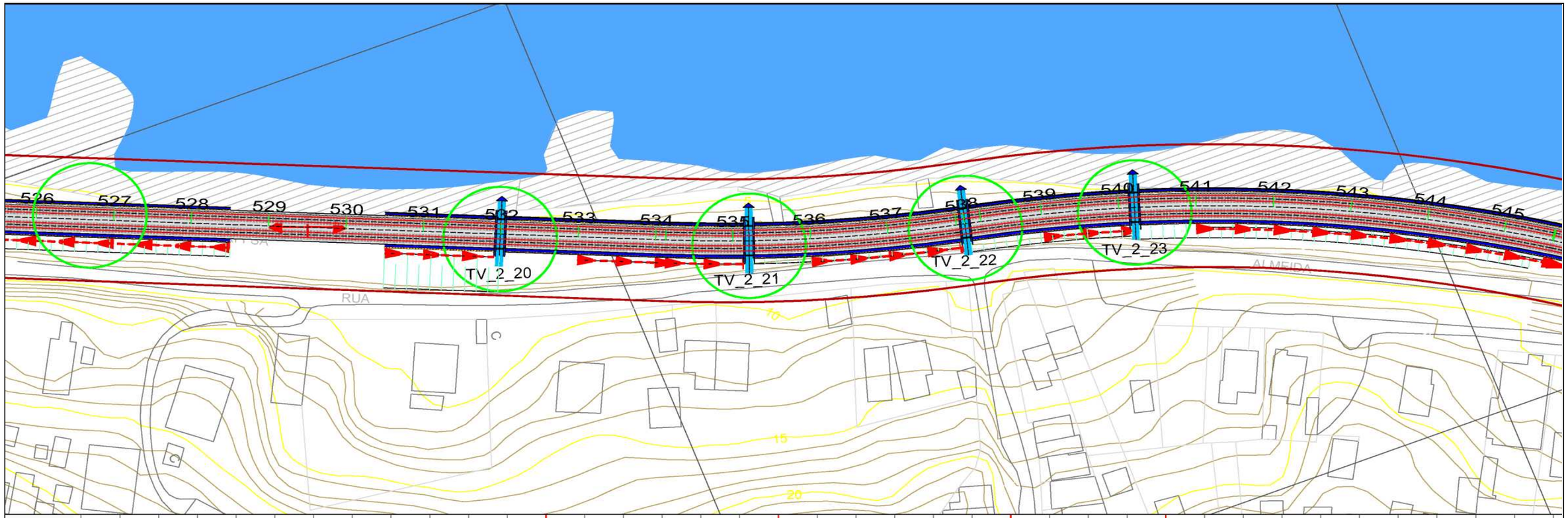
SUBJECT: DRAINAGE - FLOOR PLAN AND PROFILE

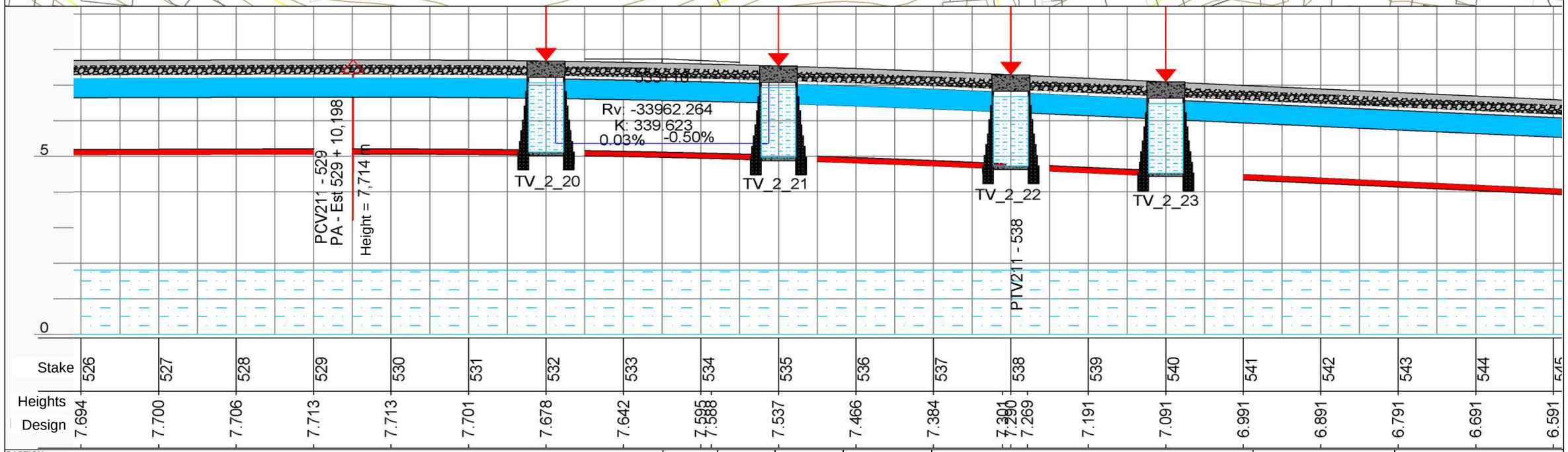
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

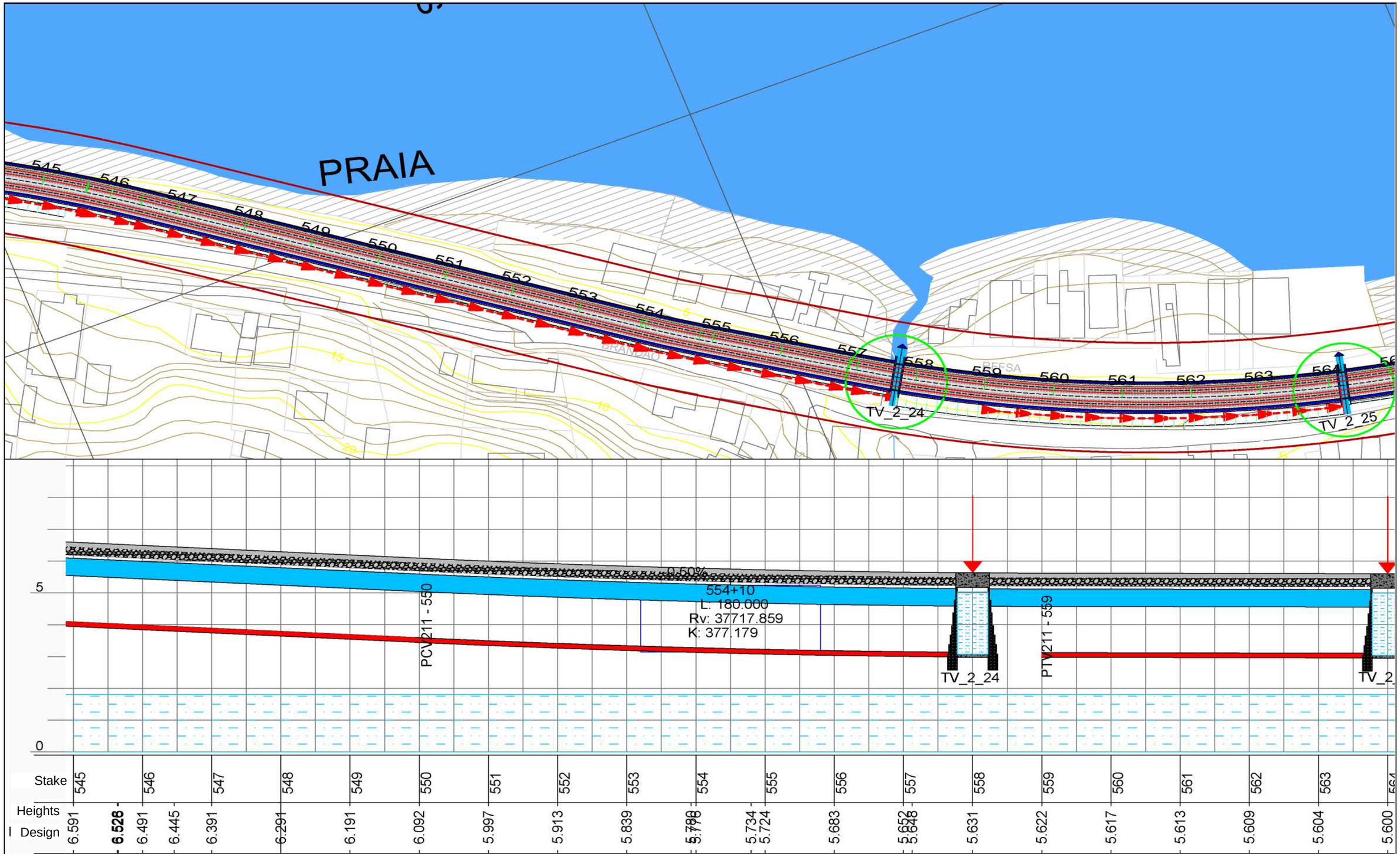
DRAWING		/ /	SHEET 20/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

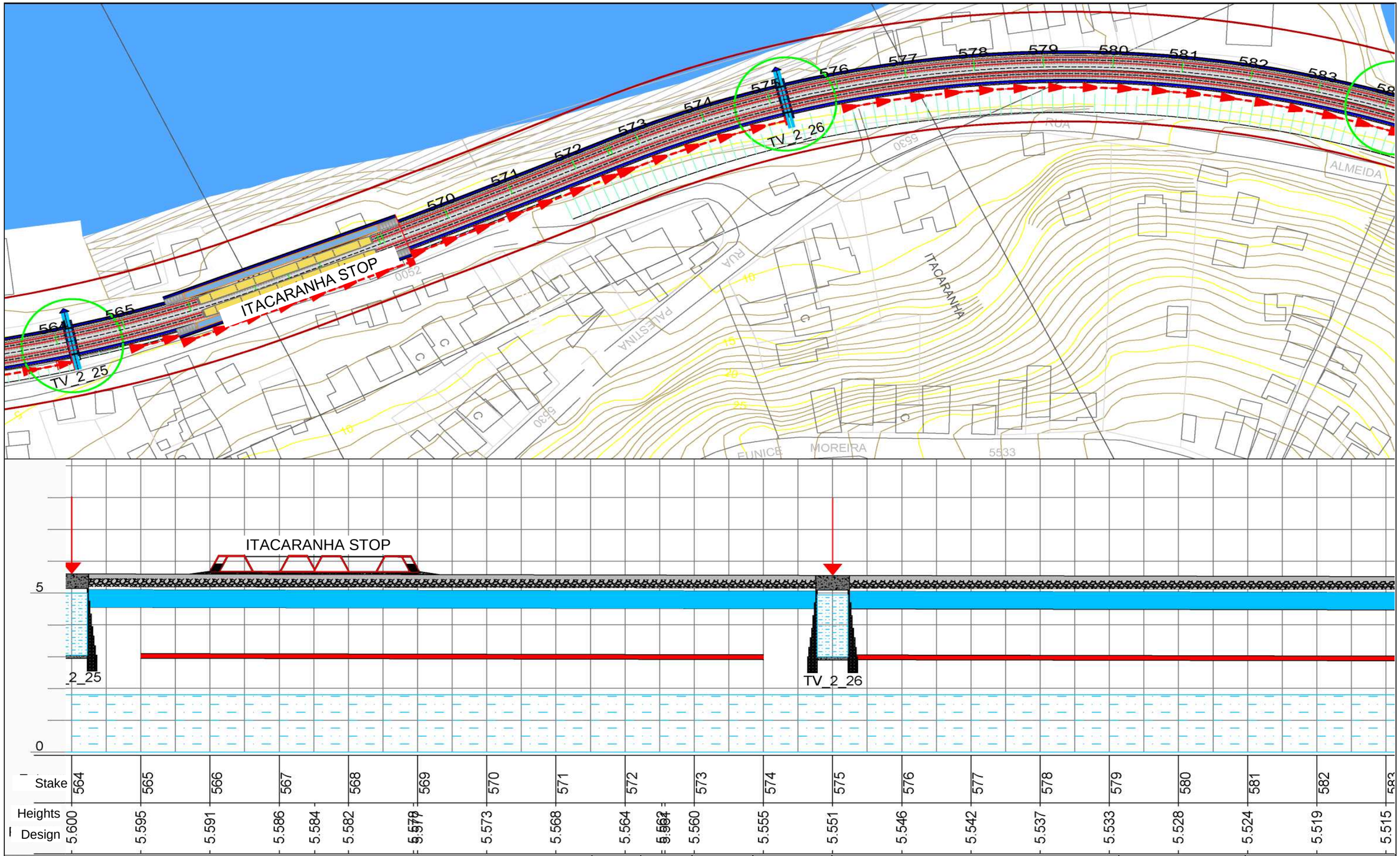
DRAWING		/ /	SHEET 21/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

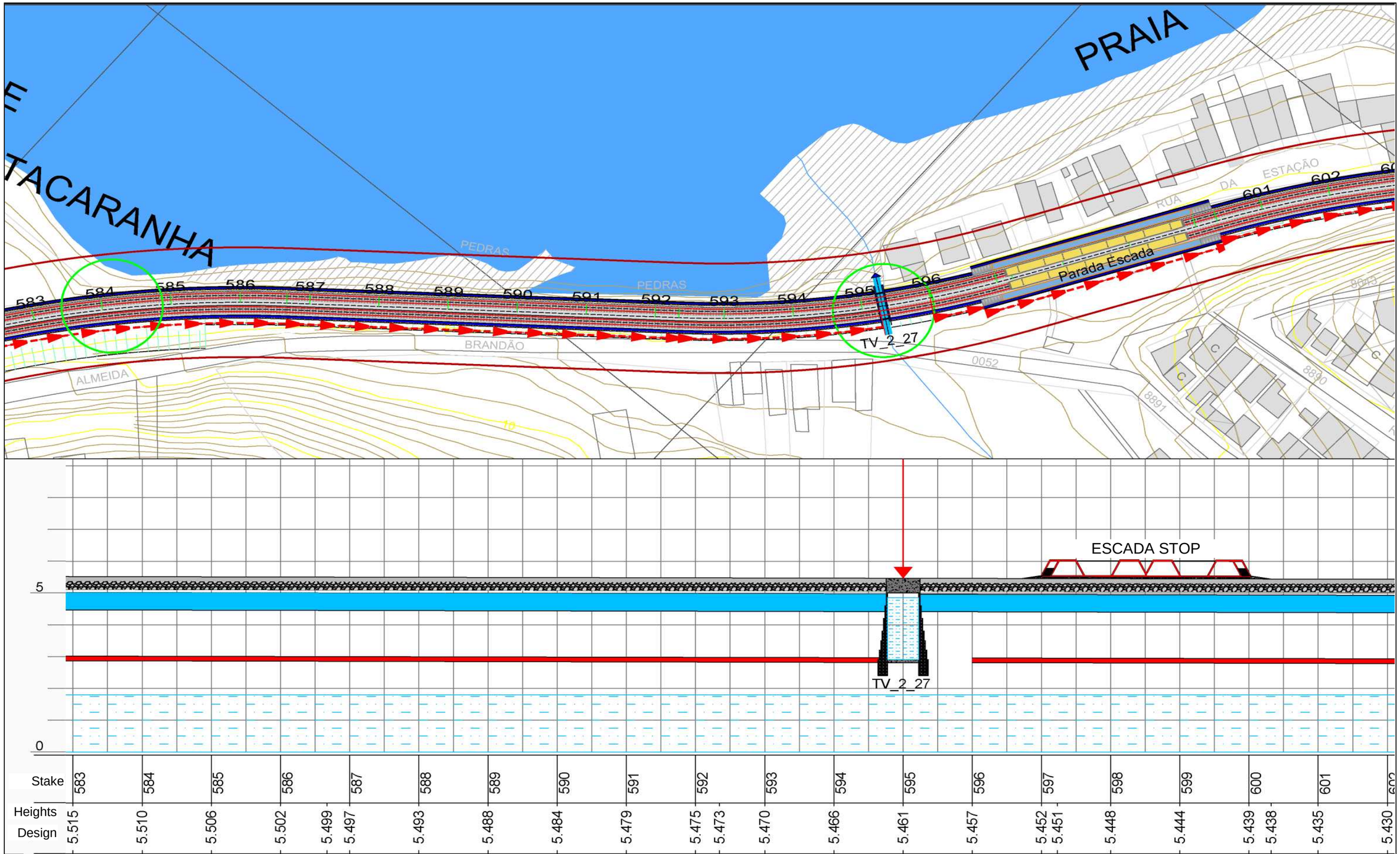
DRAWING		/ /	SHEET 22/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

TR45 Rail
Axis
TR45 Rail
Permanent Track
Higher Point
Lower Point

Tubular gallery
Collecting or Passage Box
Deep Drain (Plant)
Deep Drain (Profile)
Right of way

Rectangular channel (Plant)
Regularization of the land
Rectangular channel (Profile)
Crossing - Capped gully hole (Profile)

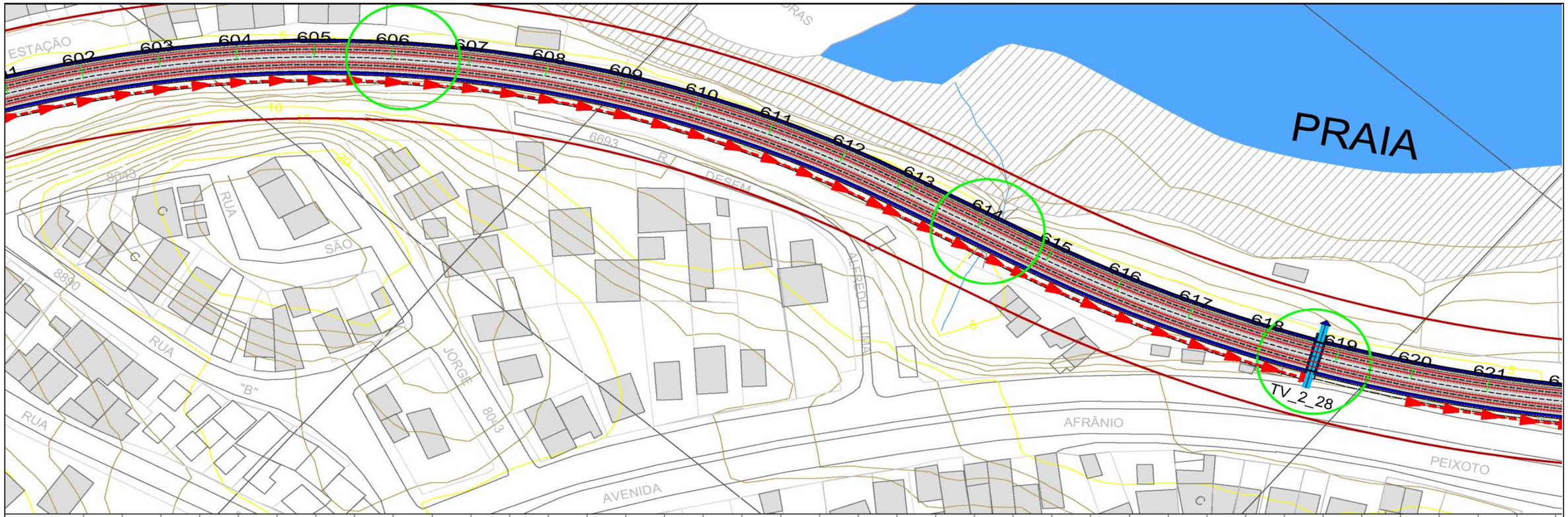
Crossing - Capped gully hole (Plant)
Potential Crossing
Maximum tide = 1.80 m

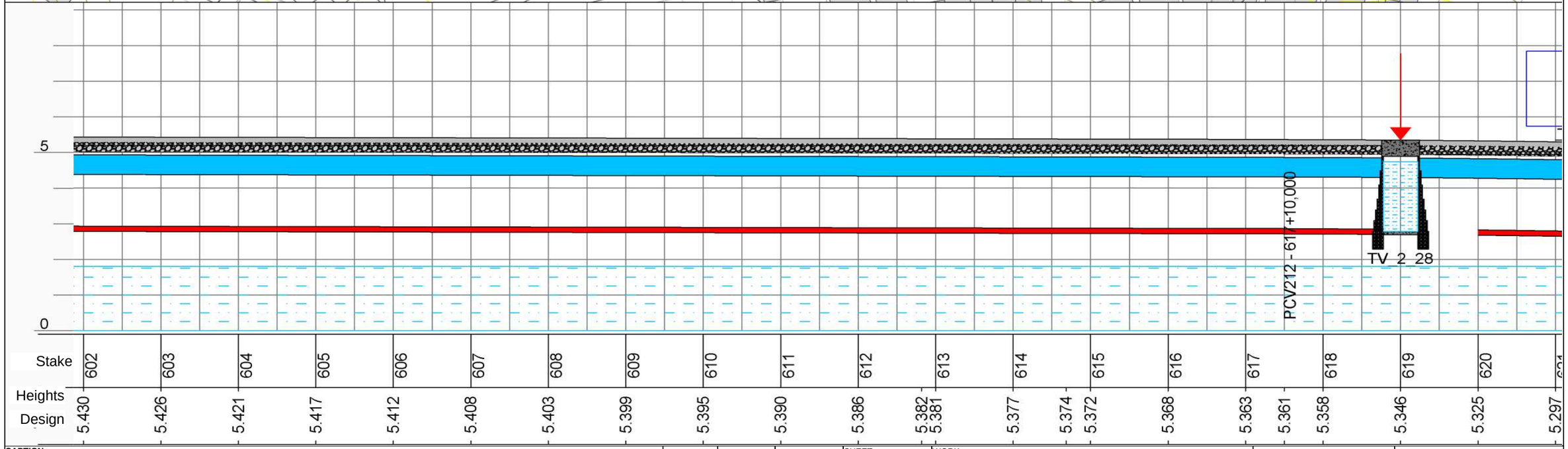
DRAWING		/ /	SHEET 23/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

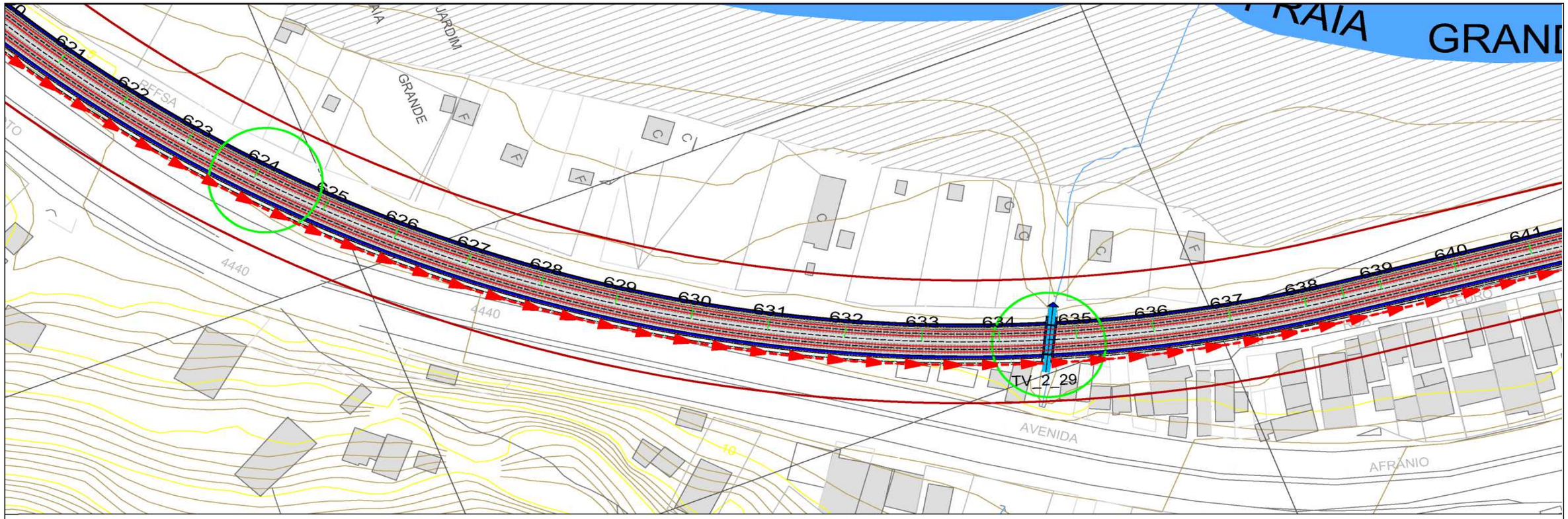
DRAWING		/ /	SHEET 24/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

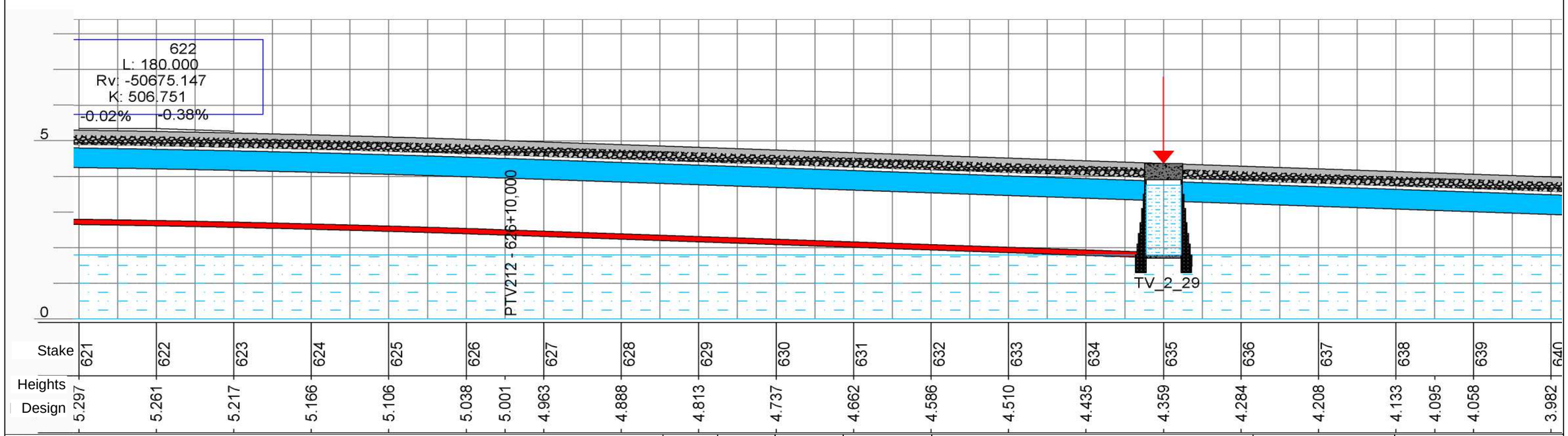
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

Axis
TR45 Rail
TR45 Rail
Permanent Track
Higher Point
Lower Point
Tubular gallery
Collecting or Passage Box
Deep Drain (Plant)
Deep Drain (Profile)
Right of way
Rectangular channel (Plant)
Regularization of the land
Rectangular channel (Profile)
Crossing - Capped gully hole (Profile)
Crossing - Capped gully hole (Plant)
Potential Crossing
Maximum tide = 1.80 m

DRAWING		/ /	SHEET 25/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY SALVADOR

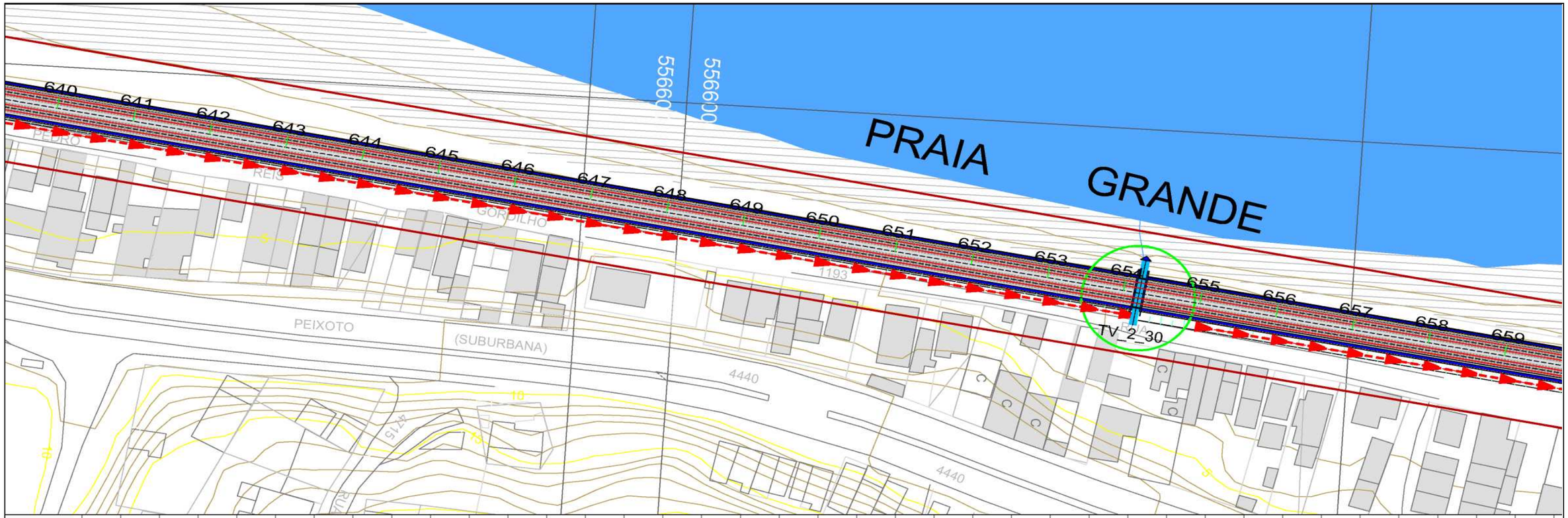
SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE

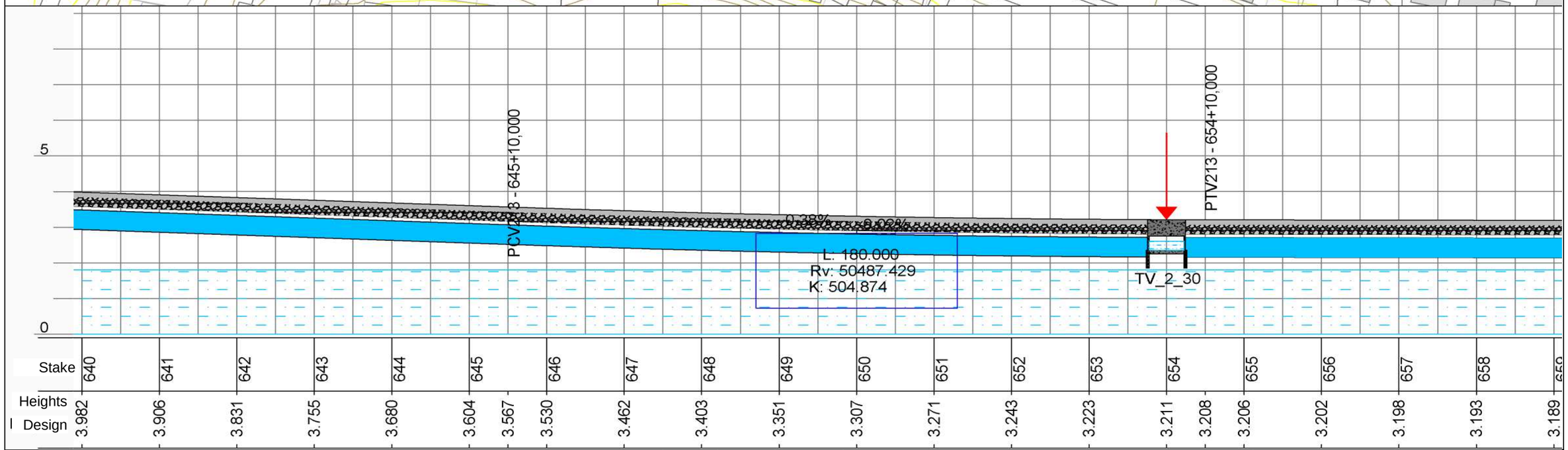
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

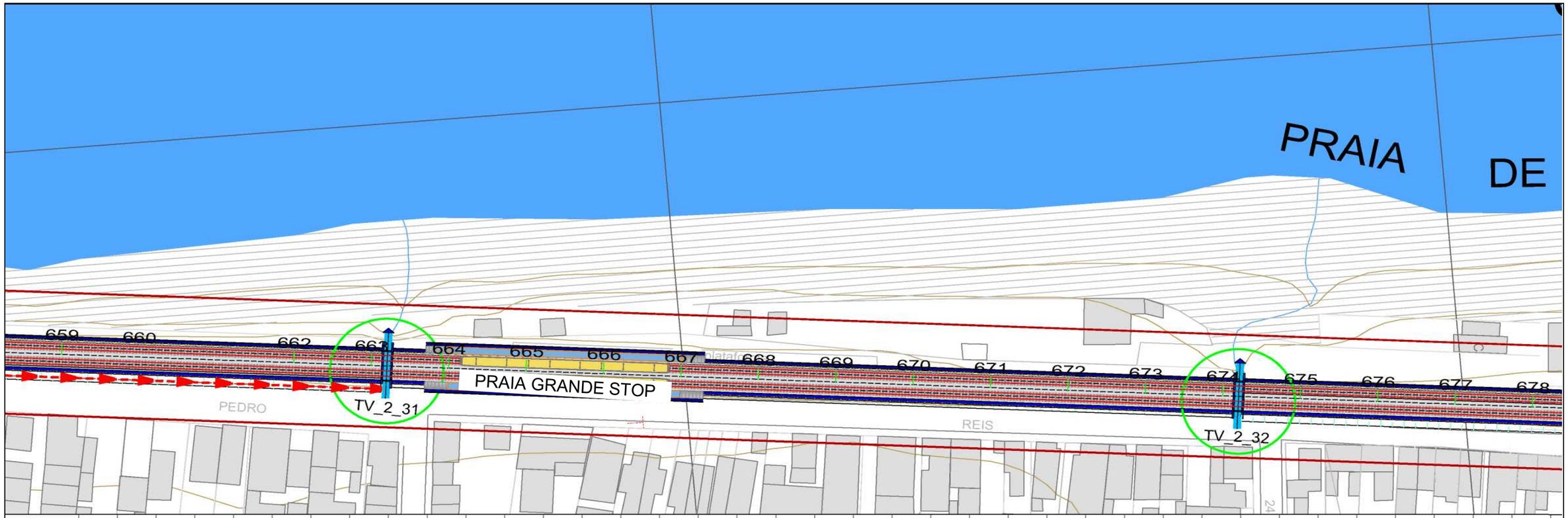
Axis
TR45 Rail
TR45 Rail
Permanent Track
Higher Point
Lower Point
Tubular gallery
Collecting or Passage Box
Deep Drain (Plant)
Deep Drain (Profile)
Right of way
Rectangular channel (Plant)
Regularization of the land
Rectangular channel (Profile)
Crossing - Capped gully hole (Profile)
Crossing - Capped gully hole (Plant)
Potential Crossing
Maximum tide = 1.80 m

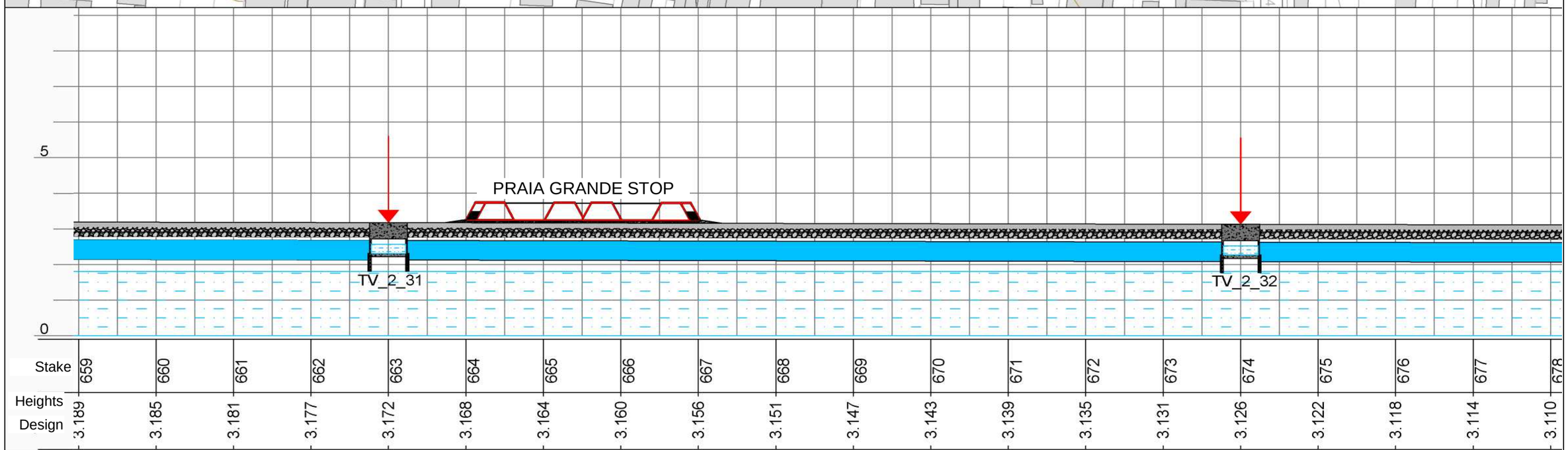
DRAWING		/ /	SHEET 26/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV





CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

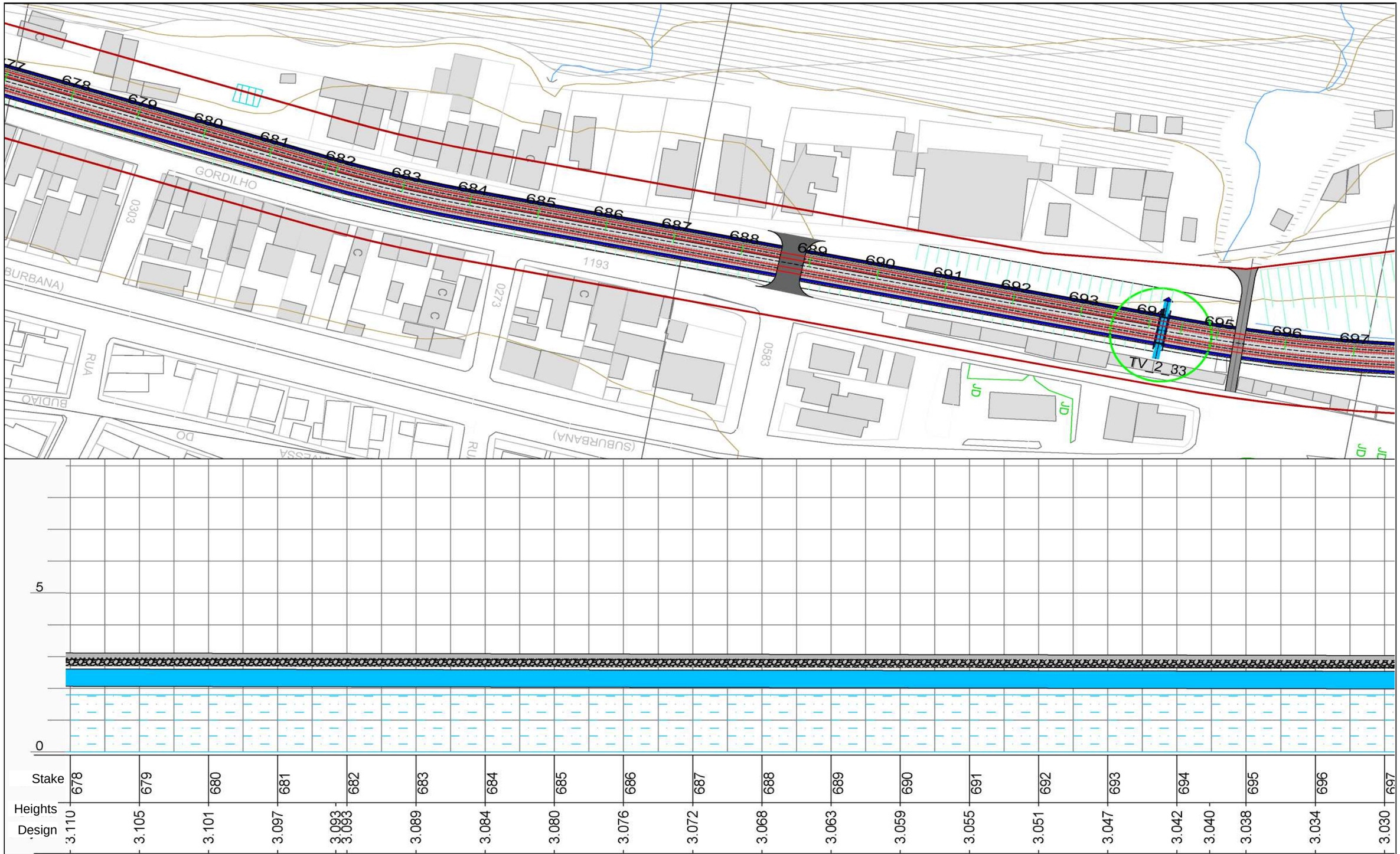
DRAWING		/ /	SHEET 27/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

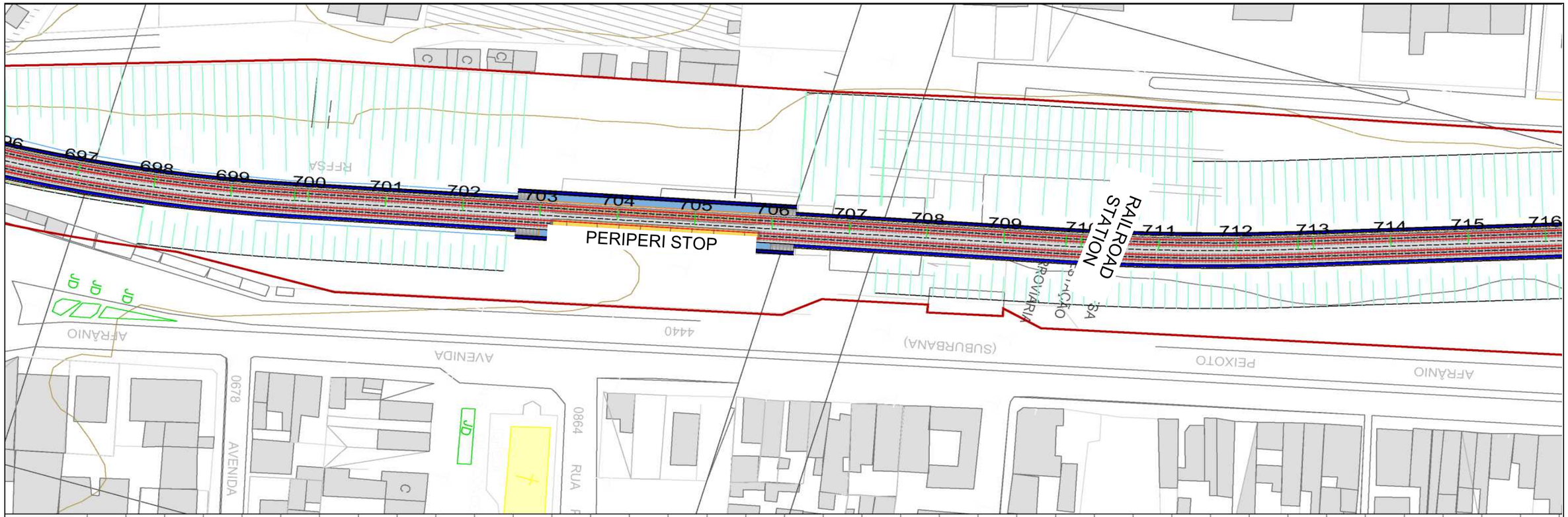
- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

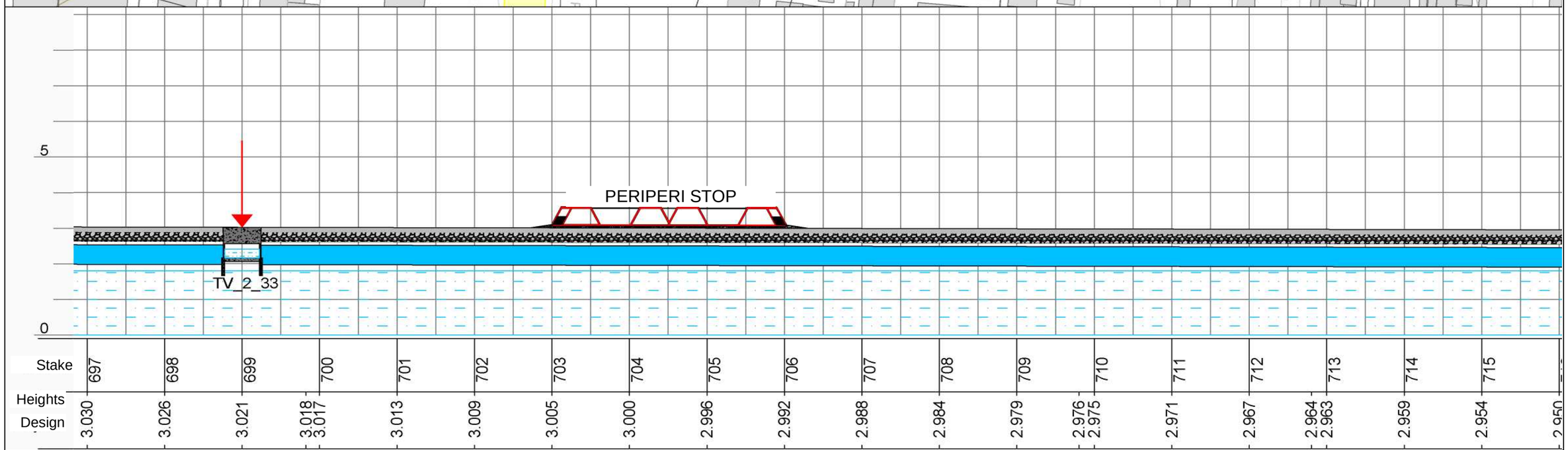
DRAWING		/ /	SHEET 28/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

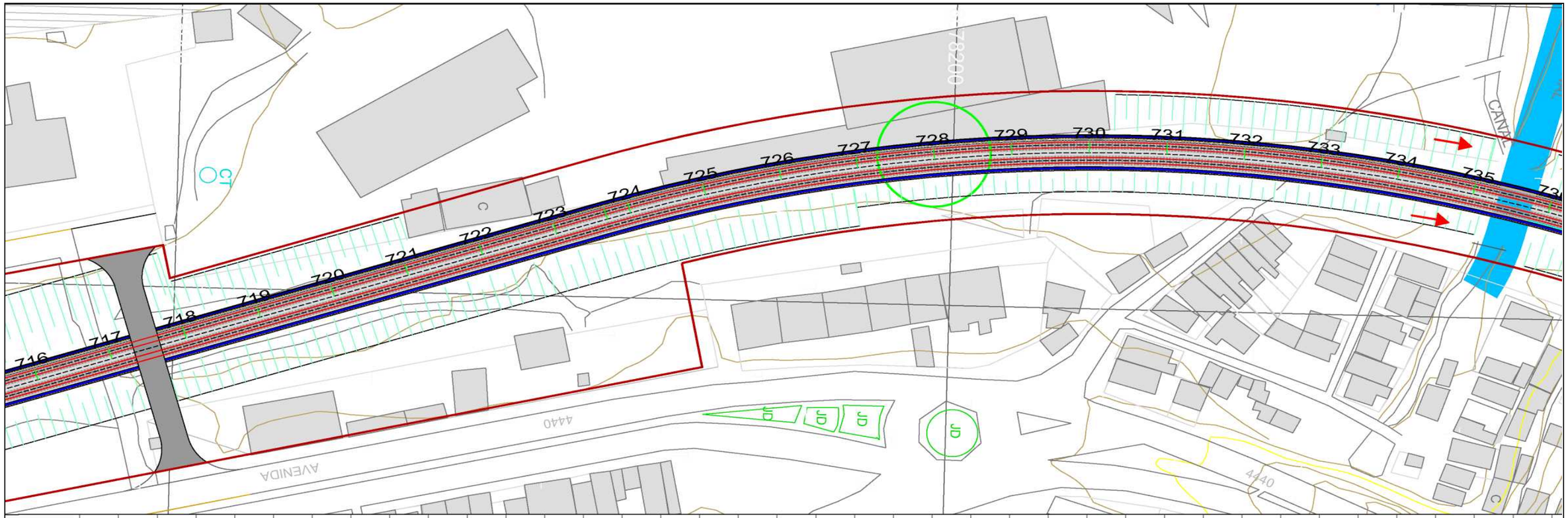
DRAWING		/ /	SHEET 29/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

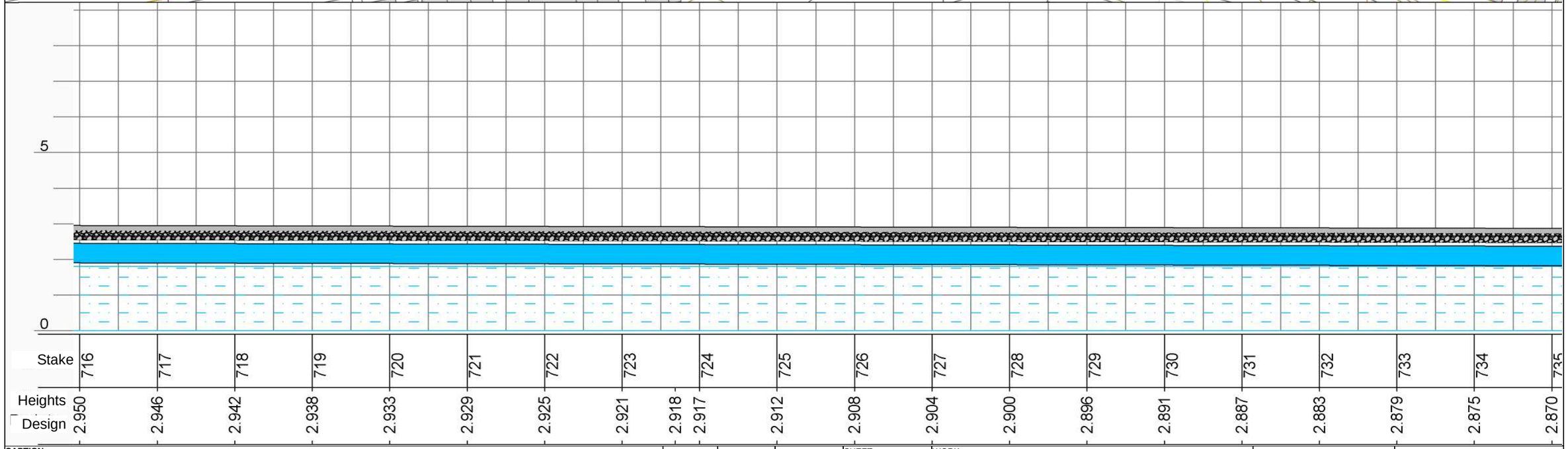
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

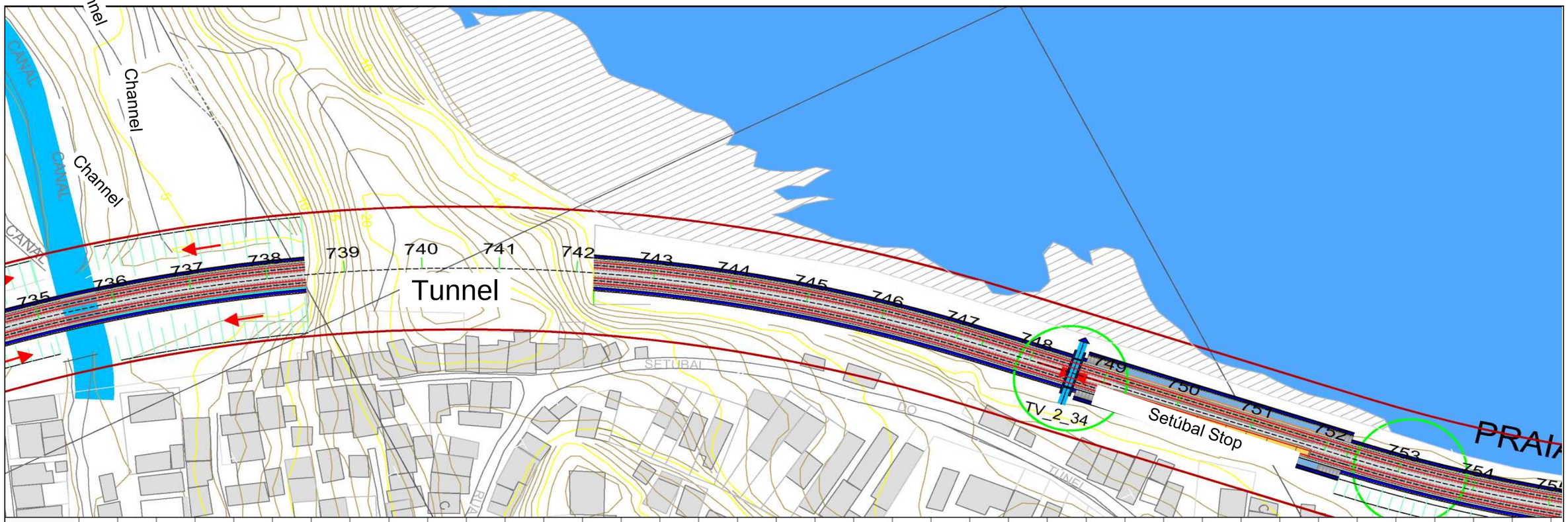
DRAWING		/ /	SHEET 30/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

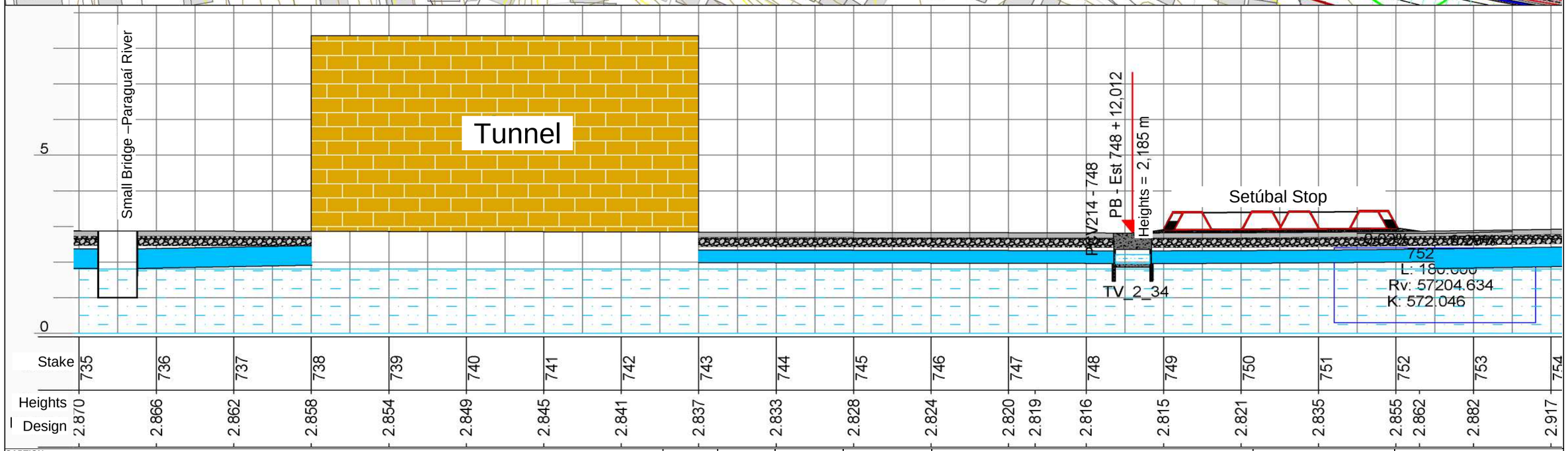
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

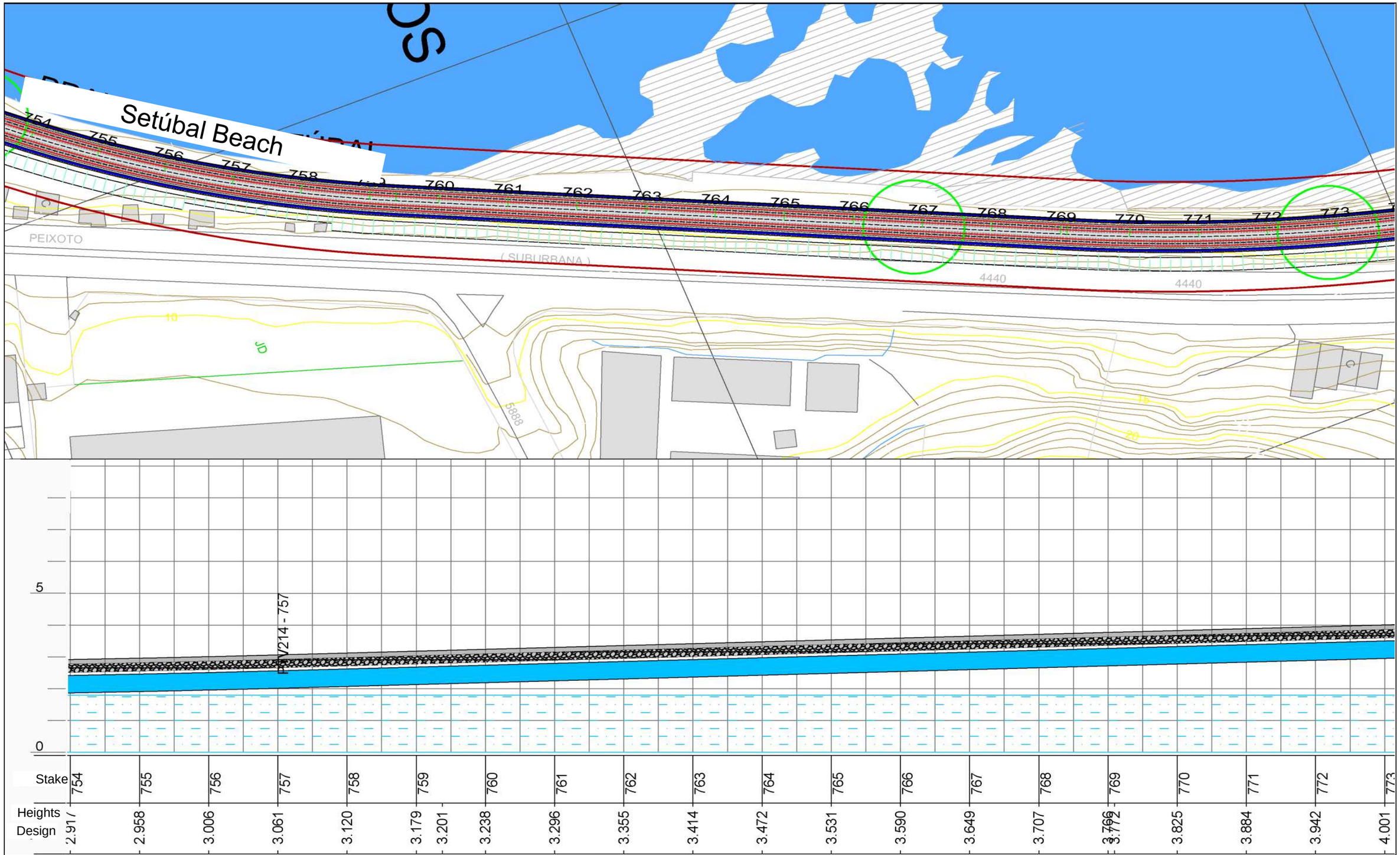
DRAWING		/ /	SHEET 31/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 32/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY SALVADOR

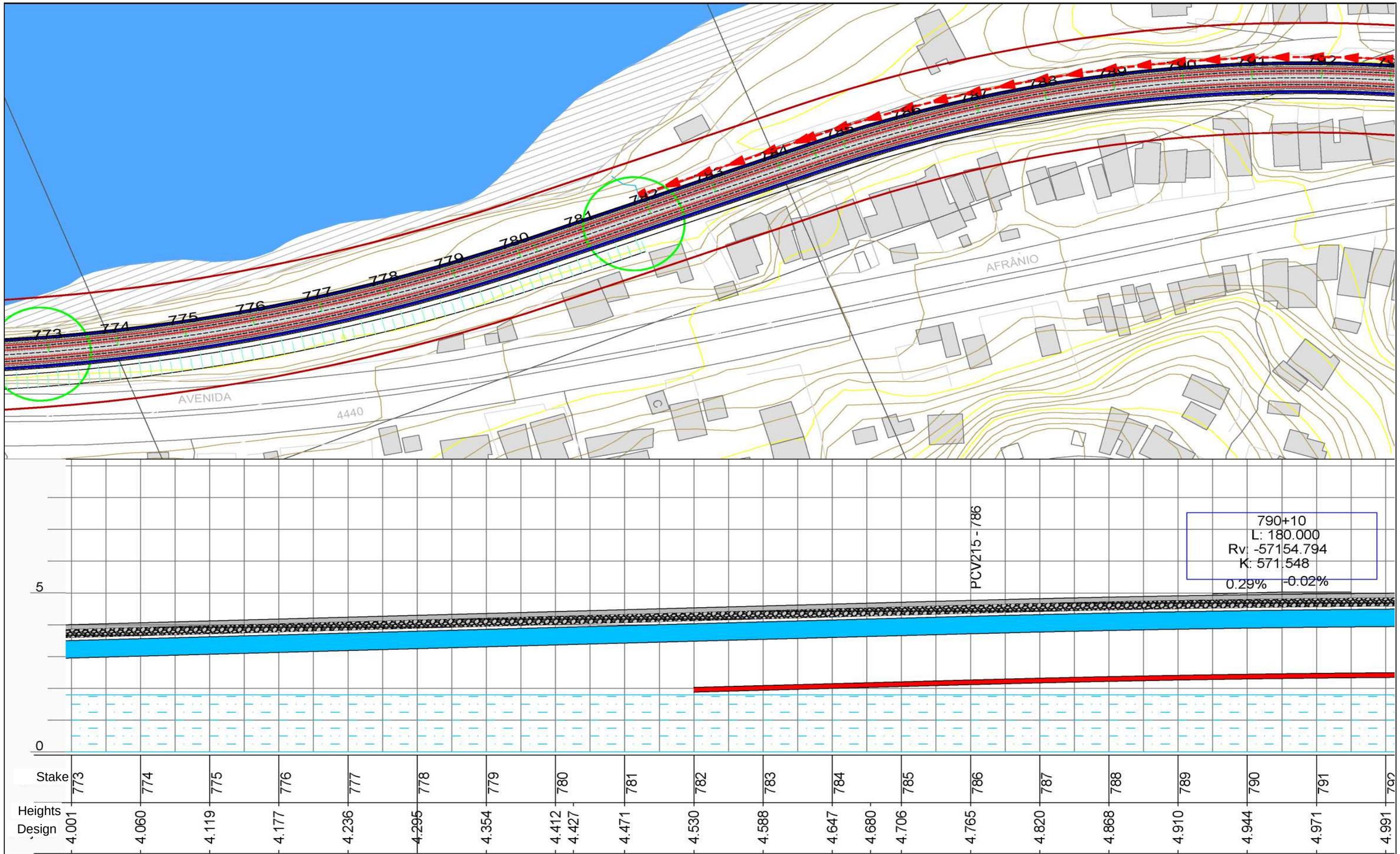
SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

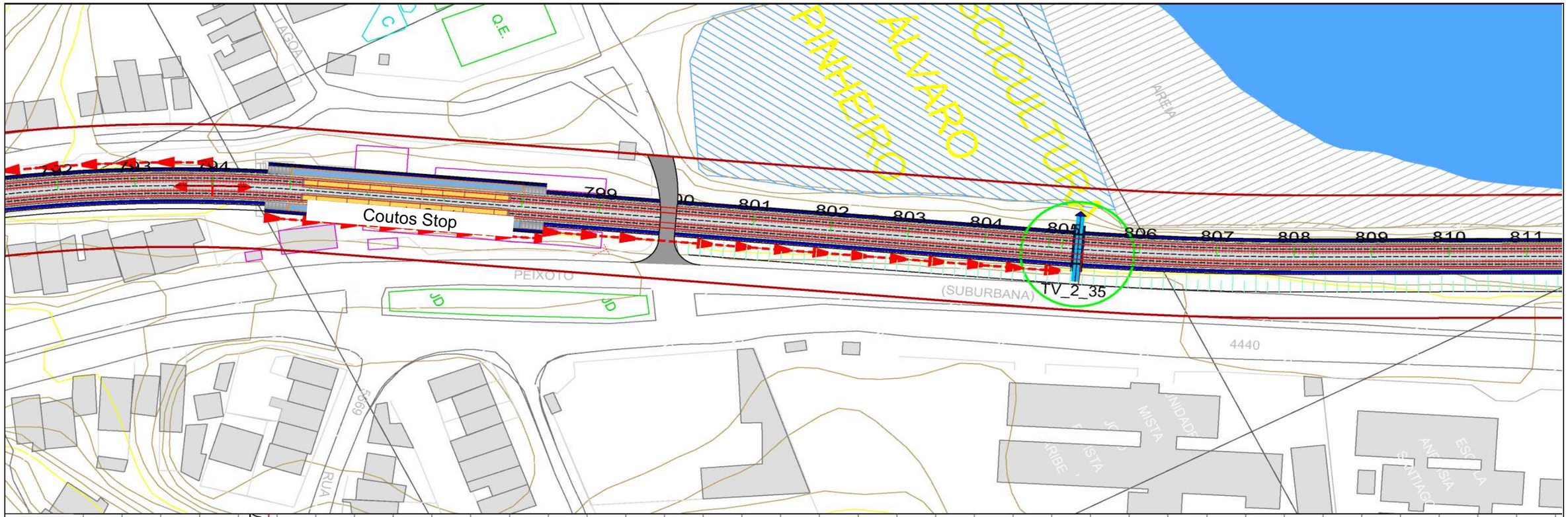
- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

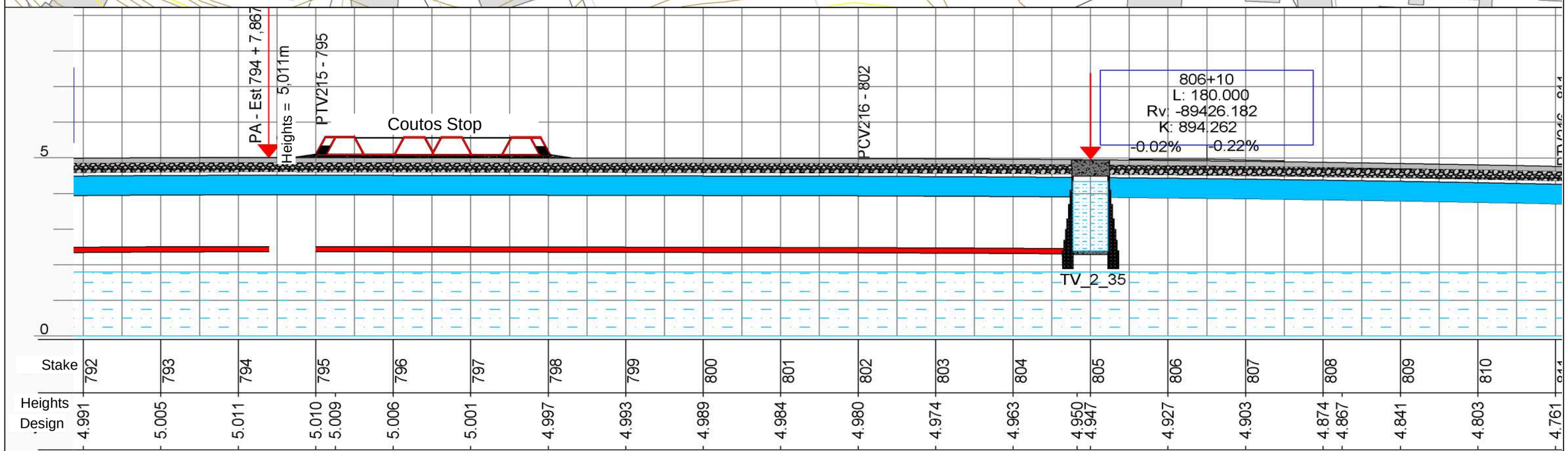
DRAWING		/ /	SHEET 33/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV





CAPTION

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 34/36
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION – CALÇADA - PARIPE

MUNICIPALITY: SALVADOR

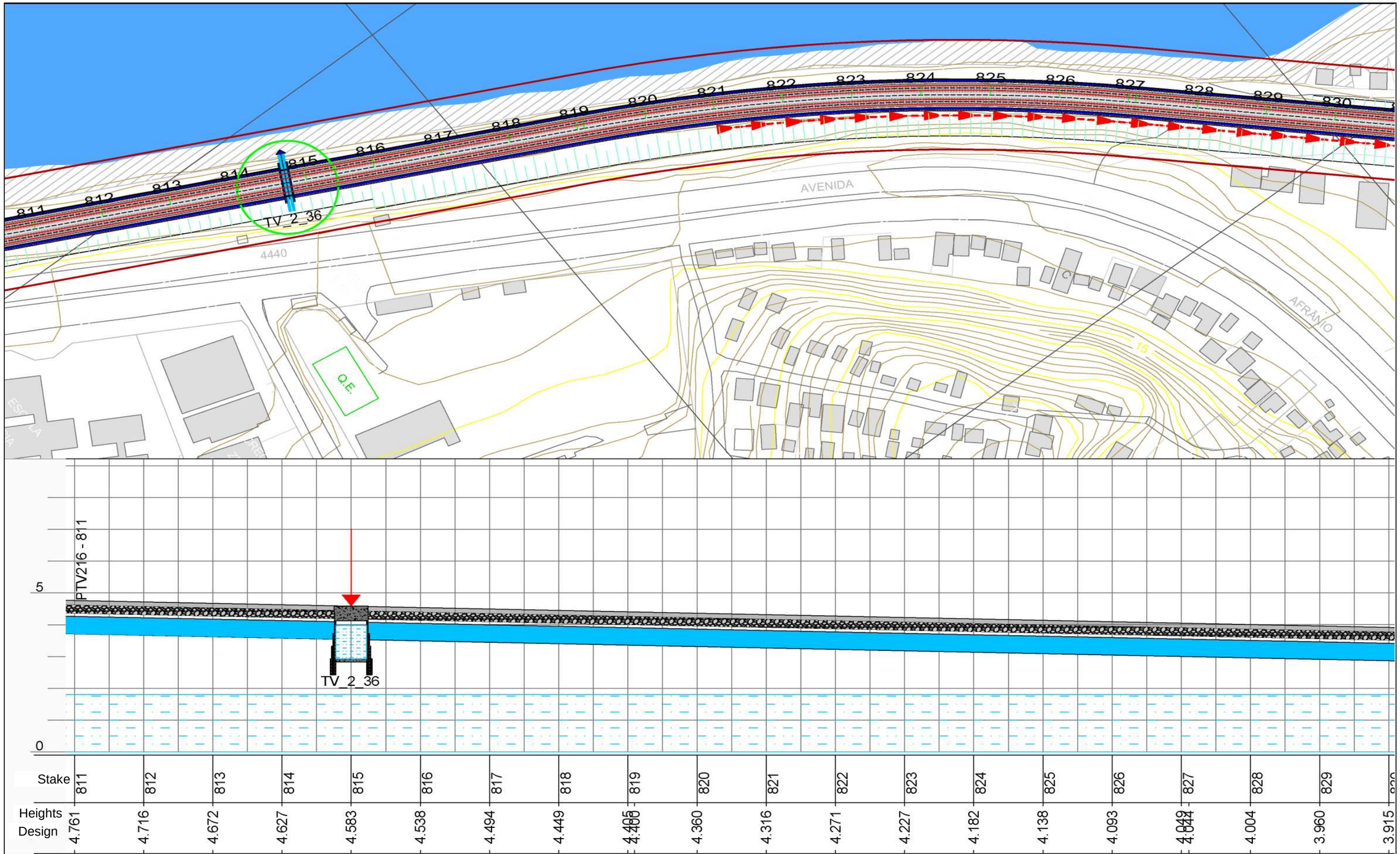
SUBJECT: DRAINAGE - FLOOR PLAN AND PROFILE

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

TR45 Rail
Axis
TR45 Rail
Permanent Track
Higher Point
Lower Point

Tubular gallery
Collecting or Passage Box
Deep Drain (Plant)
Deep Drain (Profile)
Right of way

Rectangular channel (Plant)
Regularization of the land
Rectangular channel (Profile)
Crossing - Capped gully hole (Profile)

Crossing - Capped gully hole (Plant)
Potential Crossing
Maximum tide = 1.80 m

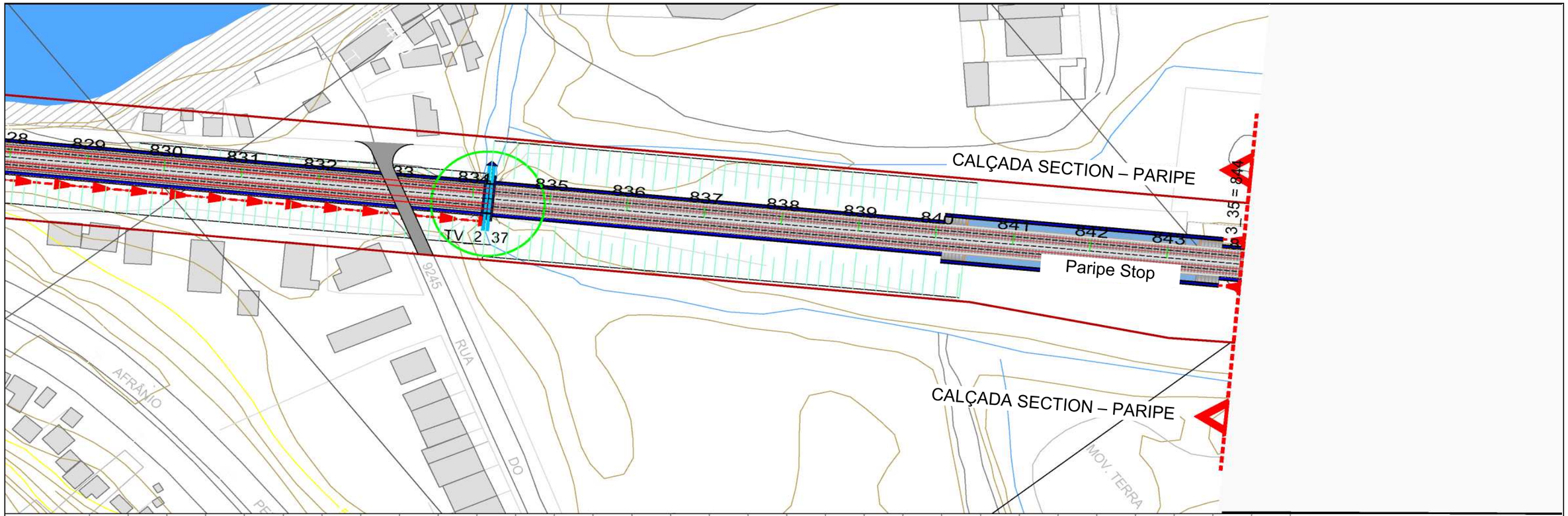
DRAWING		/ /	SHEET 35/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

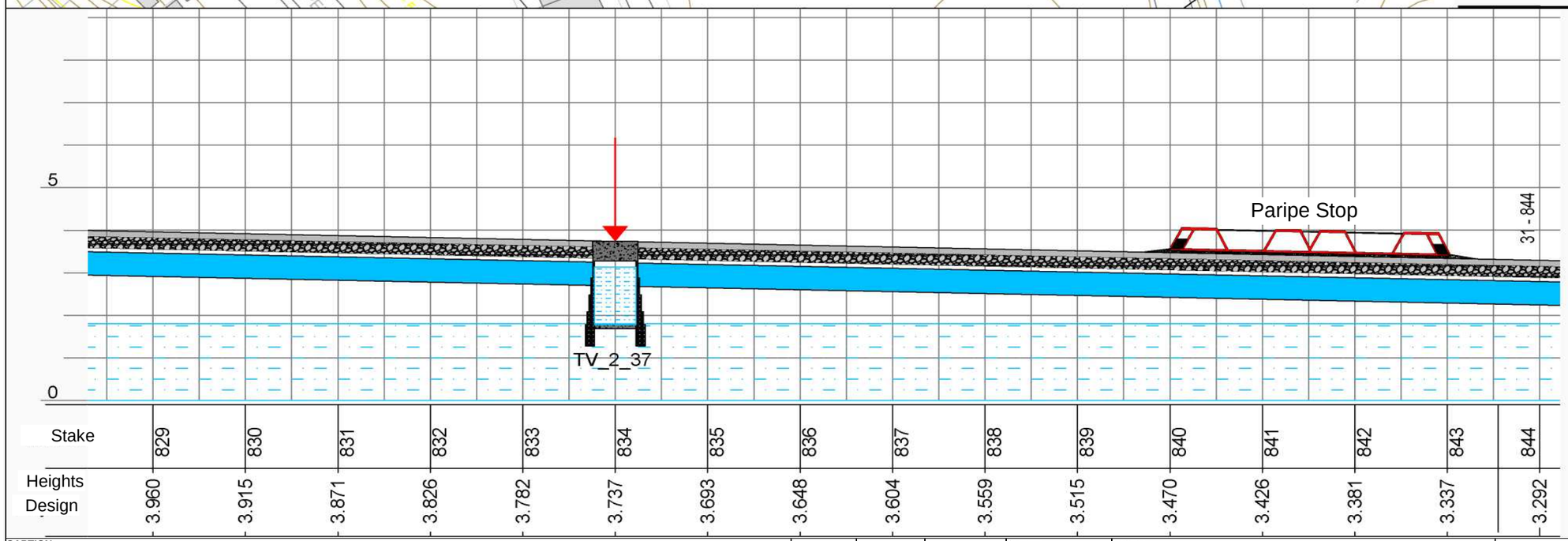
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION

- TR45 Rail
- Axis
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

DRAWING		/ /	SHEET 36/36	WORK: SECTION – CALÇADA - PARIPE
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

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CJB

LIGHT-RAIL VEHICLE
LRV

Contentions

Most existing structures are supportive of the landfill embankments or work as contention of cuts next to the slope where there are land masses of great height, occupied by houses and mostly in permanent state of saturation. The contentions deployed for construction of Av. Suburbana and side tracks to the right of way, are the responsibility of the Municipality of Salvador, and are not therefore scope of this design. The condition of the local morphology, together with the presence of expansive soils of black clay type, water circulation in gradient situation, undermining of wall base due to the sea action, oxidation of tie rods and erosion of the contained material, determine the existence of retaining walls.

On the occasion of basic and executive designs, these structures must be registered and evaluated for the preparation of their studies to be made up of specifications and calculation memories and drawings of the used solutions. The restoration of existing structures may be allowed where these interventions are technically sufficient, and in other cases should be made other contentions and/or additions.

The following are photos showing the involvement of existing structures and also suggestions of types of contentions to be used.

Overview of the retaining wall

Undermining the base of the wall

Damaged grout mortar

Undermining the base of the wall

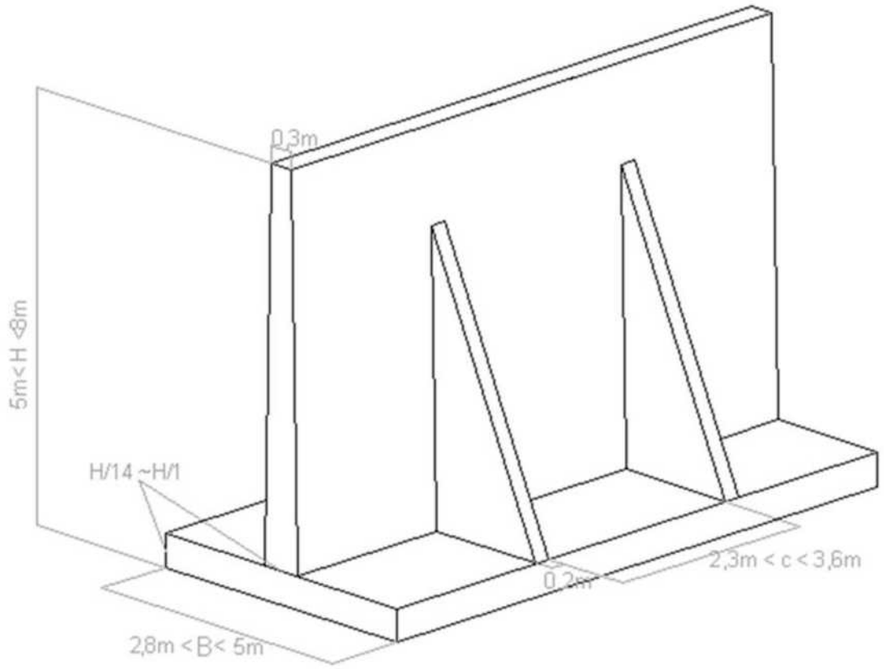
Tie-up wall

Oxidized tie rod

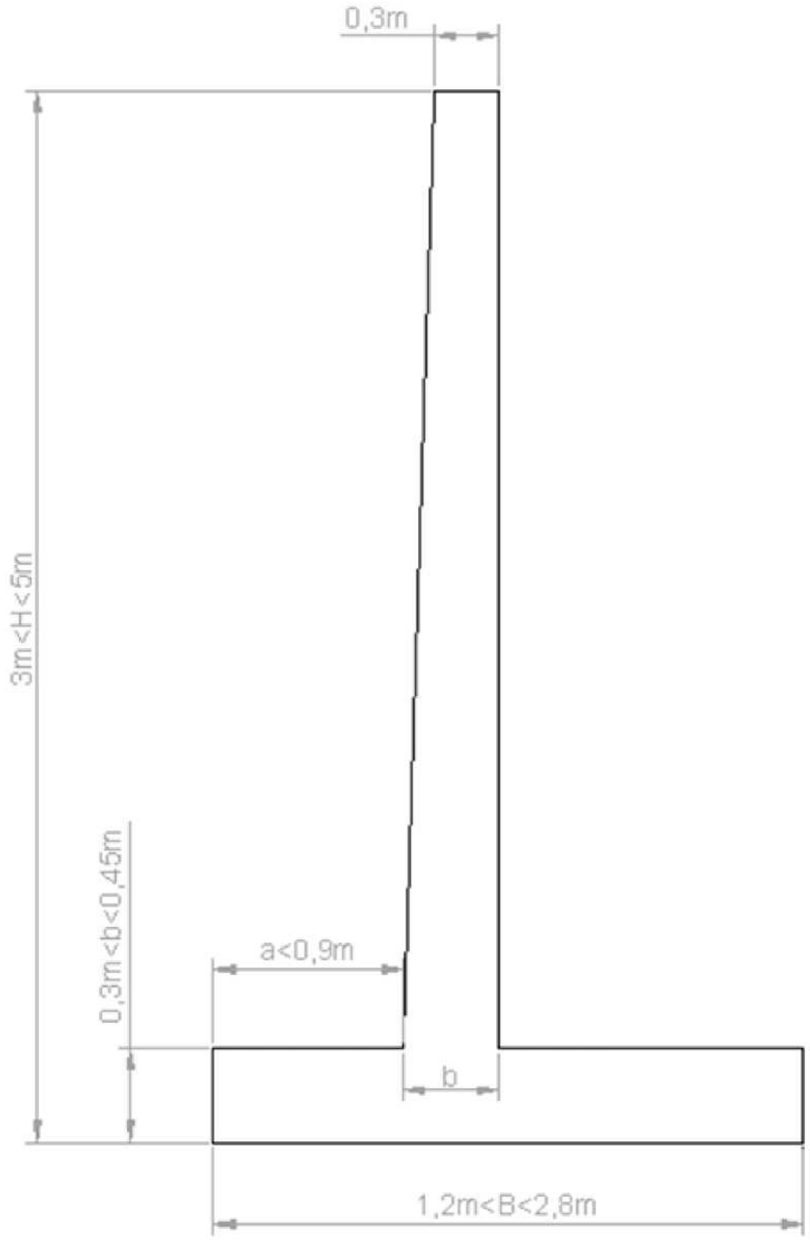
Collapsed tie-up wall

Frameworks of oxidized contention

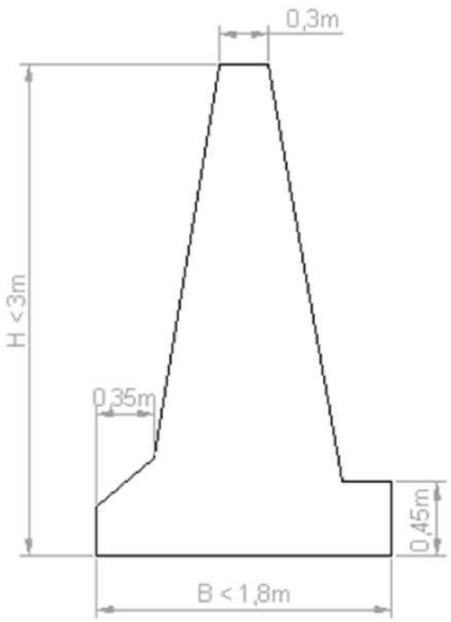
Proposed solution: Wall with buttresses



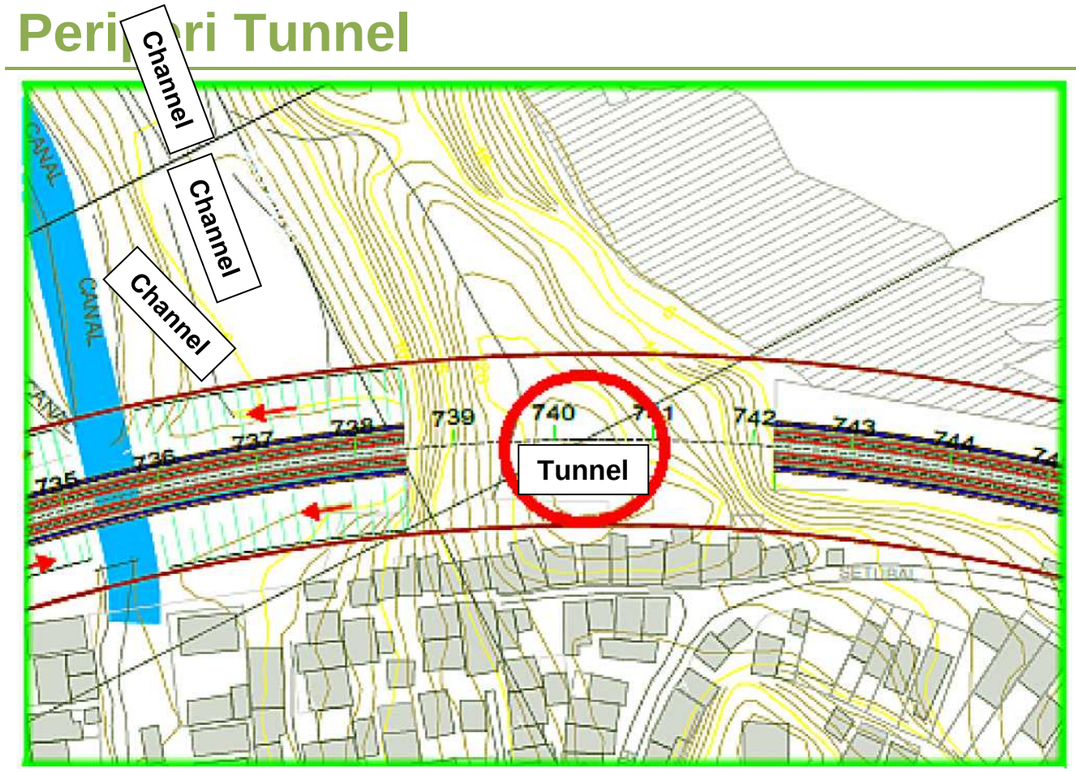
Proposed solution: Retaining wall

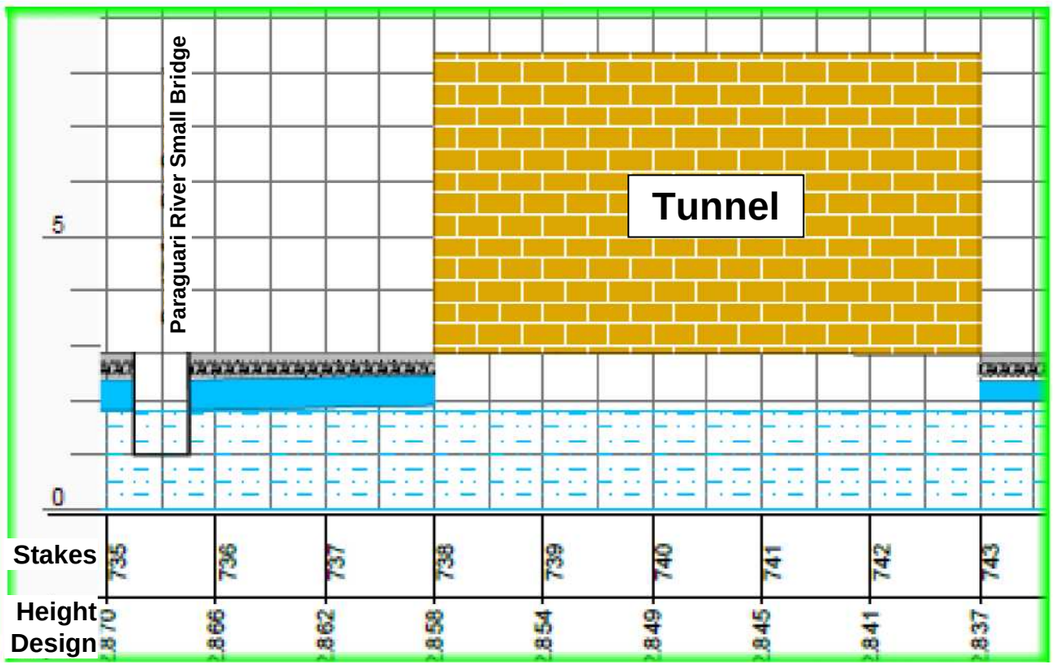


Proposed solution: Cyclopean concrete weight wall.



Periperi Tunnel





Among the stakes 738 to 743, there is an open tunnel for over 150 years, with ceramic brick masonry, considered the first tunnel to be built in Brazil. At its side (right side) there is another tunnel, more recently deployed.

These tunnels have functional and structural problems. The functional are insufficient dimensional elements to meet the clearances of the Standard, including the lack of special passage for evacuation in case of accidents. The structural have cracks and deterioration of the coating and its masonry.
This is added to the fact that there are deficiency of the internal drainage system and some points with infiltrations.

It is necessary that when preparing the Basic Design, this structure is evaluated in order to present alternatives for recovery, including the components and safety requirements, drainage, etc., or information for construction of new structures, whether in open or closed pits in the top, extended tunnels for the passage of two-way, etc., but that address the required safety devices.

Volume II - Railway Superstructure - Paripe - São Luís

Item	Content List
G_01	Presentation
G_02	Desire line
G_03	Deployment of the enterprise
G_04	Route geometrization
G_05	Drainage
G_06	Topographical Survey

Robério Bezerra & Cynthia Brito & André Cury

Presentation

The State Government is projecting a connection with the use of BRT, between the future Bus Station of Águas Claras and Paripe, near the city of São Luís. For this, it was necessary the expansion of the existing railway superstructure between Calçada and Paripe.

This expansion is designed on the old bed of the railroad in the section - Paripe - Mapele currently not used and without rails. The superstructure of the design, in this section is identical to the result of the reclassification of the section - Calçada - Paripe, the reason why this document incorporates all procedures, details and specifications contained in the core of the Preliminary Design - Volume II - Calçada - Paripe.

In this section will be built a complete dual in-line rail structure with international clearance, electrified and having at its end, in the City of São Luiz, a stop identical to the standard that will be deployed in the section - Calçada - Paripe. This stop will be used for the integration of the LRV with the BRT, coming from Águas Claras. Along the section there are some commercial and residential establishments, built on the old railroad and within the right of way of the DNIT for the railroad. The section after the deactivation of the railroad was completely covered by vegetation and urban debris. There are also remnants of rails, sleepers and ballast.

The geometry of the design kept the original horizontal route, as a way to use the existing superstructure, but purposely raised the grade in order to avoid drainage problems from natural and artificial evictions that almost flooded the entire extension of the section, as well as avoiding excavations. This elevation will occur in the sub-ballast level using crushed stone due to its neutrality in the presence of water, in order to contour the lower bed support problems, particularly the problem of neutralization of expansion, so as to avoid the need of digging in black clay. The section ends near the Macaco River, the boundary between the cities of Salvador and Simões Filho.

Desire Line

The section Paripe - São Luís is a Permanent Track that has been in operation, which we want to recover, without the need to change the route. The maintenance of the route is imposed by the need of avoiding complications with respect to the infrastructure of the railway, settled on black clay, while maintaining the pre-existing right of way, which will obligate the State Government of Bahia to make the necessary negotiations for removals / relocations to allow the reintroduction of the section to the railroad.

Thereby, it is in fact a railroad recovery, by opting for maintaining the full route that already has a defined right of way of 15.00 m wide for each side of the axis of the outer head of the left and right tracks. The State Government of Bahia, by taking over the operation of the existing Railway System, is requesting to the Federal Government, equity transfer of this right of way, owned by the Federal Government.

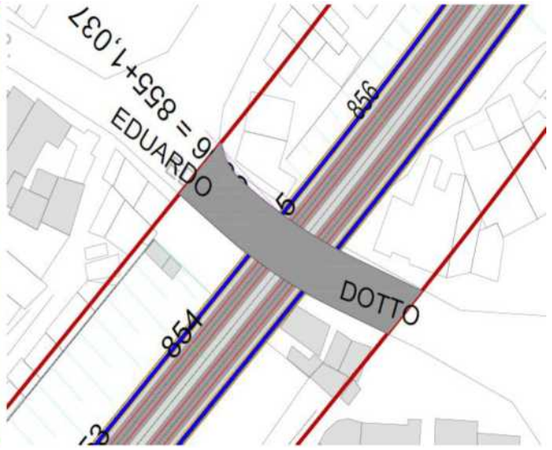
The need to use the existing track as a reference for the recovery of the Permanent Track was fundamental, and conditioned the designers to establish route maintenance procedures, considering qualified and quantified weights, geared to speed up the construction process, causing the little disruption as possible to the local and passing population, and prices capable of fitting the budgetary limits available. In order to achieve these objectives, the following activities were listed:

- ✓ Assess the locational conditions for maintenance of the route for the recovery of the Permanent Track, dual in-line, for compliance with a conventional desire line connecting Paripe to the city of São Luís;
- ✓ Assess alternative conditions of use, in this section of the LRV - Light-Rail Vehicles, powered by electricity;
- ✓ Assess the accessibility conditions for the users in each of the stops and their connection to the current road system;
- ✓ Assess the impact of the deployment of the track on the current users using vehicles and on foot;

When assessing the existing route, we tried to reconcile it to maintain a path that could meet the requirements of a rail corridor capable of operating with a train every 10 minutes to meet a demand of 50,000 passengers. The following were the main interferences and conditions to be assessed and considered in the preparation of the Basic Design:

- ✓ Conditions for deployment and access to a new Level Passage - PN_3_01, shortly after Paripe station, at the stake 855, on Rua Dr. Eduardo Dotto;

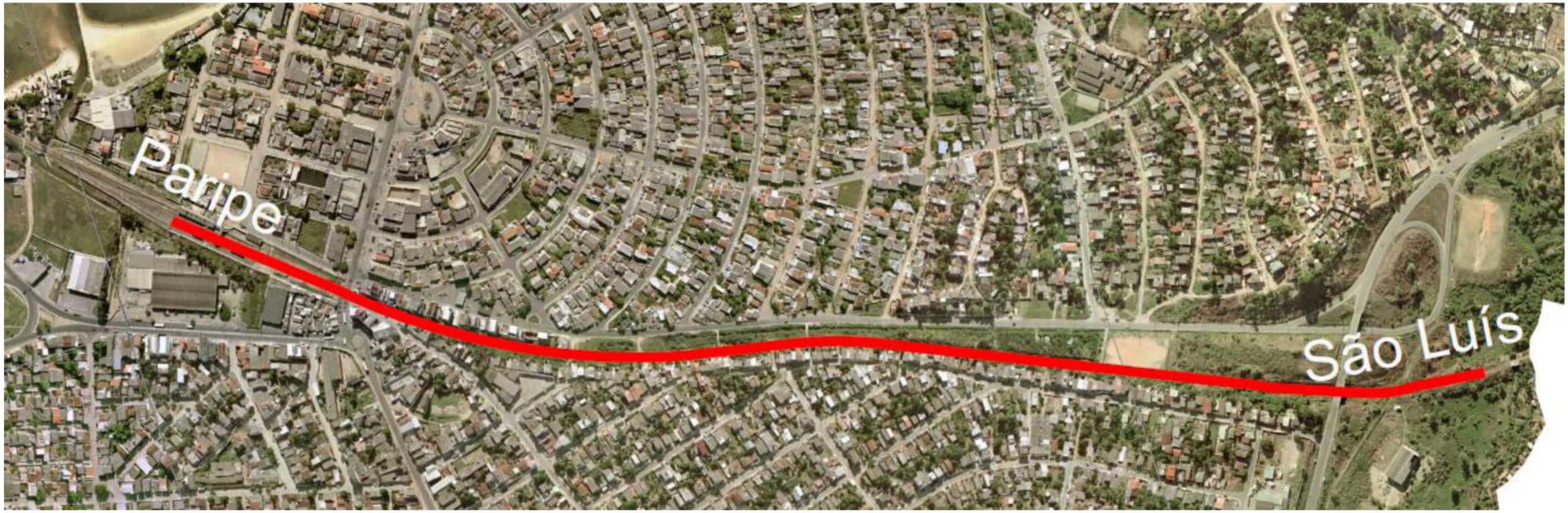
- ✓ Conditions for deployment and access to a new Boarding and Disembarkation Stop - PED_3_01, at stake 917, in São Luís;

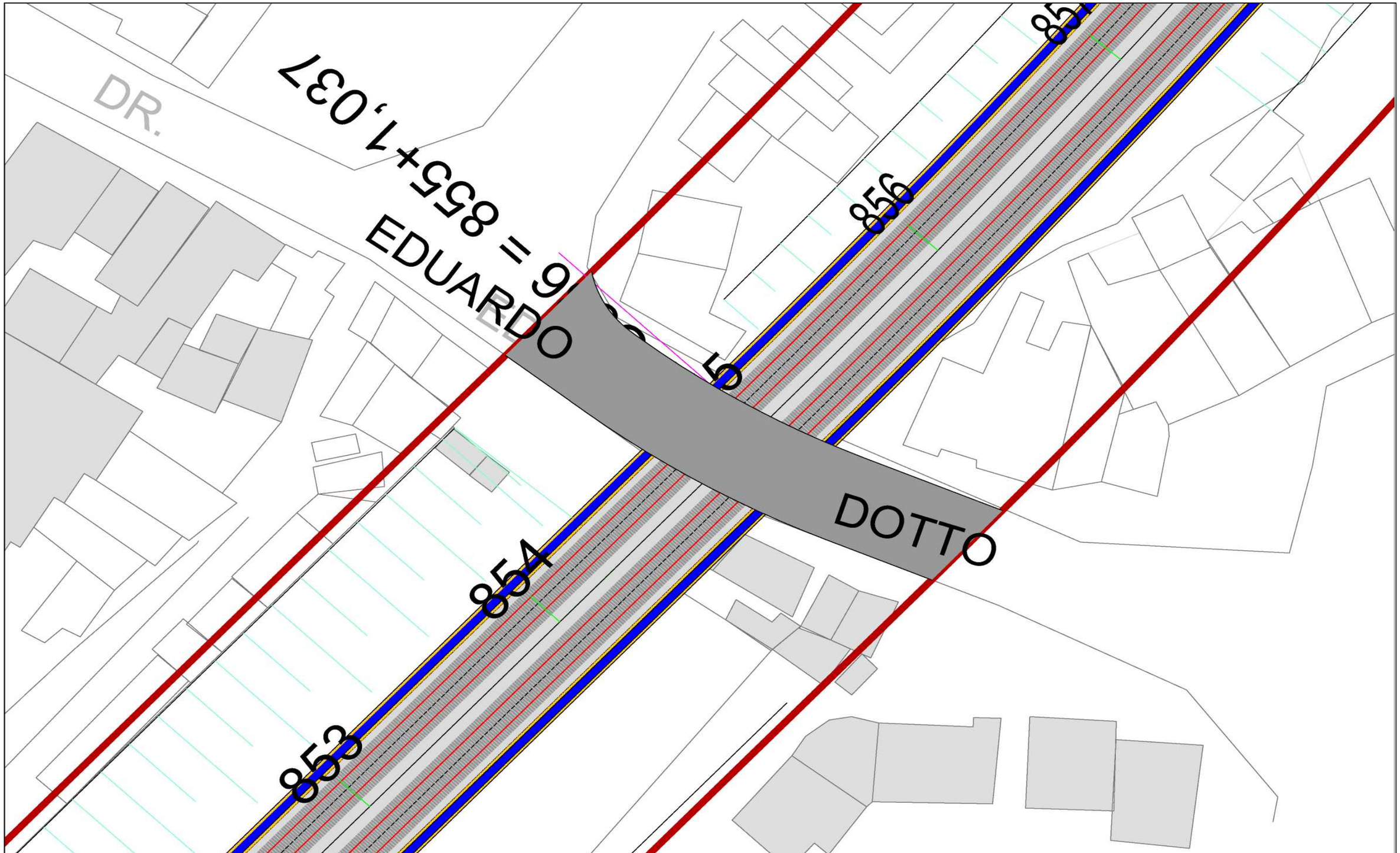


In order to establish a confrontation of locational characteristics aimed at achieving the objective of the Enterprise, evidently associated with the availability of time and financial resources, without forgetting the quantified and qualified evolution of the demand, related to the operational structure of the traffic (train, road vehicles and pedestrians), now and in the future, therefore, we comment on some conditions related to the selected desire line:

- ✓ Use of construction processes and procedures to prevent or minimize vibration and noise;
- ✓ Use of construction processes and procedures that fit within the right of way;
- ✓ Use of construction processes and procedures for the implementation of temporary fences, in order to prevent or minimize vibration and noise and offer security guarantees;
- ✓ Use of construction processes and procedures to ensure safety conditions to the existing traffic;
- ✓ Use of processes and procedures that enable multiple construction fronts in order to minimize the construction time.

Below follows a chart with the list of ***"Desire Line"*** that matches the existing route.


Paripe
São Luís



CAPTION				SHEET 01/01	WORK: SECTION - PARIPE - SÃO LUÍS	DEPARTMENT OF URBAN DEVELOPMENT
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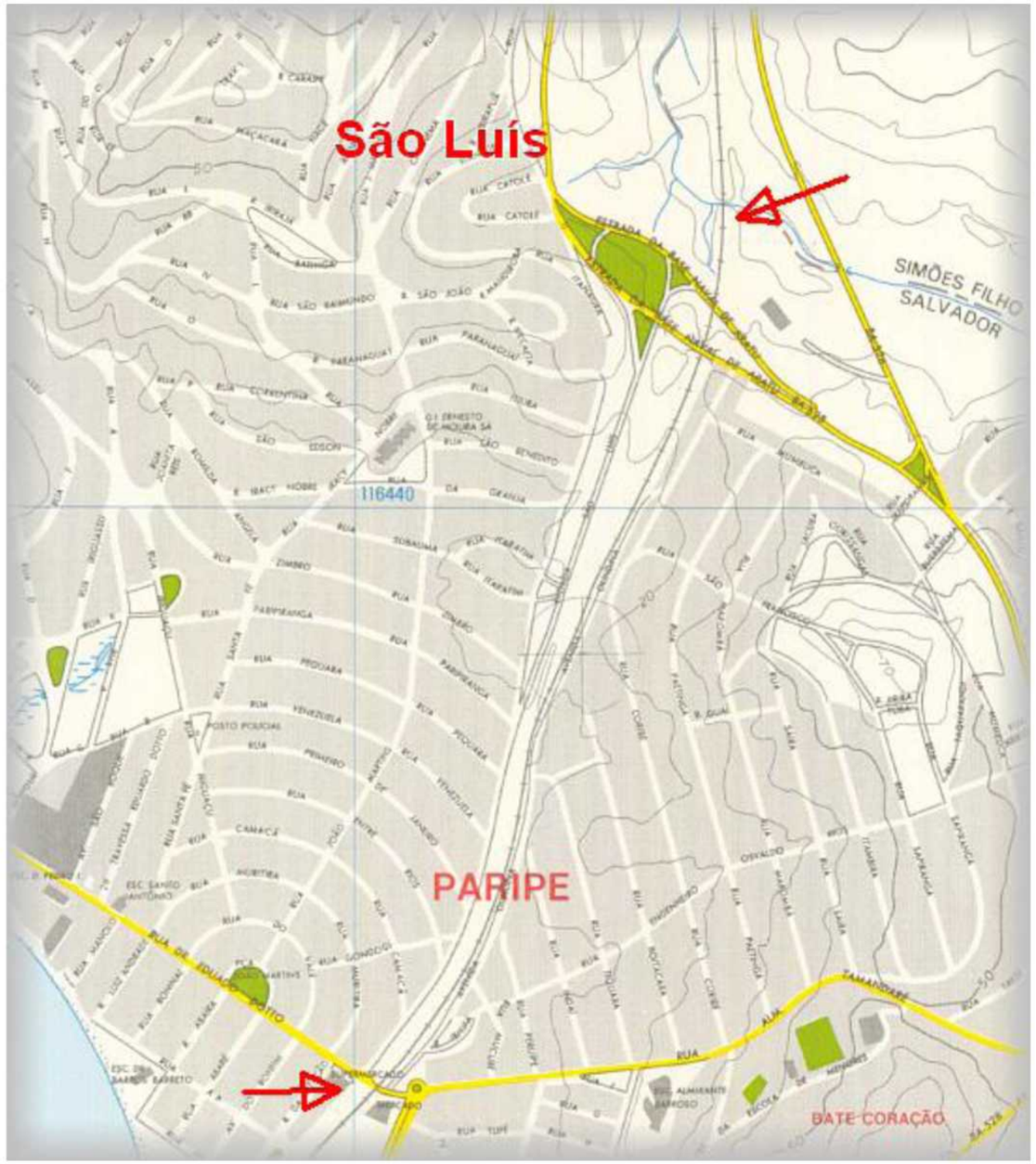
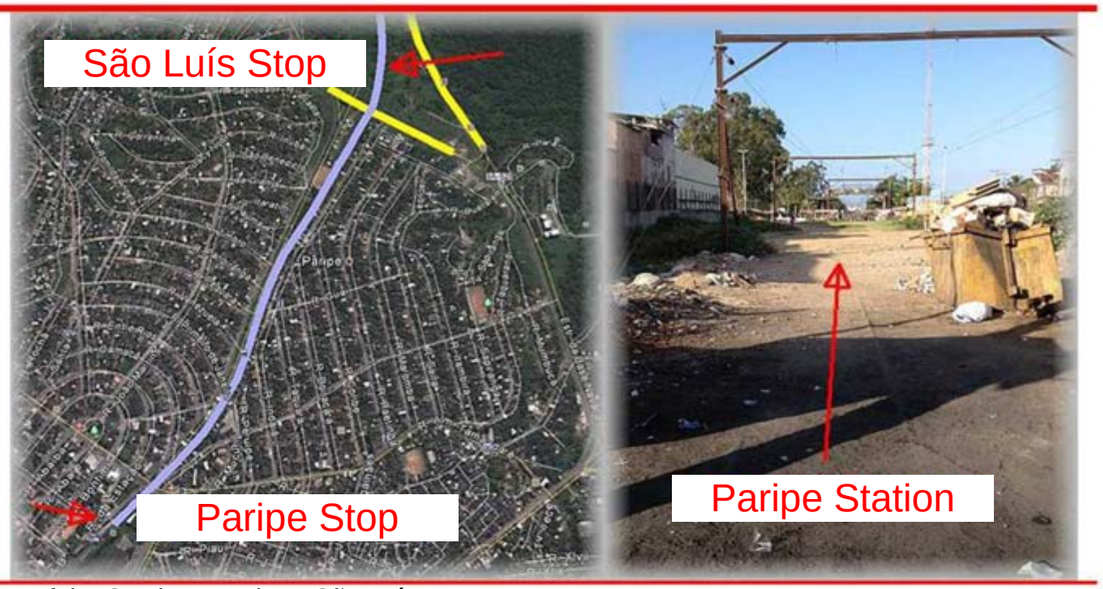
	CHECKING		/ /	SCALE 1:250	MUNICIPALITY SALVADOR	
	APPROVAL		/ /			
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT LEVEL PASSAGE 01 01 - PARIPE - RUA DR. EDUARDO DOTTO FLOOR PLAN	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				

Deployment



Section with deactivated rail shortly after Paripe Station

Aerial view of Paripe Station



View of the Section - Paripe - São Luís

View of the Section - Paripe - São Luís with traces of the former Permanent Track currently deactivated

View of the Section - Paripe - São Luís with traces of the former Permanent Track currently deactivated

Level Passage and section completely covered by vegetation

Final section where the São Luís Stop will be installed, seeing right beside a retaining wall being constructed

Retaining wall being constructed for slope containment in black clay

Route geometrization

The geometrization presented below was performed only for reference to the design elements, since there is a track, although, it is deactivated.

Axis 03	Horizontal Concordance - circular curves	16/08/2015

Elements of Polygon					Elements of the Circular Curve												Distance
code	X (m)	Y (m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	frac.	PT	PC/PT
3_0	557,584.7669	8 580 206.3081			3_0	844	0.00									
3_1	557,893.0487	8 580 532.2305	448.62	43°, 24' 24”	PCe	855	1.04	31°, 45' 37”	227.59	800.0000	443.46	0° 02' 09”	877	4.49	PT	221.04
3_2	557,978.7037	8.580 947,7998	424.30	11°, 38’ 47”	PCd	883	18.55	14°, 17" 12-	62.66	500.0000	124.67	0° 03’ 26”	890	3.23	PT	134.06
3_3	558,206.9943	8 581 417.2546	522.02	25°. 55' 59”	PCe	912	6.88	8° 58' 42”	15.70	200,0000	31.34	0° 08' 36”	913	18.22	PT	443.65
3_4	558,255.5904	8.581.576.6538	166.64	16° 51’ 18”	PCe	920	0.53	16° 17" 43’	28.63	200.0000	56.88	0° 08' 36”	922	17.41	PT	122.31
3 5	558,256.8709	8 581 687 8723	111.23	0° 00' 00”	3_5	927	0.00									82.59

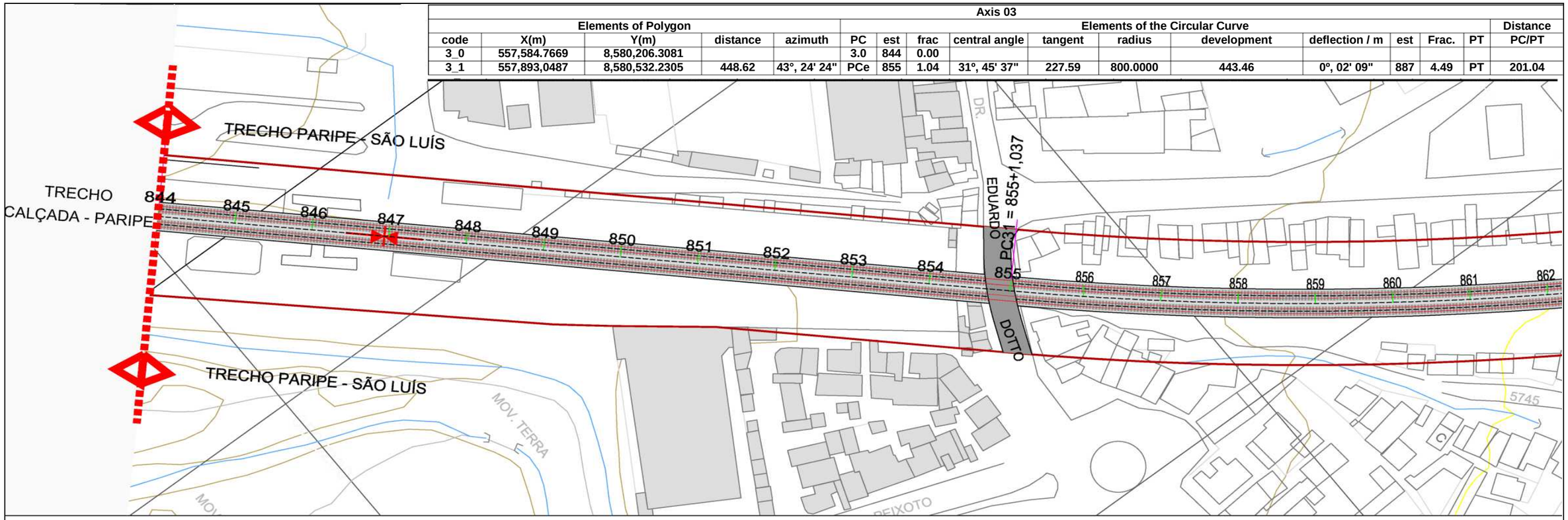
Grade Parameters of Axis _ 2

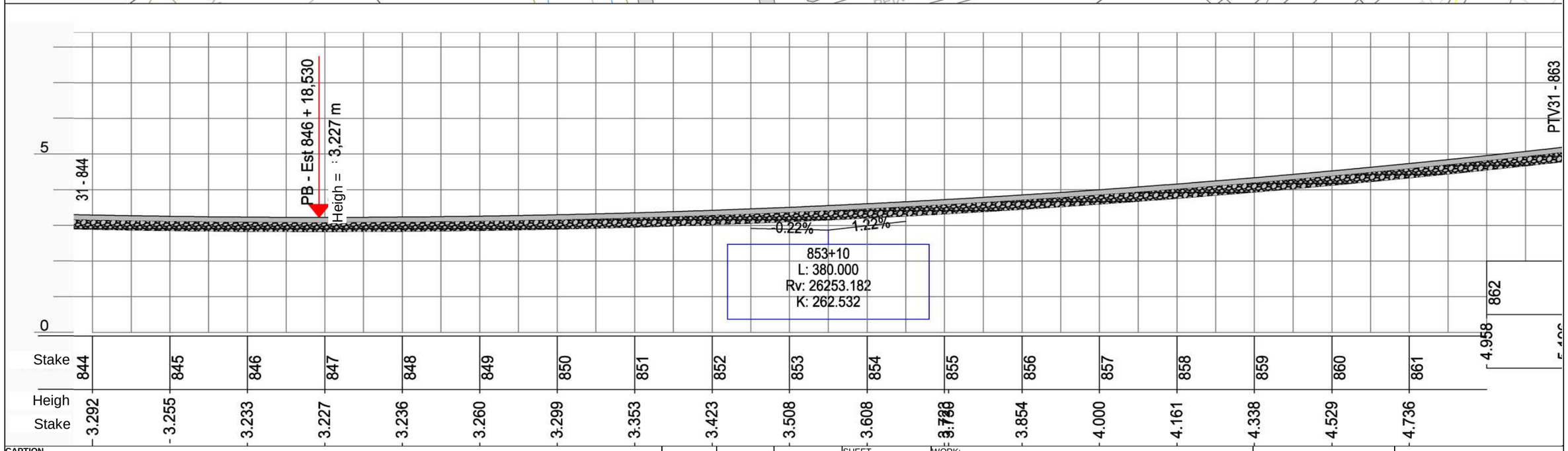
Design Condition	
Minimum	M
Desirable	D

Axis	Operating Speed	Design Speed	Visibility distance	Vertical Radius Convex	Vertical Radius Concave	Condition
2	77	90	171	7.051	4.046	d

P	C	V	declivity	distance	Y	PIV			E	Rv	P	T	V
stake	fraction	height	%	PCV / PTV	m	stake	fraction	height	m	m	stake	fraction	height
						844	00.00	3,292					
844	00.00	3,292	-0.22	0.00	380.00	853	10.00	2,869	0.688	26,253	863	00.00	5,196
915	00.00	17,934	1.22	1,040.00	200.00	920	00.00	19,159	-1.227	-4,073	925	00.00	15,474
			-3.69			927	00.00	14,000					

Axis 03																	
Elements of Polygon					Elements of the Circular Curve												Distance
code	X(m)	Y(m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	Frac.	PT	PC/PT
3_0	557,584.7669	8,580,206.3081			3.0	844	0.00									
3_1	557,893,0487	8,580,532.2305	448.62	43°, 24' 24"	PCe	855	1.04	31°, 45' 37"	227.59	800.0000	443.46	0º, 02' 09"	887	4.49	PT	201.04





CAPTION

1
Rail TR45
Rail TR45
Permanent Track

Higher Point
Lower Point
CTB Land – Right of way

DRAWING		/ /	SHEET 01/05
CHECKING		/ /	SCALE
APPROVAL		/ /	V-1:1,00 H-1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION - PARIPE - SÃO LUÍS

MUNICIPALITY: SALVADOR

SUBJECT: HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY

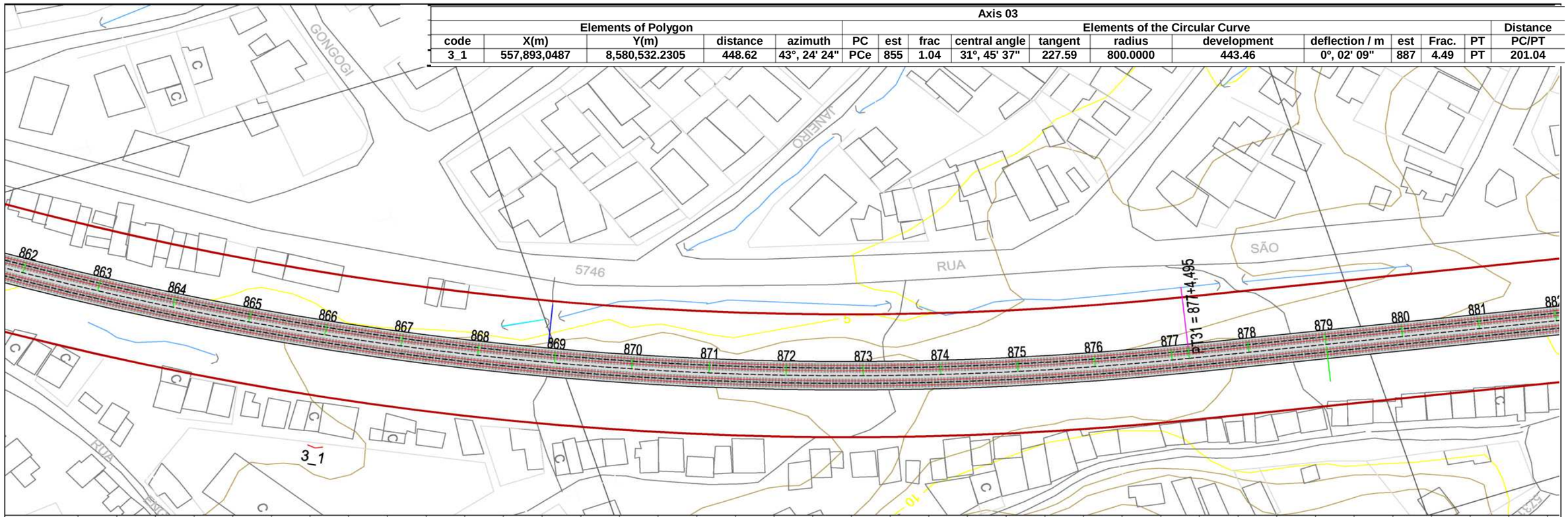
DEPARTMENT OF URBAN DEVELOPMENT

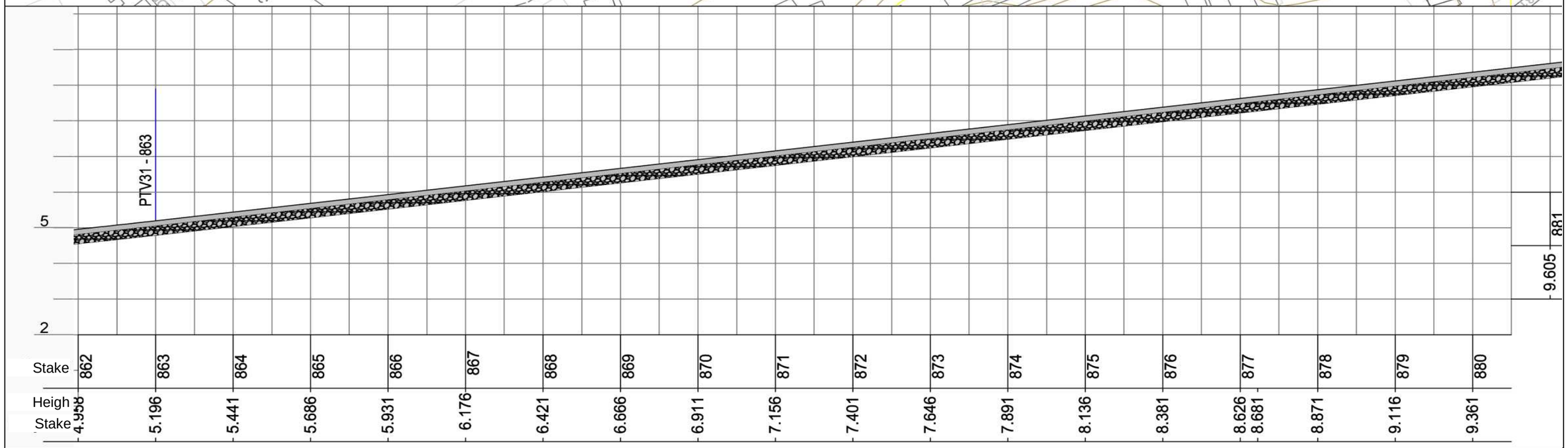
BAHIA GOVERNO DO ESTADO

CTB

LIGHT-RAIL VEHICLE
LRV

Axis 03																
Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y(m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	Frac.	PT	PC/PT
3_1	557,893,0487	8,580,532.2305	448.62	43º, 24' 24"	PCe	855	1.04	31º, 45' 37"	227.59	800.0000	443.46	0º, 02' 09"	887	4.49	PT	201.04





CAPTION

Rail TR45
Rail TR45
Permanent Track
Higher Point
Lower Point
CTB Land – Right of way

DRAWING		/ /	SHEET 02/05	WORK: SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

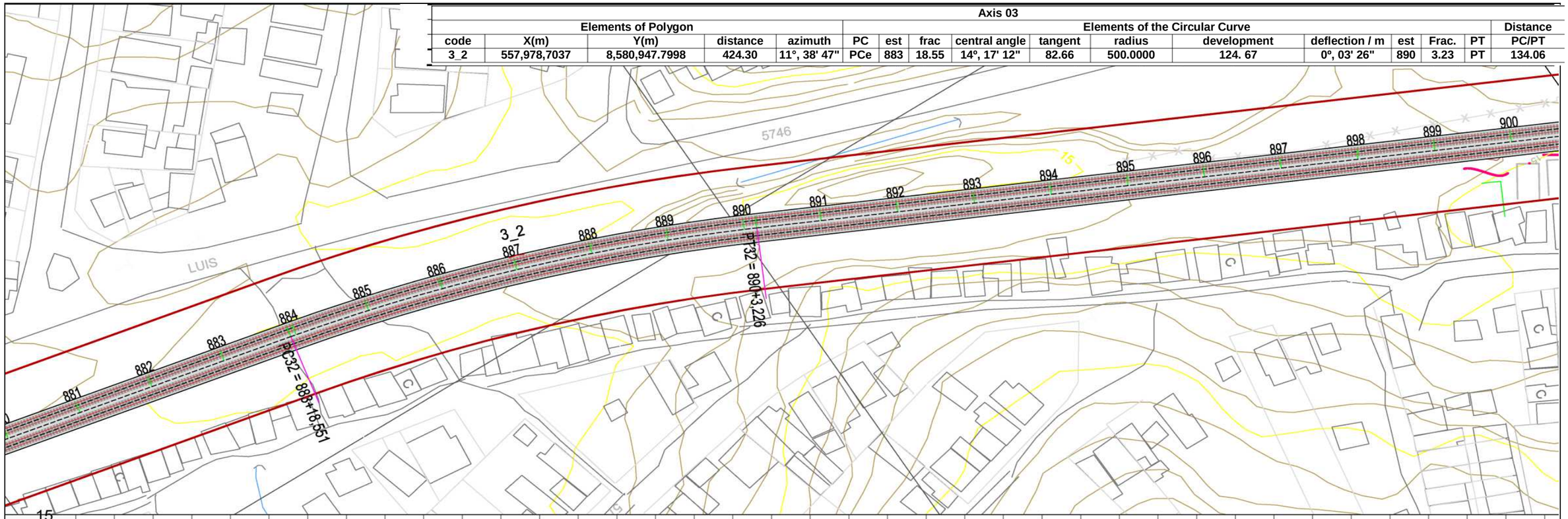
DEPARTMENT OF URBAN DEVELOPMENT

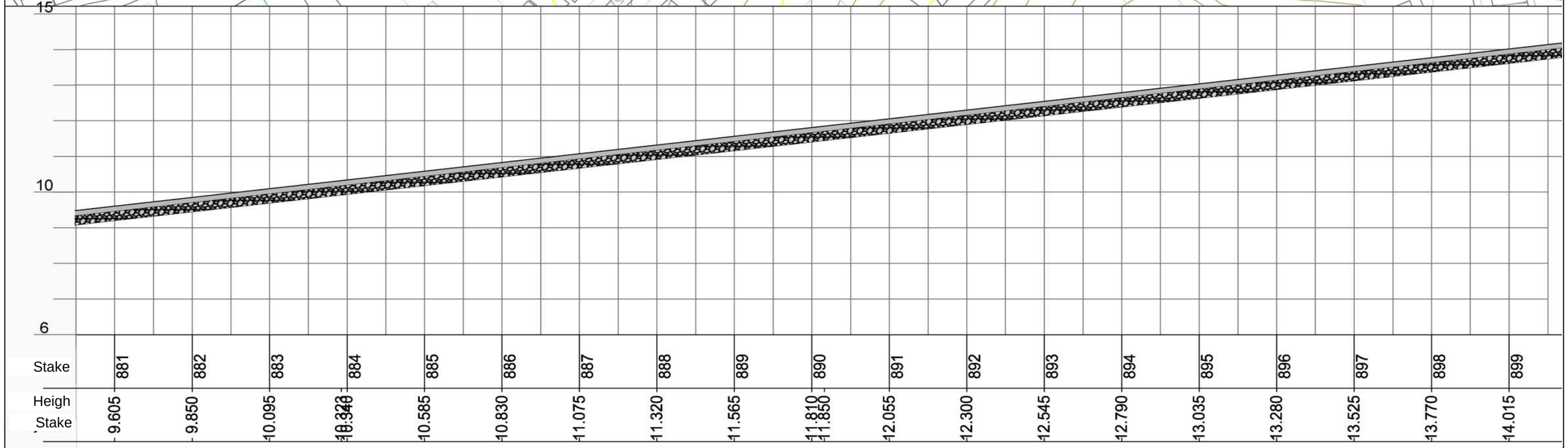
BAHIA GOVERNO DO ESTADO

CTB

LIGHT-RAIL VEHICLE
LRV

Axis 03																	
Elements of Polygon					Elements of the Circular Curve												Distance
code	X(m)	Y(m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	Frac.	PT	PC/PT
3_2	557,978,7037	8,580,947.7998	424.30	11°, 38' 47"	PCe	883	18.55	14º, 17' 12"	82.66	500.0000	124. 67	0º, 03' 26"	890	3.23	PT	134.06





CAPTION

Rail TR45
Rail TR45
Permanent Track
Higher Point
Lower Point
CTB Land – Right of way

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APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

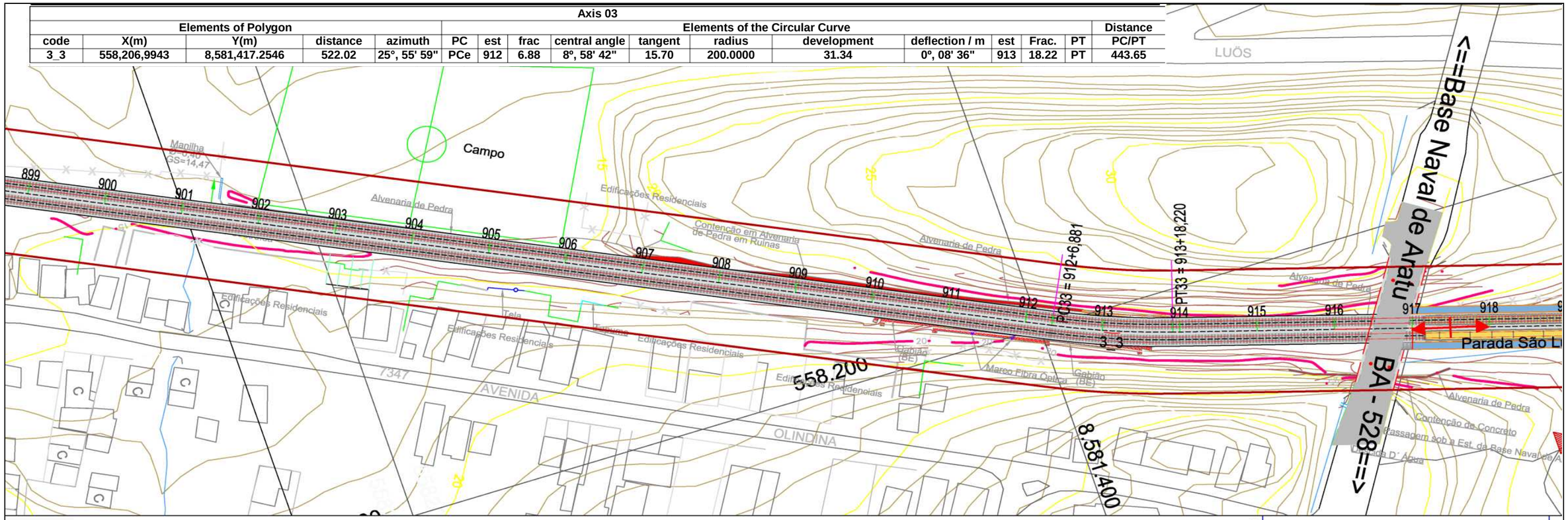
BAHIA GOVERNO DO ESTADO

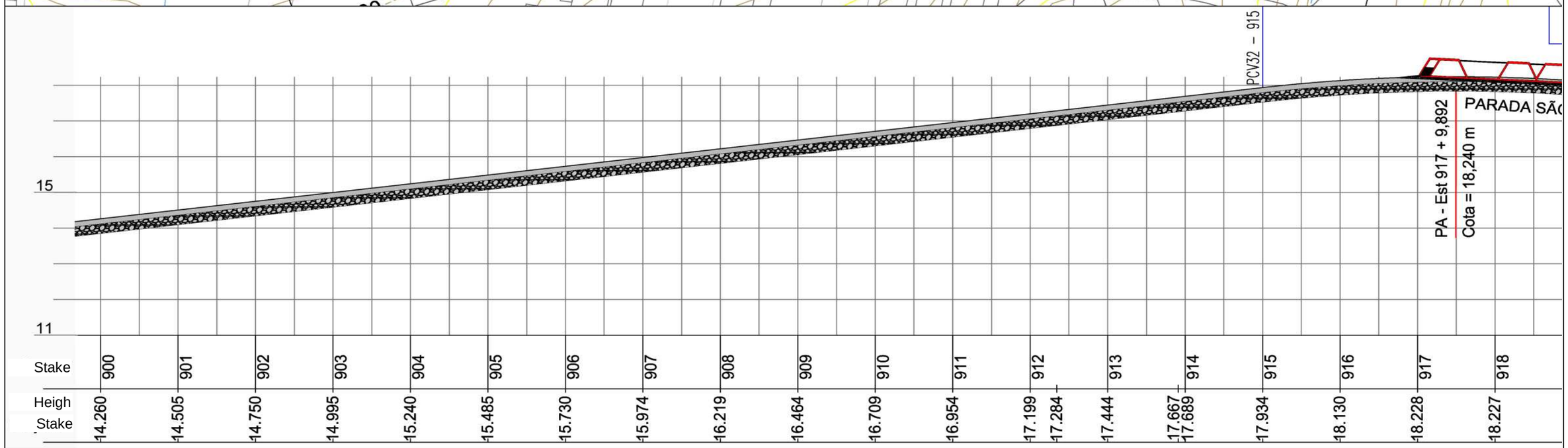
CTB

LIGHT-RAIL VEHICLE
LRV

Axis 03

Elements of Polygon					Elements of the Circular Curve											Distance
code	X(m)	Y(m)	distance	azimuth	PC	est	frac	central angle	tangent	radius	development	deflection / m	est	Frac.	PT	PC/PT
3_3	558,206,9943	8,581,417.2546	522.02	25°, 55' 59"	PCe	912	6.88	8º, 58' 42"	15.70	200.0000	31.34	0º, 08' 36"	913	18.22	PT	443.65





CAPTION

- Rail TR45
- Rail TR45
- Permanent Track
- Higher Point
- Lower Point
- CTB Land – Right of way

DRAWING		/ /	SHEET 04/05
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000
APPROVAL		/ /	
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DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION - PARIPE - SÃO LUÍS

MUNICIPALITY: SALVADOR

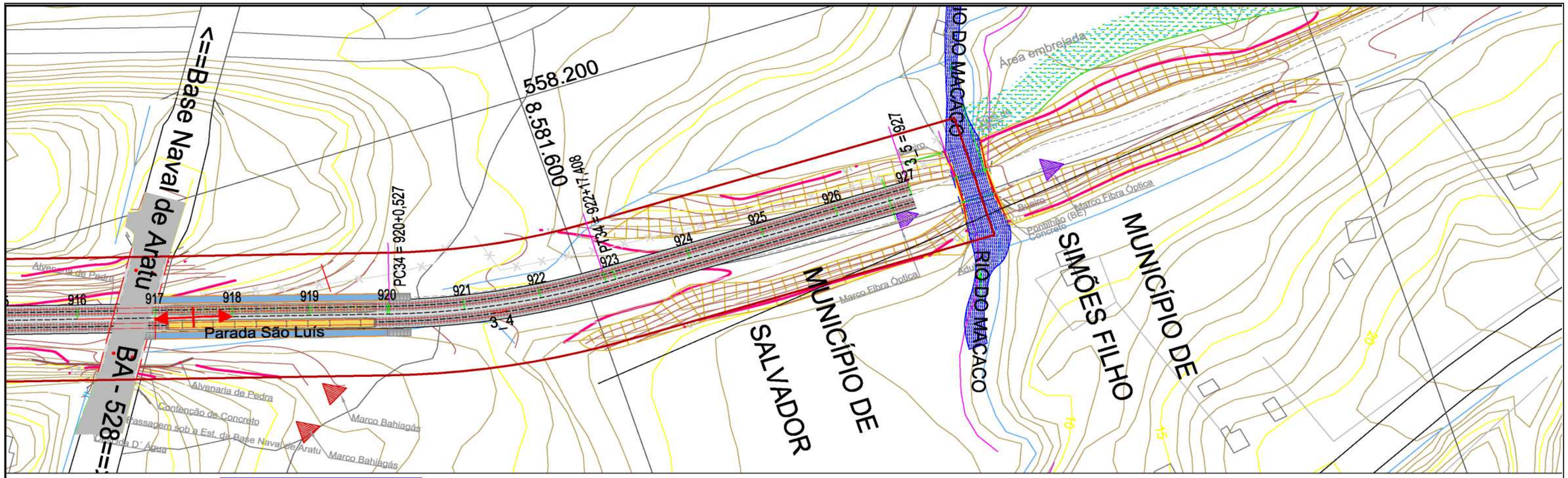
SUBJECT: HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY

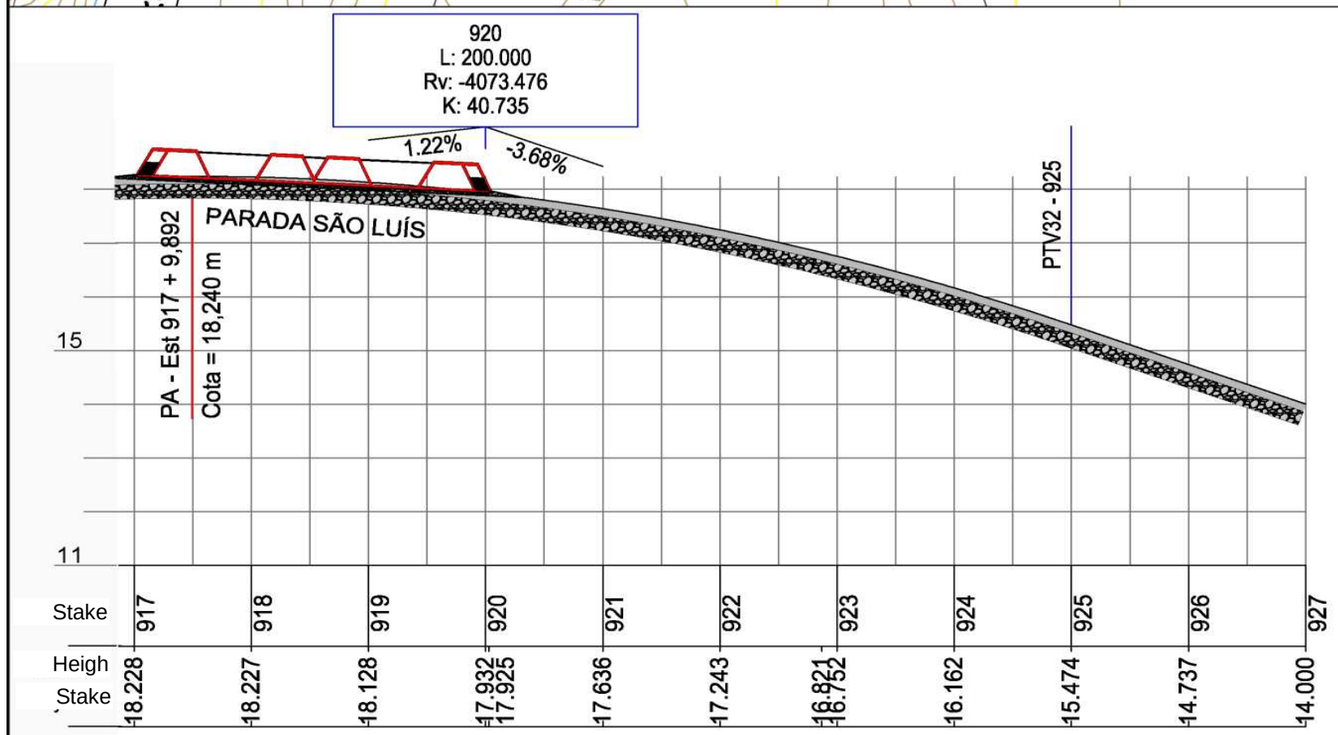
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CTB

LIGHT-RAIL VEHICLE
LRV





CAPTION

1
Rail TR45
Rail TR45
Permanent Track

Higher Point
Lower Point
CTB Land – Right of way

DRAWING		/ /	SHEET 05/05	WORK: SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT HORIZONTAL AND VERTICAL REFERENTIAL GEOMETRY
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

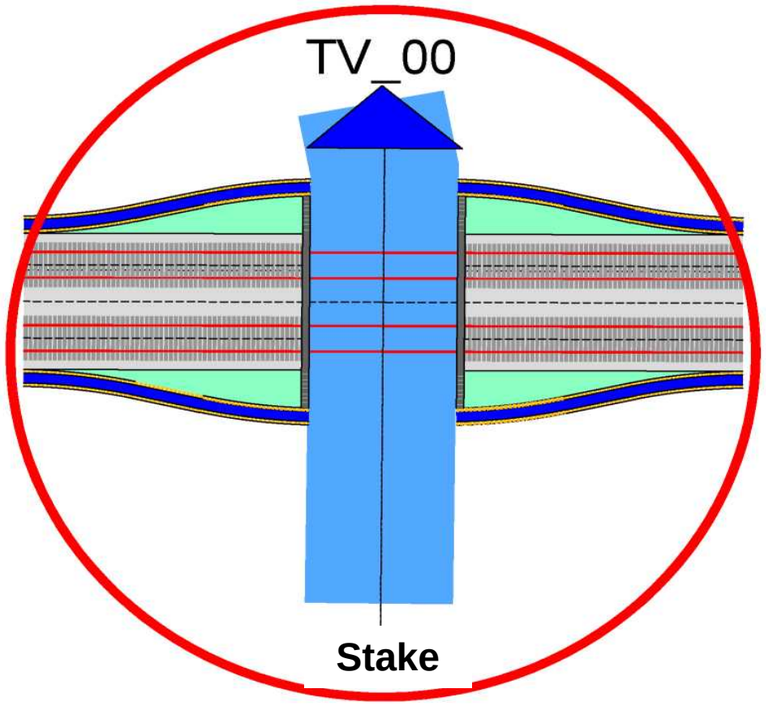
BAHIA GOVERNO DO ESTADO

CTB

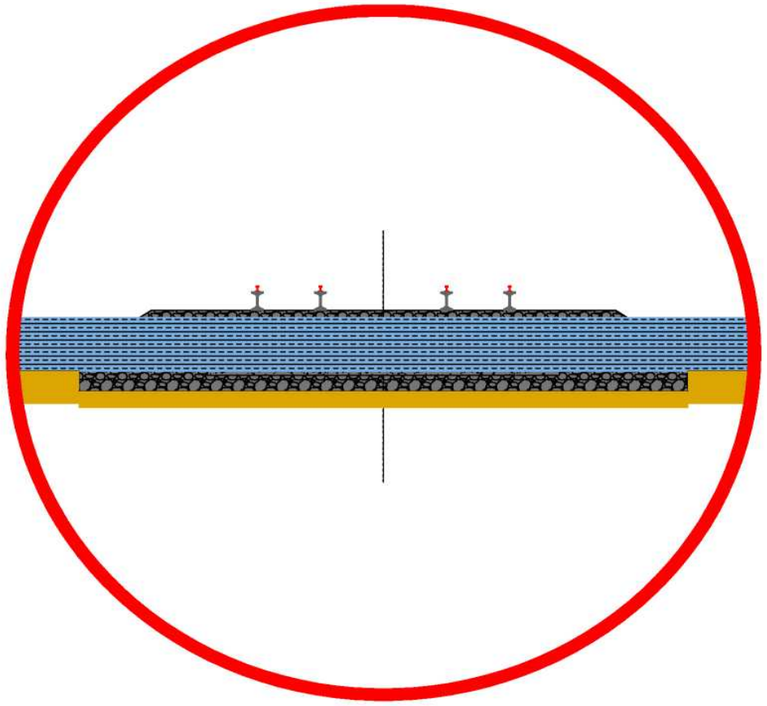
LIGHT-RAIL VEHICLE
LRV

CAPPED GULLY HOLE

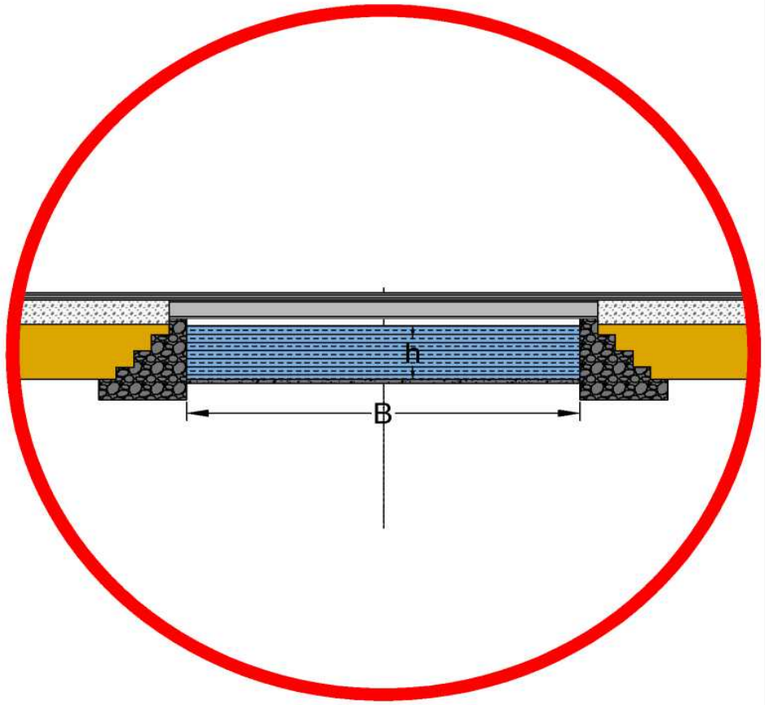
FLOOR PLAN



SECTION



PROFILE



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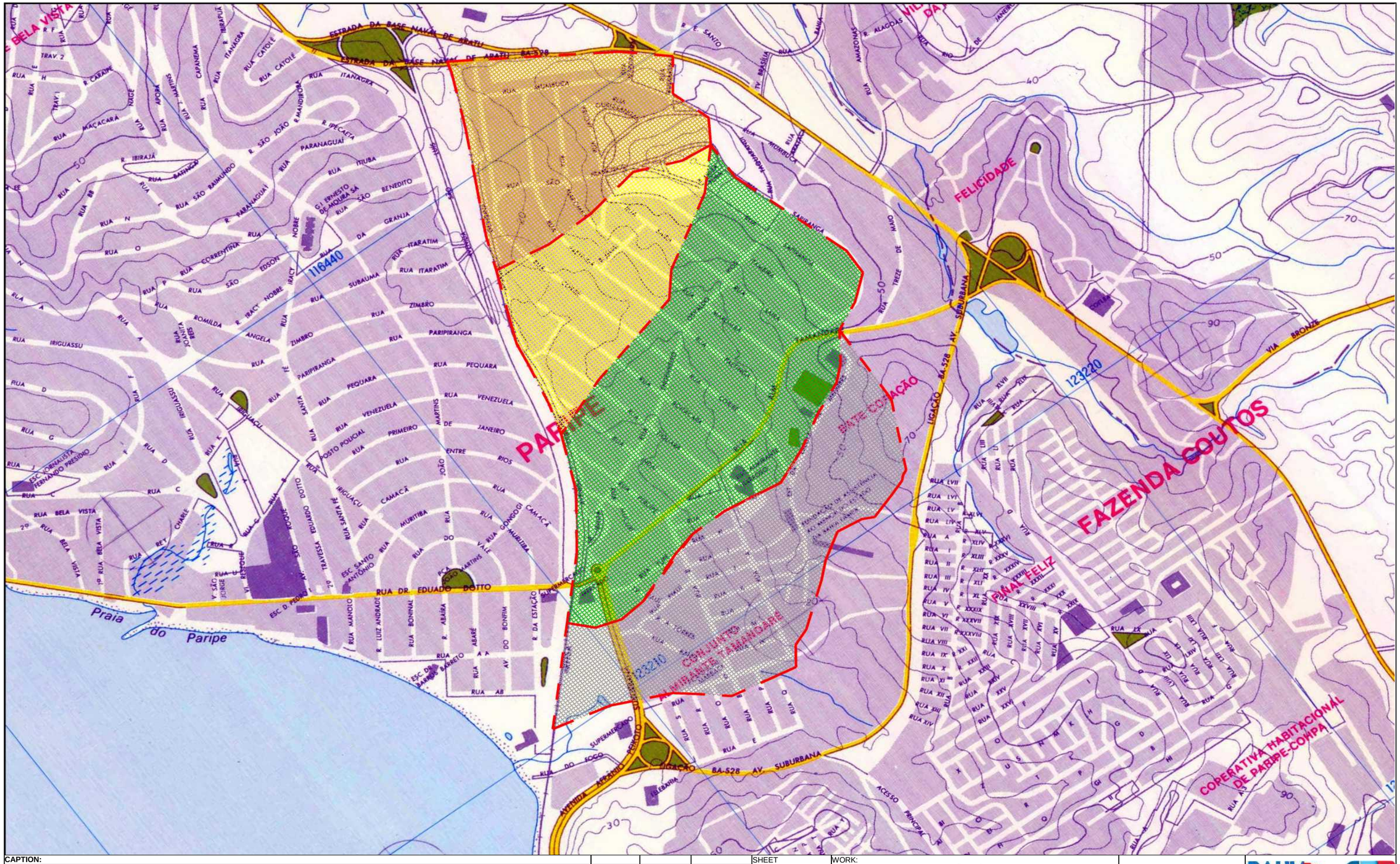
	CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR	
	APPROVAL		/ /	NO SCALE		
	DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE - FLOOR PLAN, SECTION AND PROFILE	LIGHT-RAIL VEHICLE LRV
	DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA				
	DESIGN	Civil Engineer André Cury Lima - 83992-D/BA				



CAPTION:

DRAWING		/ /	SHEET	01/01
CHECKING		/ /	SCALE	
APPROVAL		/ /	NO SCALE	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

WORK: SECTION - PARIPE - SÃO LUÍS

MUNICIPALITY: SALVADOR

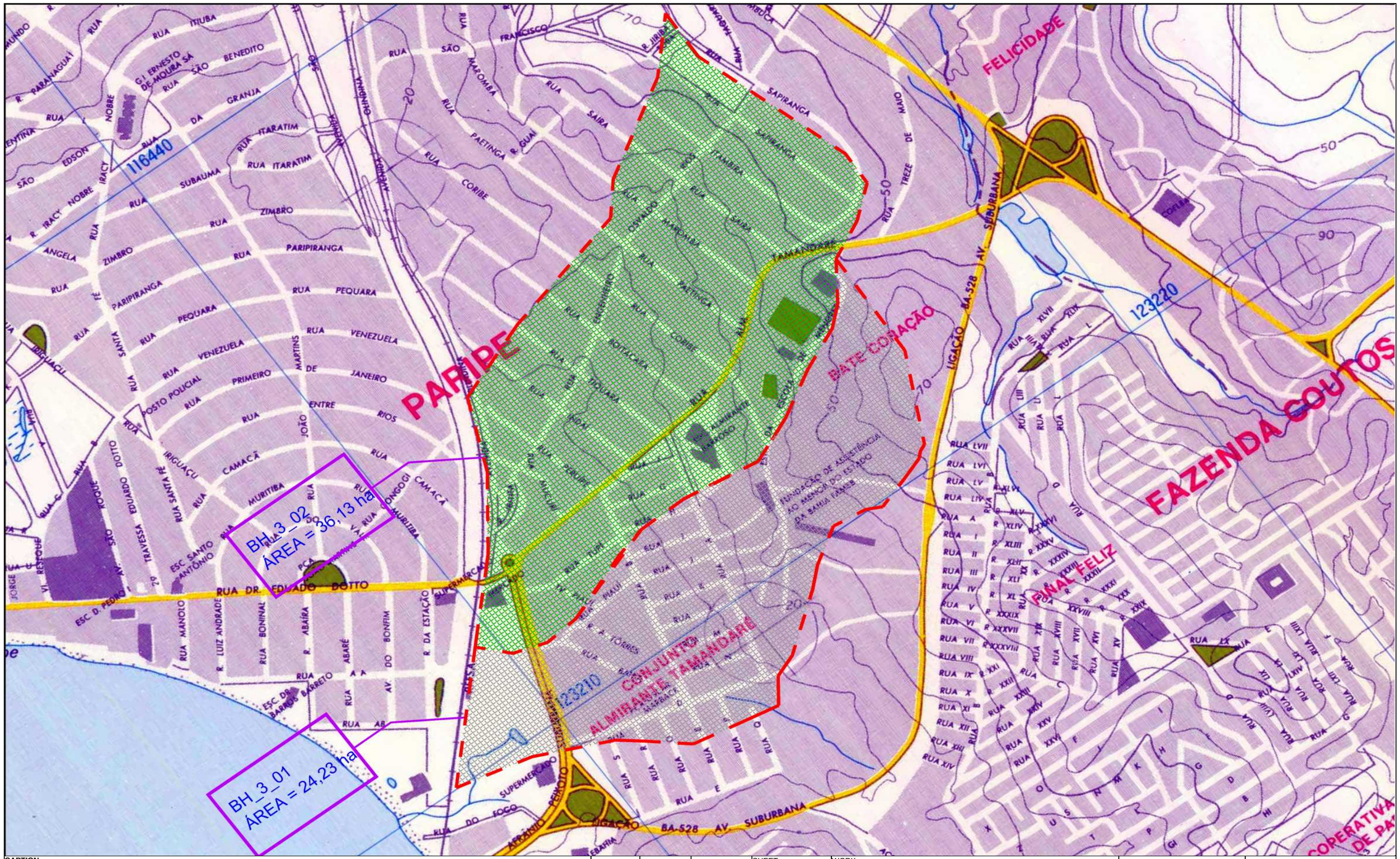
SUBJECT: DRAINAGE
CONTRIBUTION BASINS - BLOCK 3

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION:

			SHEET	WORK:
DRAWING		/ /	01/02	SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE	MUNICIPALITY
APPROVAL		/ /	NO SCALE	SALVADOR
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			DRAINAGE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			CONTRIBUTION BASINS - BLOCK 3_01

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

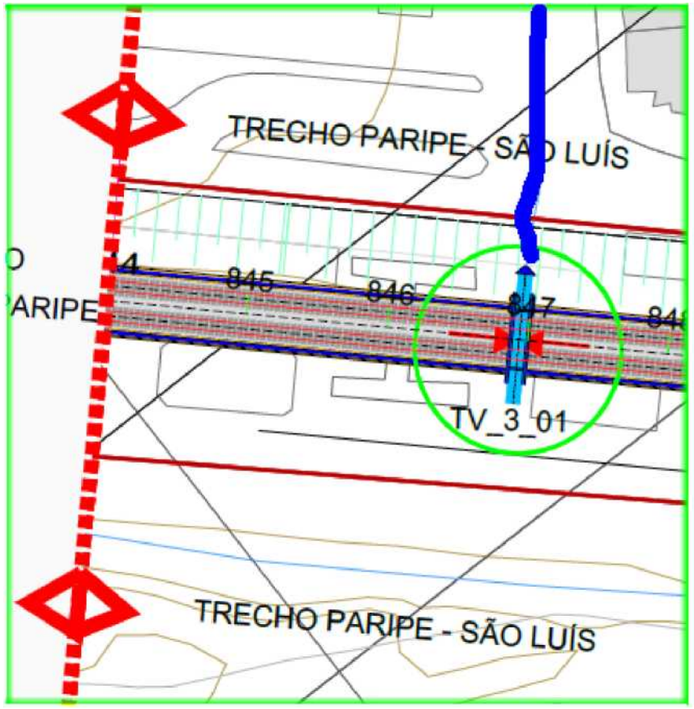
LIGHT-RAIL VEHICLE
LRV

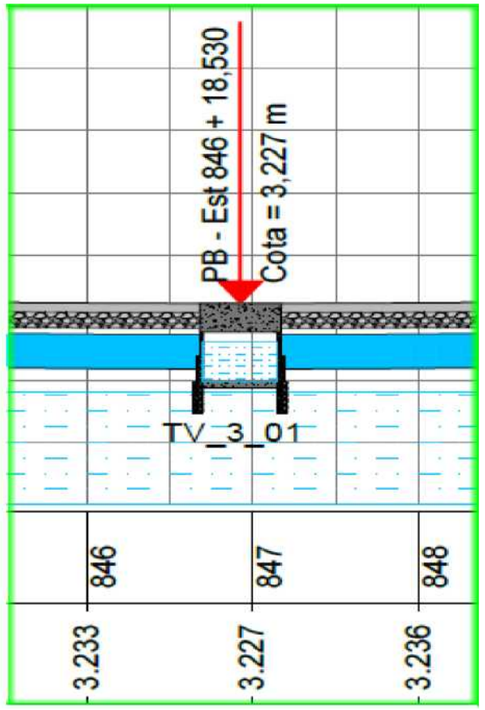
Sizing Worksheet

Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0,8		n =	0,016	
code	declivity	tc	int	Area	Q=C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_3_01	0.20%	5.00	409.84	24.23	7,944.37	2.04	4.50	1.00	0.86
TV_3_02	0.20%	5.99	399.76	36.13	11,554.53	2.17	6.00	1.00	0.89

Valley crossing TV_3_1

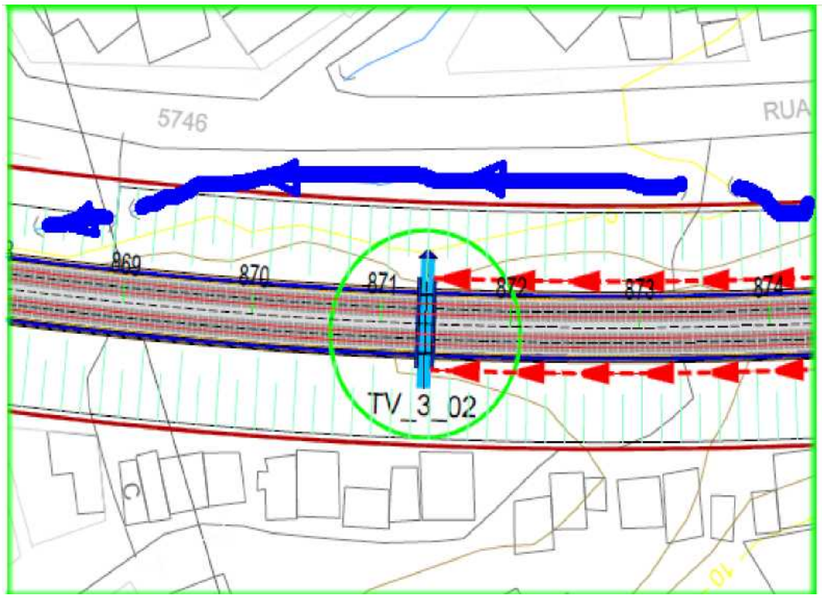


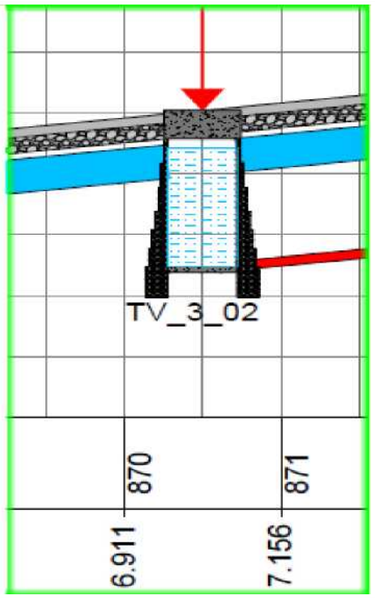


This crossing TV_3_01 is medium-size crossing and have different hydraulic behavior due to local morphological conditions. This is a lowered basin and with low concentration time. It is located in a deployment height with the influence of variations of tidal height differences.

On the occasion of preparation of the Basic Design, an assessment of their functional and structural conditions should be made, in order to check their ability and decide either for structural and functional recovery or expansion, in order to meet the flow rate sections. Their load and unload ditches should be geometrized to meet the required flow rate section.

Block 3_01 - Paripe Center Basins

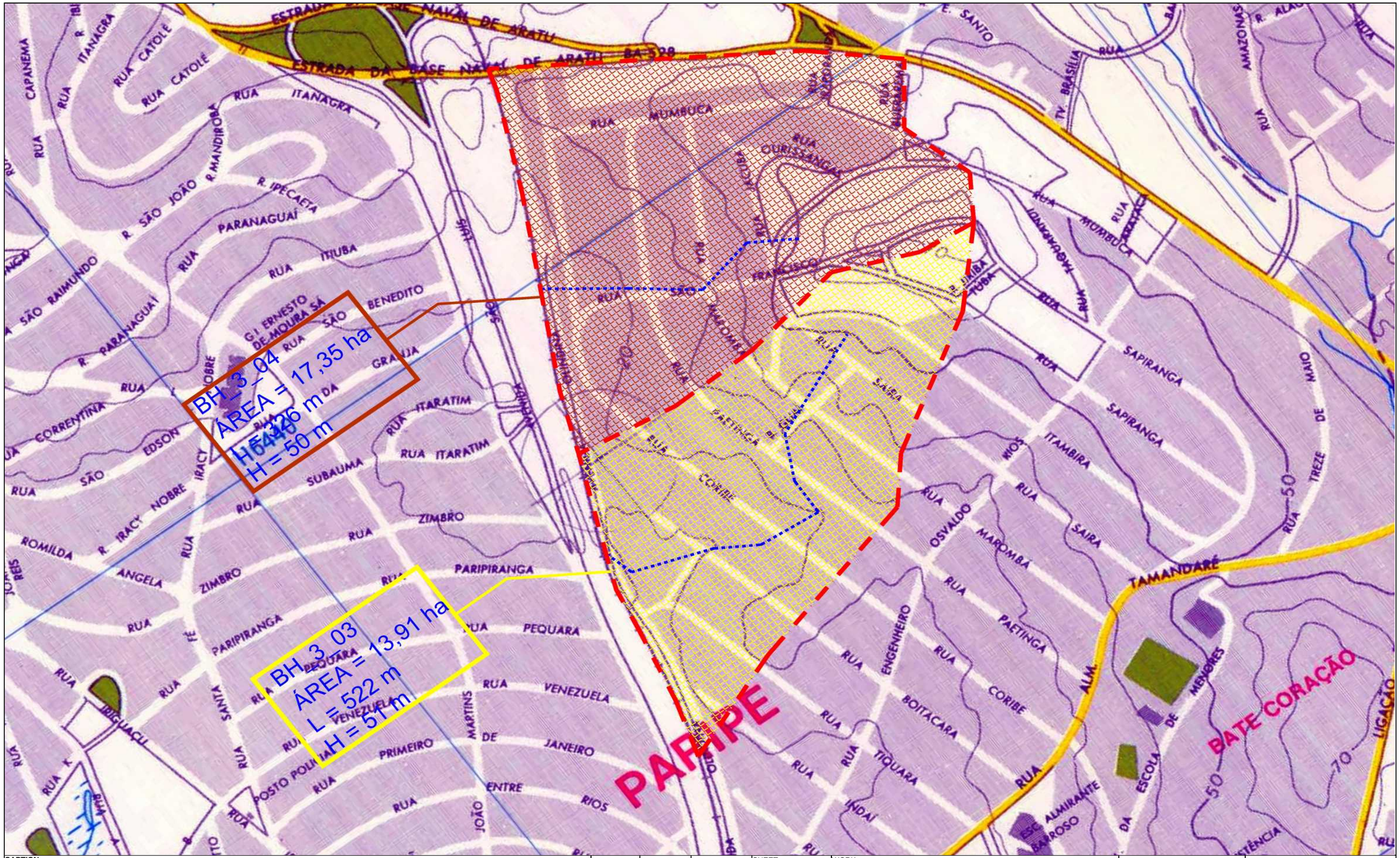




This crossing TV_3_02 is medium-size crossing and have different hydraulic behavior due to local morphological conditions. This is a lowered basin and with low concentration time. It is located in a deployment height with no influence of variations of tidal height differences.

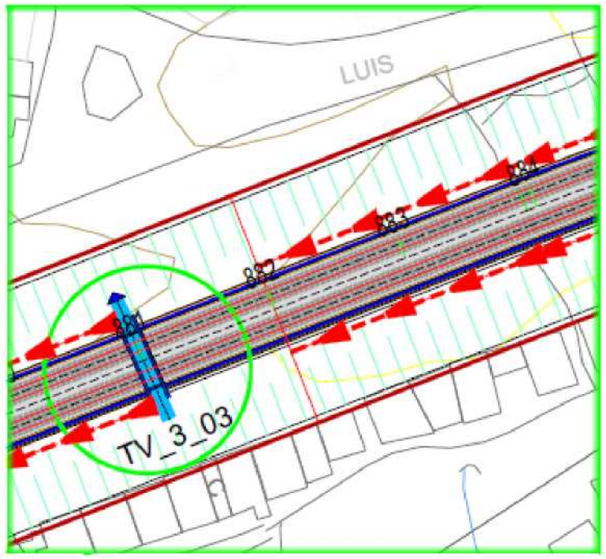
On the occasion of preparation of the Basic Design, an assessment of their functional and structural conditions should be made, in order to check their ability and decide either for structural and functional recovery or expansion, in order to meet the flow rate sections. Their load and unload ditches should be geometrized to meet the required flow rate section.

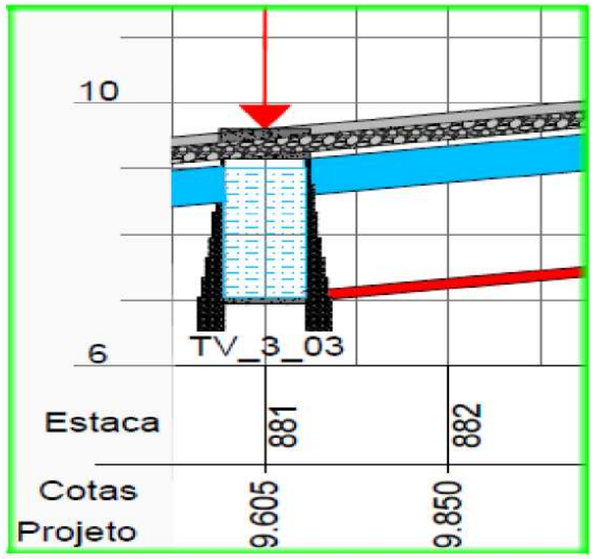
It will be deployed two rows of deep drains on either side to release in this crossing.


BH_3_04
AREA = 17,35 ha
L = 326 m
H = 50 m
BH_3_03
ÁREA = 13,91 ha
L = 522 m
H = 51 m
PARIPE
BATE CORAÇÃO
ESTRADA DA BASE NAVAL DE ARATU
RUA MUMBUCA
RUA OURISSANGA
RUA SÃO FRANCISCO
RUA MAROMBÁ
RUA PALESTINA
RUA SAIRA
RUA SAPIRANGA
RUA ITAMBIRA
RUA OSVALDO
RUA PAETINGA
RUA CORIBE
RUA BOITACARA
RUA TIQUARA
RUA INDAI
RUA ENGENHEIRO
RUA TAMANDARÉ
RUA ITARATIM
RUA ZIMBRO
RUA PARIPIRANGA
RUA PEQUARA
RUA VENEZUELA
RUA PRIMEIRO DE JANEIRO
RUA ENTRE RIOS
RUA SUBAUMA
RUA ITANAGRA
RUA CATOLÉ
RUA ITUBA
RUA PARANAGUÁ
RUA CORRENTINA
RUA ROMILDA
RUA ANGELA
RUA SÃO RAIMUNDO
RUA SÃO BENEDITO
RUA GRAÚNA
RUA EDSON
RUA IRACY NOBRE
RUA CAPANEMA
RUA IRIQUAÇU
RUA SANTA FÉ
RUA SÃO JOÃO
RUA MARTINS
RUA JOÃO REIS
RUA MAYO
RUA TREZE DE MAYO
RUA AMAZONAS
RUA TV. BRASÍLIA
RUA ALM. BARROSO
RUA ESCOLA DE MENORES
RUA ESC. ALMIRANTE BARROSO
RUA GEN. ERNESTO DE MOURA SÁ
RUA R. IPECAETA
RUA R. MANDIROBA
RUA R. PARANAGUÁ
RUA R. SÃO JOÃO
RUA R. IRACY NOBRE
RUA R. TIBIRIÇÁ
RUA R. ALAG
RUA R. E. SANTO
RUA R. ARAPORANGA
RUA R. ARAGUAÍNA
RUA R. JACIARA
RUA R. TORRE
RUA R. SÃO RAIMUNDO
RUA R. PARANAGUÁ
RUA R. CORRENTINA
RUA R. ROMILDA
RUA R. ANGELA
RUA R. IRACY NOBRE
RUA R. SÃO JOÃO
RUA R. MARTINS
RUA R. JOÃO REIS
RUA R. MAYO
RUA R. TREZE DE MAYO
RUA R. AMAZONAS

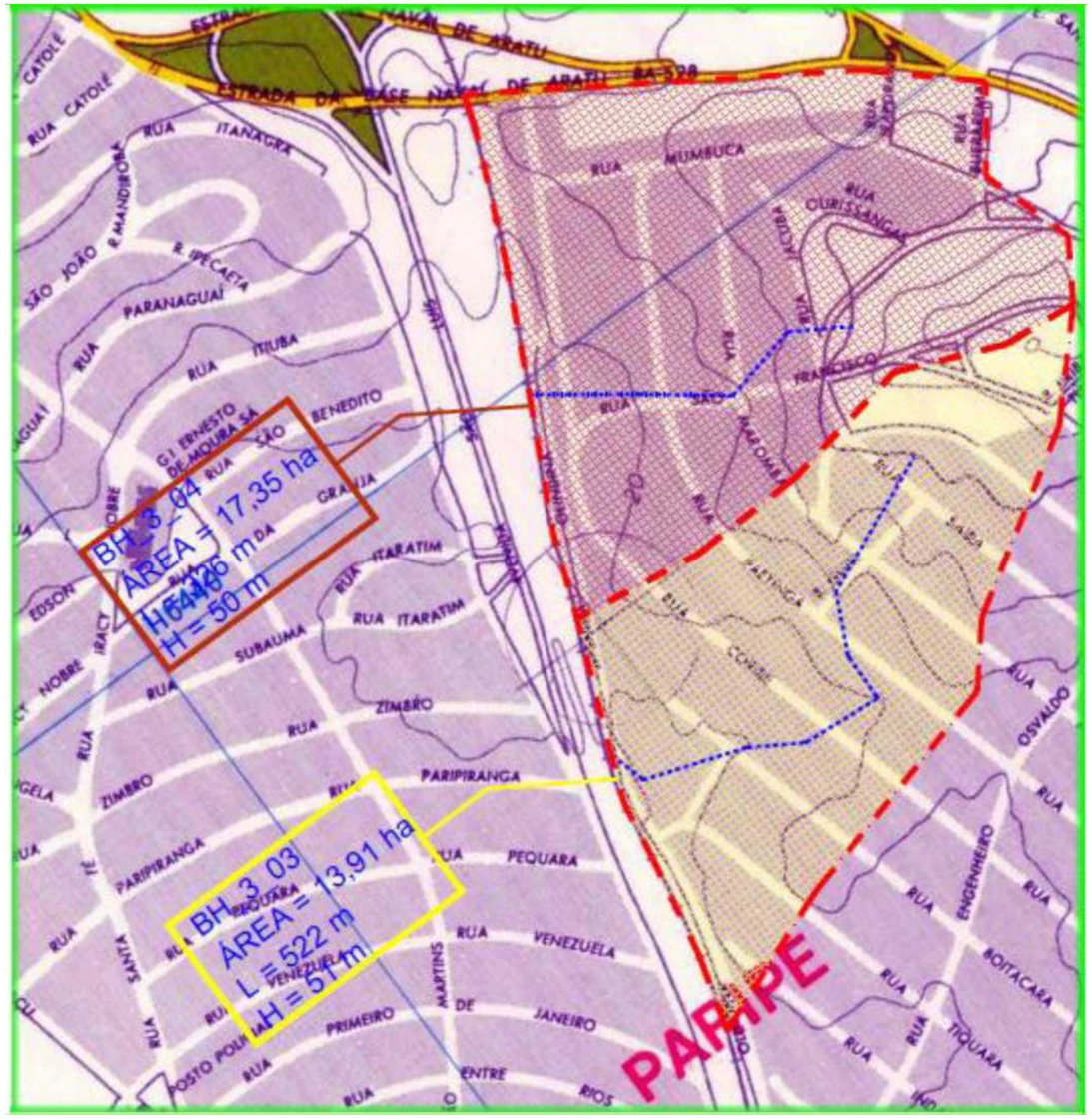
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0,8		n =	0.016	
code	declivity	tc	int	Area	Q=C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_3_03	0.20%	5.00	409.84	13.91	4,560.72	1.84	3.00	1.00	0.83
TV_3_04	0.20%	5.00	409.84	17.35	5,688.60	1.92	3.50	1.00	0.85

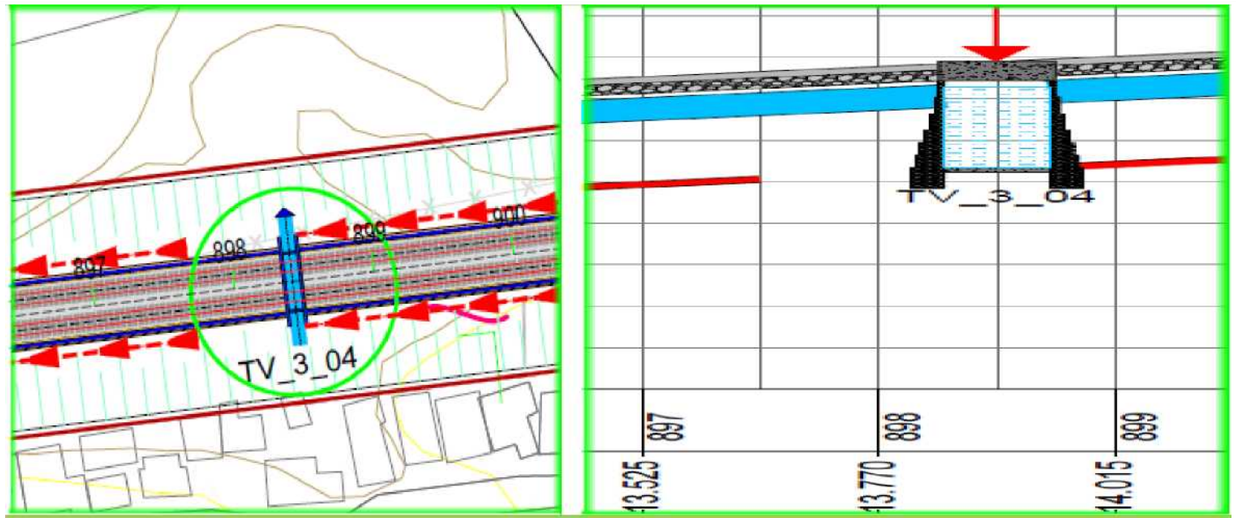




Block 3_02 - Naval Base Viaduct Basins



Crossing TV_3_03



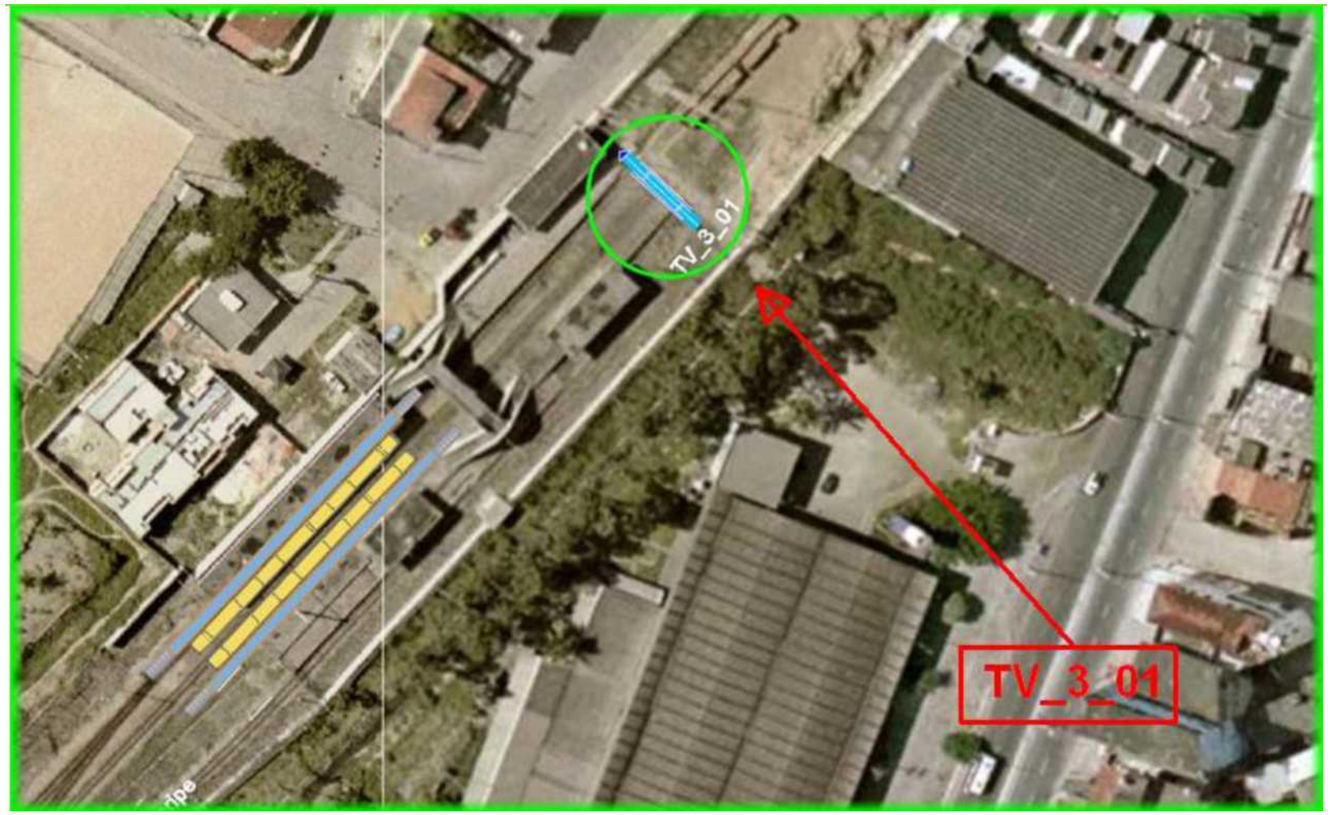
Crossing TV_3_04

These crossings TV_3_03 and TV_3_04 are medium-size crossing and have different hydraulic behavior due to local morphological conditions. These are lowered basins and with low concentration time. They are located in a deployment height with no influence of variations of tidal height differences.

On the occasion of preparation of the Basic Design, an assessment of their functional and structural conditions should be made, in order to check their ability and decide either for structural and functional recovery or expansion, in order to meet the flow rate sections. Their load and unload ditches should be geometrized to meet the required flow rate section.

It will be deployed two rows of deep drains on either side to release in this crossing.

Capped Gully Holes - Cartogram



Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0,8		n =	0.016	
code	declivity	tc	int	Area	Q=C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_3_01	0.20%	5.00	409.84	24.23	7,944.37	2.04	4.50	1.00	0.86

It is a large-size basin with release near the sea, and requires cleaning services.

It has small concentration time, the thalweg line has low slope and the combination of these factors do not provide the occurrence of accentuated flood peaks.

Capped Gully Holes – Cartogram

Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		N =	0.016	
code	declivity	tc	int	Area	Q=C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_3_02	0.20%	5.99	399.76	36.13	11,554.53	2.17	6.00	1.00	0.89

It is a large-size basin with release near the sea, and requires cleaning services.

It has small concentration time, the thalweg line has low slope and the combination of these factors do not provide the occurrence of accentuated flood peaks.

Capped Gully Holes – Cartogram

Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	declivity	tc	int	Area	Q=C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_3_03	0.20%	5.00	409.84	13.91	4,560.72	1.84	3.00	1.00	0.83

It is a large-size basin with release near the sea, and requires cleaning services.

It has small concentration time, the thalweg line has low slope and the combination of these factors do not provide the occurrence of accentuated flood peaks.

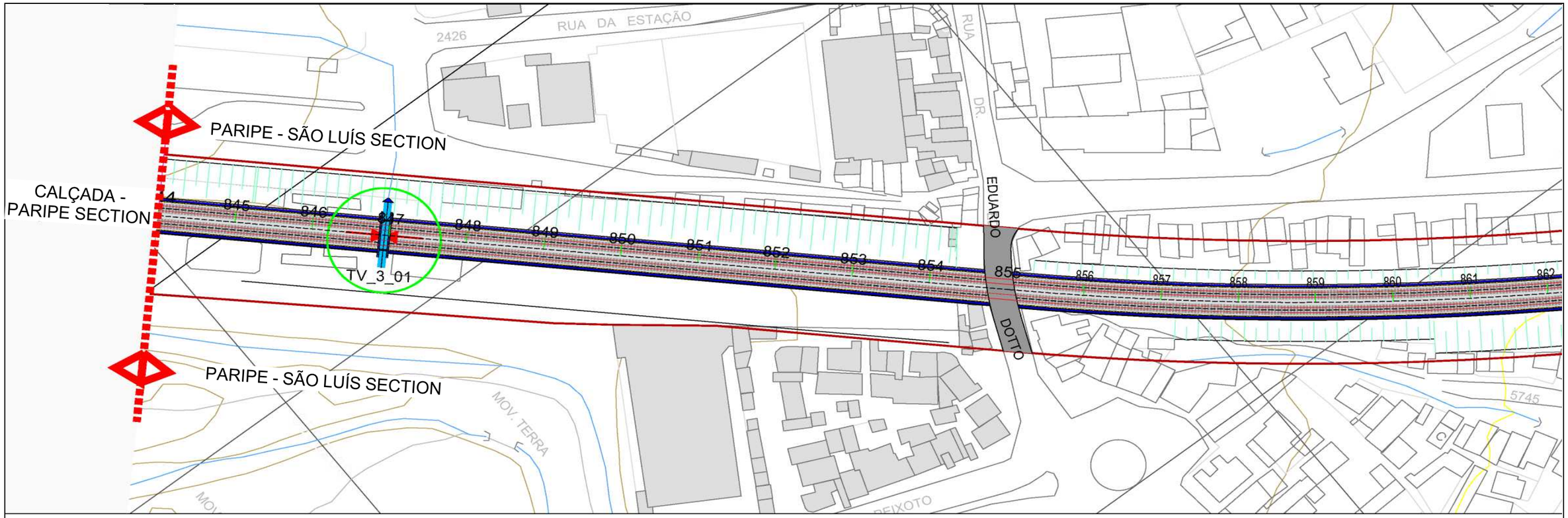
Capped Gully Holes – Cartogram

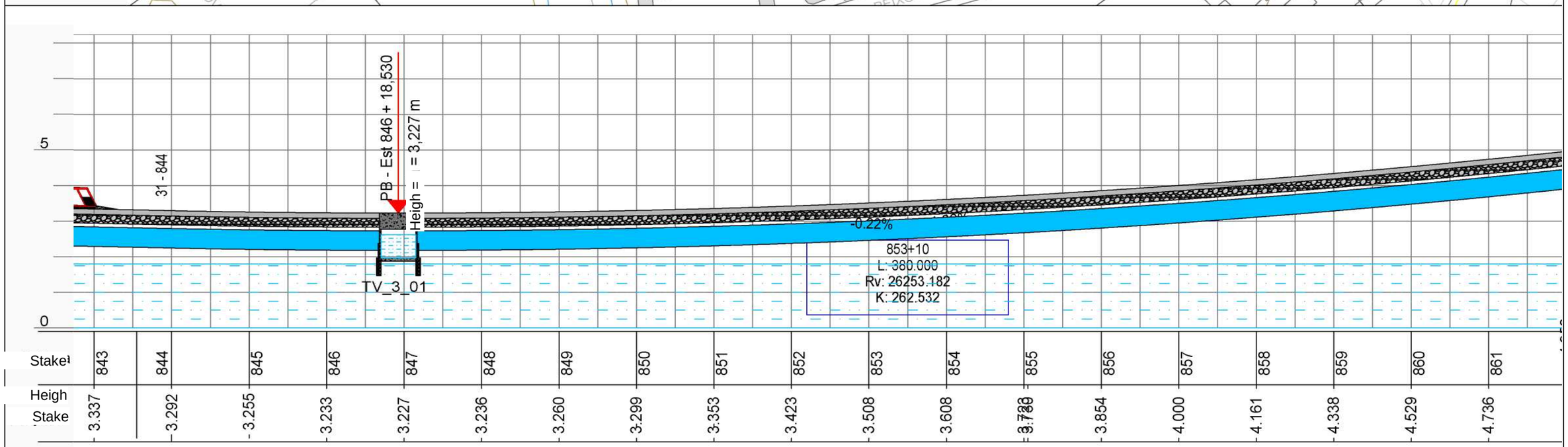
Capped Gully Holes – Sizing

Crossing	01	Tr =	25	C =	0.8		n =	0.016	
code	declivity	tc	int	Area	Q=C.i.A	Speed	Base	Height	Y
(m)	(%)	(min)	(l/s.ha)	(ha)	(l/s)	V - m/s	m	m	m
TV_3_04	0.20%	5.00	409.84	17.35	5,688.60	1.92	3.50	1.00	0.85

It is a large-size basin with release near the sea, and requires cleaning services.

It has small concentration time, the thalweg line has low slope and the combination of these factors do not provide the occurrence of accentuated flood peaks.





CAPTION:

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

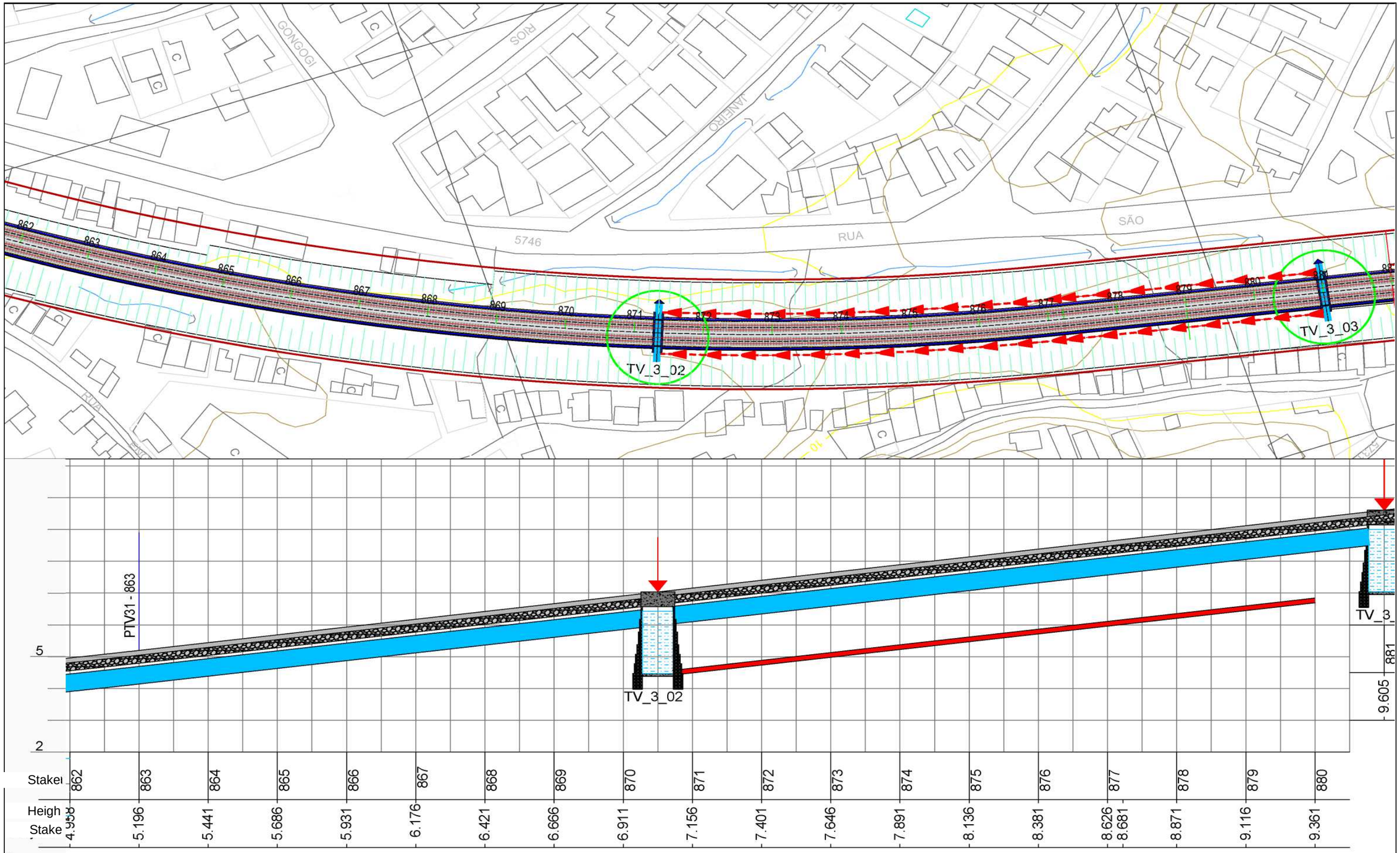
DRAWING		/ /	SHEET 01/05	WORK: SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION:

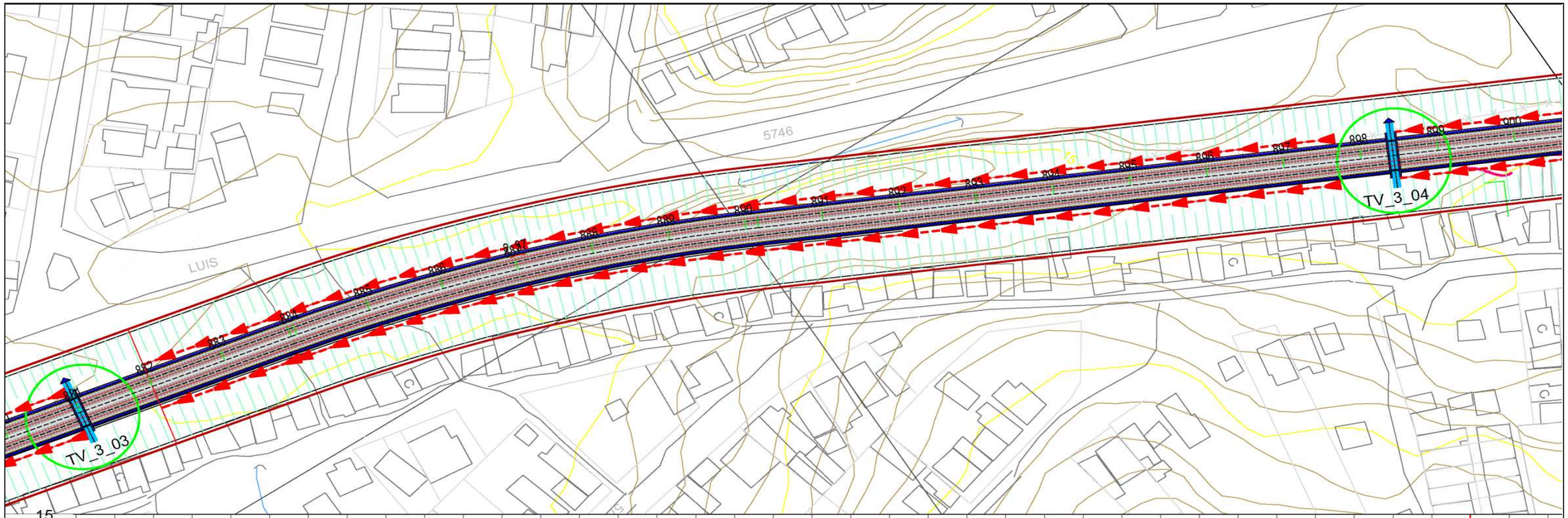
- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

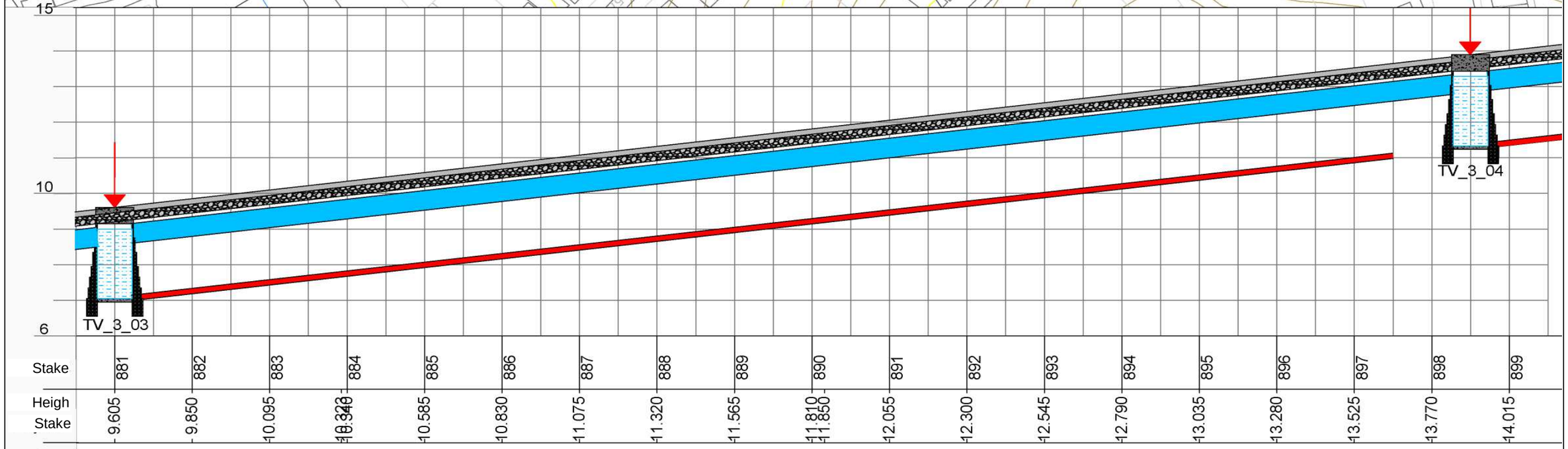
DRAWING		/ /	SHEET 02/05	WORK: SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV





CAPTION:

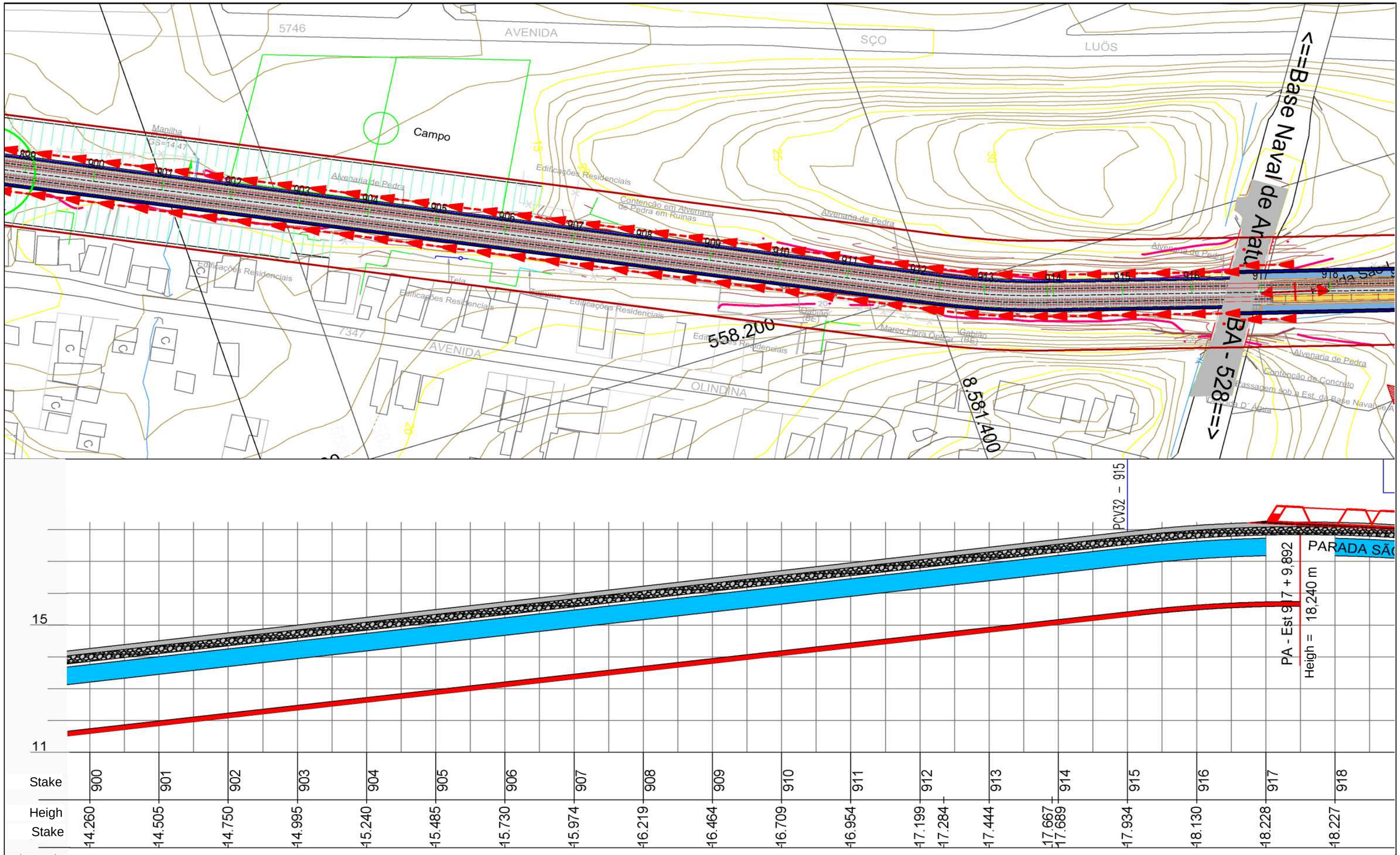
Axis | TR45 Rail | TR45 Rail | Permanent Track
Higher Point
Lower Point
Tubular gallery
Collecting or Passage Box
Deep Drain (Plant)
Deep Drain (Profile)
Right of way
Rectangular channel (Plant)
Regularization of the land
Rectangular channel (Profile)
Crossing - Capped gully hole (Profile)
Crossing - Capped gully hole (Plant)
Potential Crossing
Maximum tide = 1.80 m

DRAWING		/ /	SHEET 03/05	WORK: SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

LIGHT-RAIL VEHICLE
LRV



CAPTION:

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

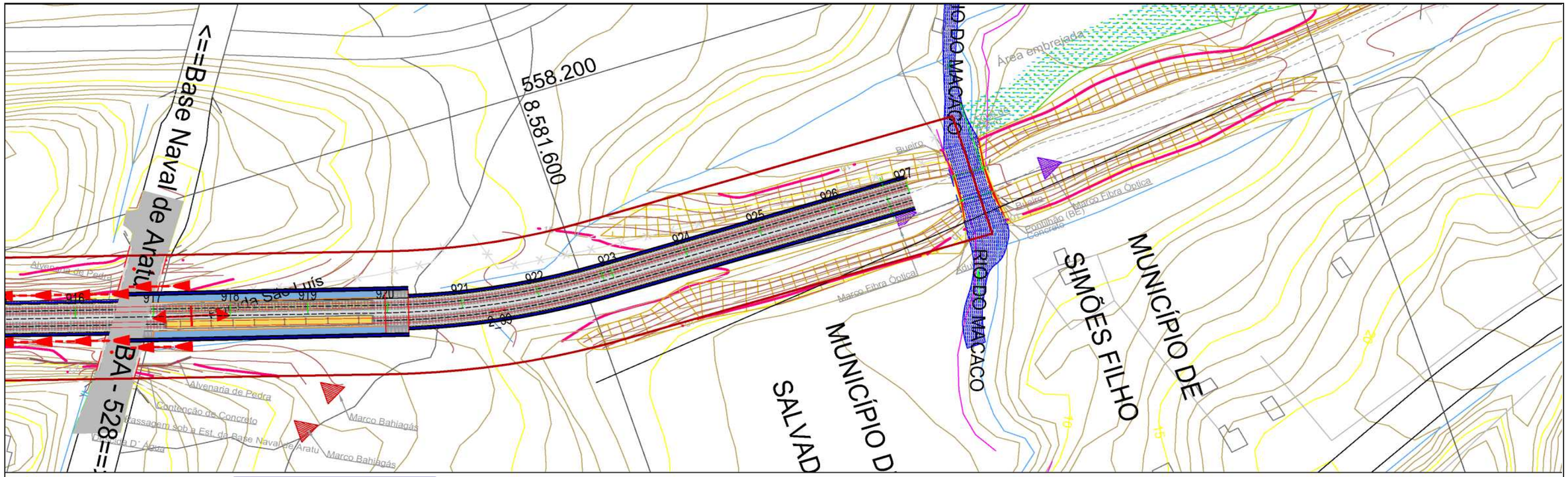
DRAWING		/ /	SHEET 04/05	WORK: SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE V-1:1,00 H-1:1,000	MUNICIPALITY SALVADOR
APPROVAL		/ /		
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

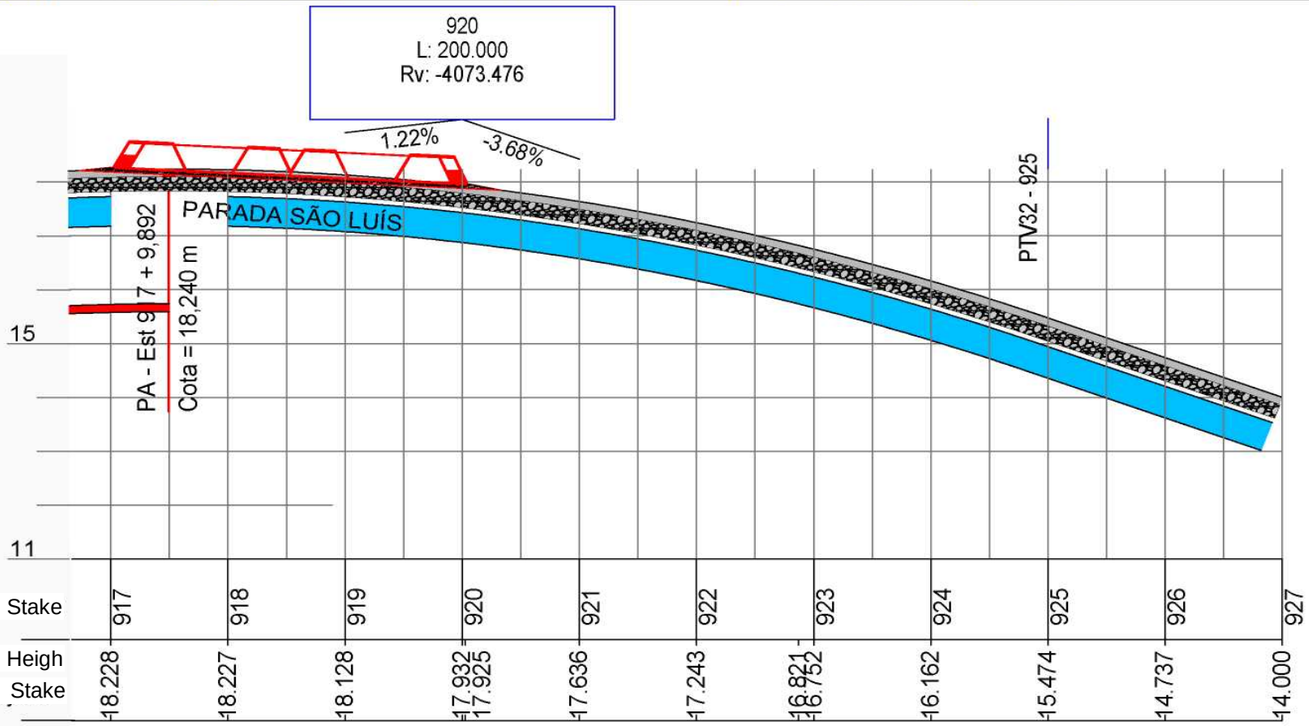
DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV





CAPTION:

- Axis
- TR45 Rail
- TR45 Rail
- Permanent Track
- Higher Point
- Lower Point
- Tubular gallery
- Collecting or Passage Box
- Deep Drain (Plant)
- Deep Drain (Profile)
- Right of way
- Rectangular channel (Plant)
- Regularization of the land
- Rectangular channel (Profile)
- Crossing - Capped gully hole (Profile)
- Crossing - Capped gully hole (Plant)
- Potential Crossing
- Maximum tide = 1.80 m

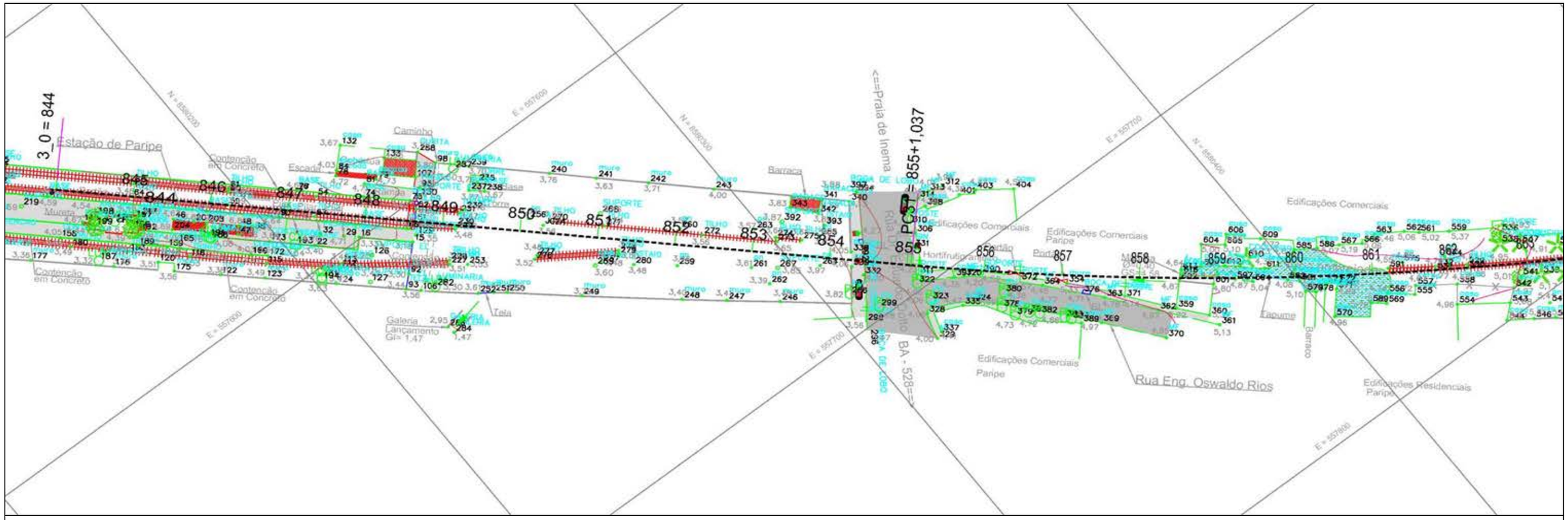
DRAWING		/ /	SHEET 05/05	WORK: SECTION - PARIPE - SÃO LUÍS
CHECKING		/ /	SCALE	MUNICIPALITY SALVADOR
APPROVAL		/ /	V-1:1,00 H-1:1,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			SUBJECT DRAINAGE - FLOOR PLAN AND PROFILE
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



EXISTING MILESTONE(S)

* PLANIMETRIC REFERENCE:
STATION: SSAI - RBMC - IBGE
UTM COORDINATES: N 8,565,561.750
E 552,438.838
CENTRAL MERIDIAN (MC): 39° WGR.
HORIZONTAL DATUM: SIRGAS 2000
LOCATION: DEPLOYED AT AVENIDA DAS NAUS, S/N - COMÉRCIO NEIGHBORHOOD, IN THE PREMISES OF THE PORT AUTHORITY OF SALVADOR/BA.

* ALTIMETRIC REFERENCE:
STATION: RN 00164
HEIGHT: 4.3467
LOCATION: LOCATED AT THE END OF AV. AFRÂNIO PEIXOTO (SUBURBANA), IN THE JUNCTION WITH RUA ALMIRANTE TAMANDARÉ, IN THE PLACE WITH THE SAME NAME.
STATION: RN 2566P
HEIGHT: 31.1046
LOCATION: 9 M AT THE RIGHT OF THE MAIN DOOR, 1 M FROM THE RAILROAD, IN THE BEGINNING OF THE PLATFORM FLOOR, 1 M AT THE RIGHT OF THE LAST COLUMN OF THE RAILWAY STATION BUILDING, IN THE CITY CENTER
VERTICAL DATUM: IMBITUBA

CAPTION

- TRAFFIC LIGHT
- PEDESTRIAN TRAFFIC LIGHT
- PLATE
- UTILITY POLE WITH OVERHEAD WIRING
- LUM STREET LAMP
- TP PUBLIC PHONE
- BL STORMWATER DRAIN
- WATER DROP
- PV MANHOLE
- PVEsg SEWAGE PIT
- PVDren DRAINAGE PIT
- PVElet ELECTRICITY PIT
- PVTel TELEPHONY PIT
- CX BOX
- EDIFICATION
- WALL
- CHANNEL
- CURB
- FENCE
- RUNWAY EDGE
- ROAD
- STONEWORK
- CONTAINMENT
- RAILROAD
- TRANSMISSION LINE
- SLOPE
- INTERMEDIATE CURVE
- 30 MASTER CURVE
- CXEsg SEWAGE BOX
- CXD DRAINAGE BOX
- TREE
- COCONUT TREE
- LARGE-SIZE TREE
- TOPOGRAPHIC STATION
- TUBING MILESTONE
- CONCRETE BASE 50 X 40
- SIGNPOST FOR ROAD AND RAIL TRANSPORT SERVICES
- BE GOOD CONDITION
- MARSH / MANGROVE AREA
- STONE FLOORING
- ASPHALT FLOORING
- CEMENTED FLOORING
- PIPELINE MILESTONES
- FIBER OPTIC MILESTONES
- KILOMETRIC MILESTONES
- BAHIAGÁS MILESTONE
- M MEDIUM CONDITION
- P POOR CONDITION

CAPTION
1
Axis

DRAWING		/ /	SHEET 01/05
CHECKING		/ /	SCALE
APPROVAL		/ /	1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

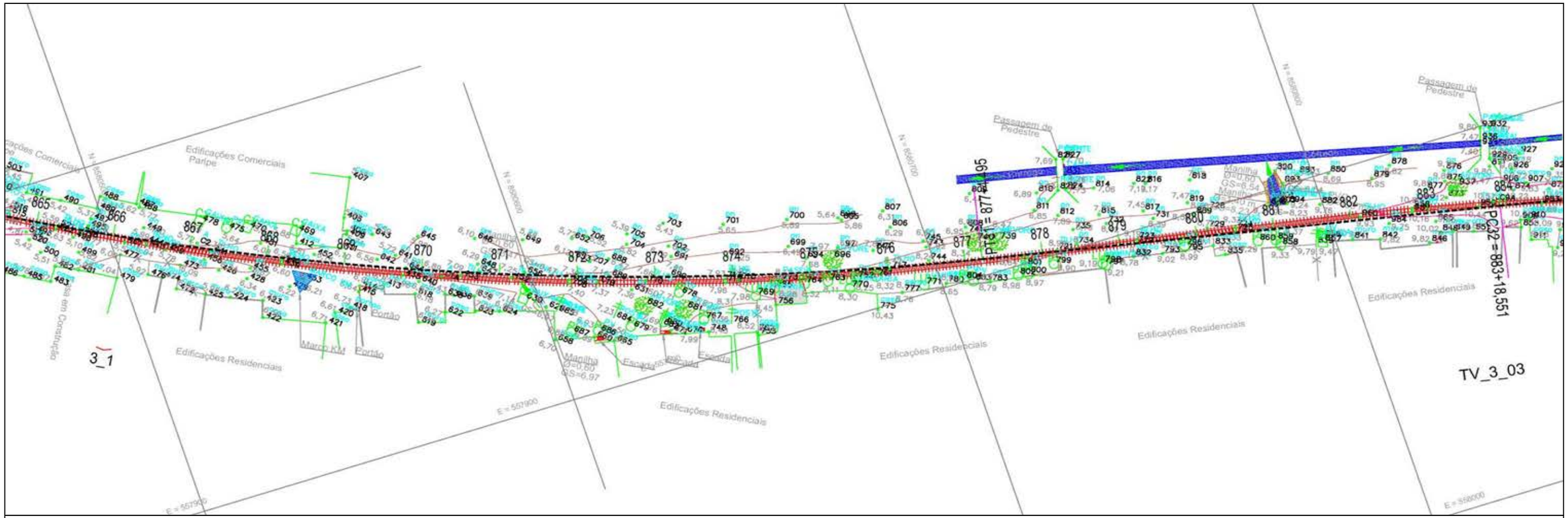
WORK: SECTION - PARIPE - SÃO LUÍS
MUNICIPALITY: SALVADOR
SUBJECT: TOPOGRAPHIC BASE CONVENTIONAL TOPOGRAPHY

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



EXISTING MILESTONE(S)

* PLANIMETRIC REFERENCE:
STATION: SSAI - RBMC - IBGE
UTM COORDINATES: N 8,565,561.750
E 552,438.838
CENTRAL MERIDIAN (MC): 39° WGR.
HORIZONTAL DATUM: SIRGAS 2000
LOCATION: DEPLOYED AT AVENIDA DAS NAUS, S/N - COMÉRCIO NEIGHBORHOOD, IN THE PREMISES OF THE PORT AUTHORITY OF SALVADOR/BA.

* ALTIMETRIC REFERENCE:
STATION: RN 00164
HEIGHT: 4.3467
LOCATION: LOCATED AT THE END OF AV. AFRÂNIO PEIXOTO (SUBURBANA), IN THE JUNCTION WITH RUA ALMIRANTE TAMANDARÉ, IN THE PLACE WITH THE SAME NAME.

STATION: RN 2566P
HEIGHT: 31.1046
LOCATION: 9 M AT THE RIGHT OF THE MAIN DOOR, 1 M FROM THE RAILROAD, IN THE BEGINNING OF THE PLATFORM FLOOR, 1 M AT THE RIGHT OF THE LAST COLUMN OF THE RAILWAY STATION BUILDING, IN THE CITY CENTER

VERTICAL DATUM: IMBITUBA

CAPTION

- TRAFFIC LIGHT
- PEDESTRIAN TRAFFIC LIGHT
- PLATE
- UTILITY POLE WITH OVERHEAD WIRING
- LUM STREET LAMP
- TP PUBLIC PHONE
- BL STORMWATER DRAIN
- WATER DROP
- PV MANHOLE
- PVEsg SEWAGE PIT
- PVDren DRAINAGE PIT
- PVElet ELECTRICITY PIT
- PVTel TELEPHONY PIT
- CX BOX
- EDIFICATION
- WALL
- CHANNEL
- CURB
- FENCE
- RUNWAY EDGE
- ROAD
- STONEWORK
- CONTAINMENT
- RAILROAD
- TRANSMISSION LINE
- SLOPE
- INTERMEDIATE CURVE
- 30 MASTER CURVE
- CXEsg SEWAGE BOX
- CXD DRAINAGE BOX
- TREE
- COCONUT TREE
- LARGE-SIZE TREE
- TOPOGRAPHIC STATION
- TUBING MILESTONE
- CONCRETE BASE 50 X 40
- SIGNPOST FOR ROAD AND RAIL TRANSPORT SERVICES
- BE GOOD CONDITION
- MARSH / MANGROVE AREA
- STONE FLOORING
- ASPHALT FLOORING
- CEMENTED FLOORING
- PIPELINE MILESTONES
- FIBER OPTIC MILESTONES
- KILOMETRIC MILESTONES
- BAHIAGÁS MILESTONE
- M MEDIUM CONDITION
- P POOR CONDITION

CAPTION
1
Axis

DRAWING		/ /	SHEET 02/05
CHECKING		/ /	SCALE
APPROVAL		/ /	1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

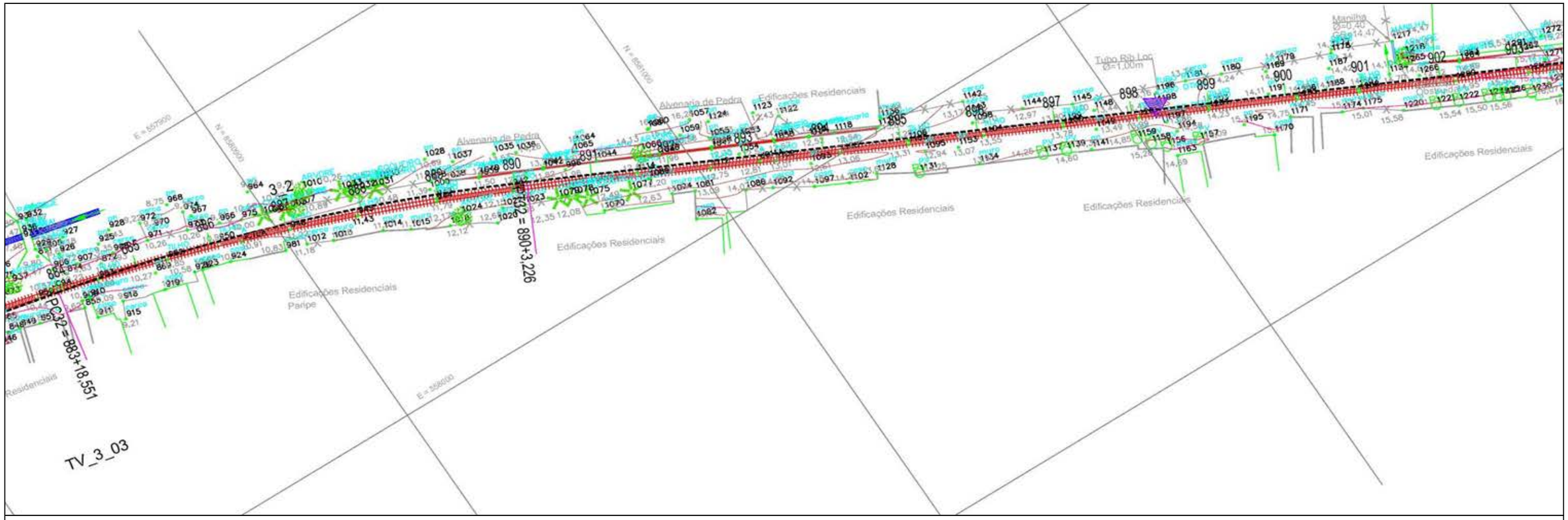
WORK: SECTION - PARIPE - SÃO LUÍS
MUNICIPALITY: SALVADOR
SUBJECT: TOPOGRAPHIC BASE CONVENTIONAL TOPOGRAPHY

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



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VERTICAL DATUM: IMBITUBA

CAPTION

TRAFFIC LIGHT
PEDESTRIAN TRAFFIC LIGHT
PLATE
UTILITY POLE WITH OVERHEAD WIRING
STREET LAMP
PUBLIC PHONE
STORMWATER DRAIN
WATER DROP
MANHOLE
SEWAGE PIT
DRAINAGE PIT
ELECTRICITY PIT
TELEPHONY PIT
BOX

EDIFICATION
WALL
CHANNEL
CURB
FENCE
RUNWAY EDGE
ROAD
STONEWORK
CONTAINMENT
RAILROAD
TRANSMISSION LINE
SLOPE
INTERMEDIATE CURVE
MASTER CURVE

SEWAGE BOX
DRAINAGE BOX
TREE
COCONUT TREE
LARGE-SIZE TREE
TOPOGRAPHIC STATION
TUBING MILESTONE
CONCRETE BASE 50 X 40
SIGNPOST FOR ROAD AND RAIL TRANSPORT SERVICES
GOOD CONDITION

MARSH / MANGROVE AREA
STONE FLOORING
ASPHALT FLOORING
CEMENTED FLOORING
PIPELINE MILESTONES
FIBER OPTIC MILESTONES
KILOMETRIC MILESTONES
BAHIAGÁS MILESTONE
MEDIUM CONDITION
POOR CONDITION

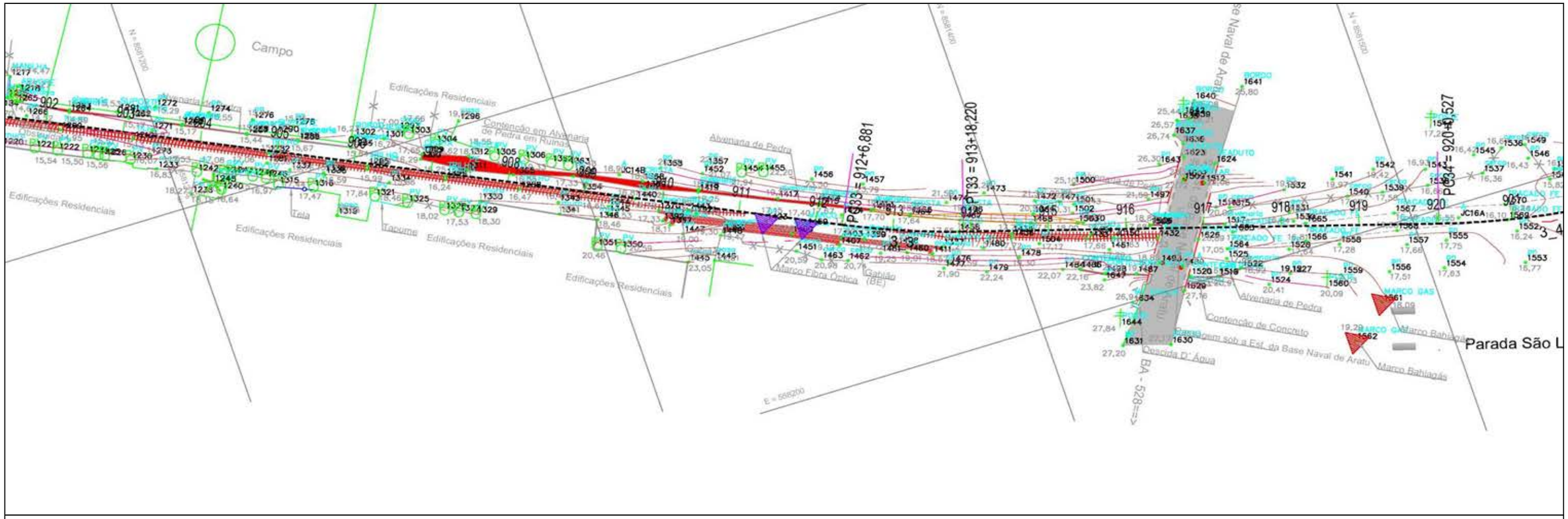
CAPTION
Axis

DRAWING		/ /	SHEET 03/05
CHECKING		/ /	SCALE
APPROVAL		/ /	1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION - PARIPE - SÃO LUÍS
MUNICIPALITY: SALVADOR
SUBJECT: TOPOGRAPHIC BASE CONVENTIONAL TOPOGRAPHY

DEPARTMENT OF URBAN DEVELOPMENT
BAHIA GOVERNO DO ESTADO
CJB

LIGHT-RAIL VEHICLE
LRV



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VERTICAL DATUM: IMBITUBA

CAPTION

- TRAFFIC LIGHT
- PEDESTRIAN TRAFFIC LIGHT
- PLATE
- UTILITY POLE WITH OVERHEAD WIRING
- LUM STREET LAMP
- TP PUBLIC PHONE
- BL STORMWATER DRAIN
- WATER DROP
- PV MANHOLE
- PVEsg SEWAGE PIT
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- PVElet ELECTRICITY PIT
- PVTel TELEPHONY PIT
- CX BOX
- EDIFICATION
- WALL
- CHANNEL
- CURB
- FENCE
- RUNWAY EDGE
- ROAD
- STONEWORK
- CONTAINMENT
- RAILROAD
- TRANSMISSION LINE
- SLOPE
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- CXEsg SEWAGE BOX
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- FIBER OPTIC MILESTONES
- KILOMETRIC MILESTONES
- BAHIAGÁS MILESTONE
- M MEDIUM CONDITION
- P POOR CONDITION

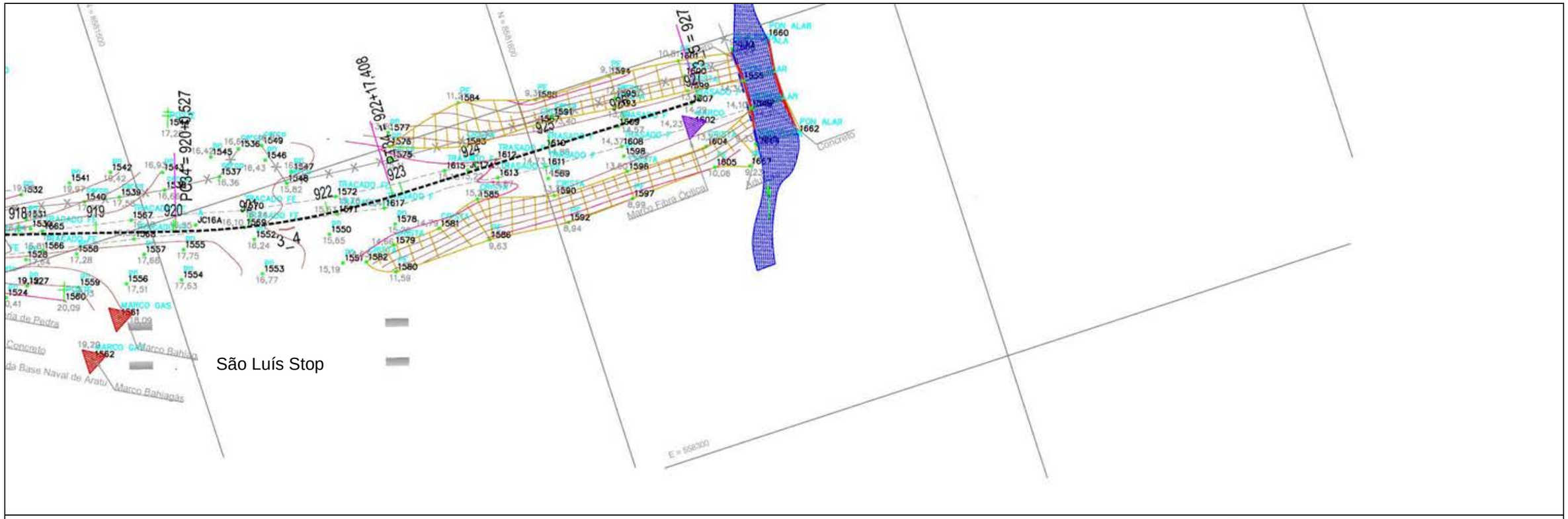
CAPTION
1
Axis

DRAWING		/ /	SHEET 04/05
CHECKING		/ /	SCALE
APPROVAL		/ /	1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

WORK: SECTION - PARIPE - SÃO LUÍS
MUNICIPALITY: SALVADOR
SUBJECT: TOPOGRAPHIC BASE
CONVENTIONAL TOPOGRAPHY

DEPARTMENT OF URBAN DEVELOPMENT
BAHIA GOVERNO DO ESTADO
CJB

LIGHT-RAIL VEHICLE
LRV



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VERTICAL DATUM: IMBITUBA

CAPTION

- TRAFFIC LIGHT
- PEDESTRIAN TRAFFIC LIGHT
- PLATE
- UTILITY POLE WITH OVERHEAD WIRING
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- PUBLIC PHONE
- STORMWATER DRAIN
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- MANHOLE
- SEWAGE PIT
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- CEMENTED FLOORING
- PIPELINE MILESTONES
- FIBER OPTIC MILESTONES
- KILOMETRIC MILESTONES
- BAHIAGÁS MILESTONE
- MEDIUM CONDITION
- POOR CONDITION

CAPTION
1
Axis

DRAWING		/ /	SHEET 05/05
CHECKING		/ /	SCALE
APPROVAL		/ /	1:1,000
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA		
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA		
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA		

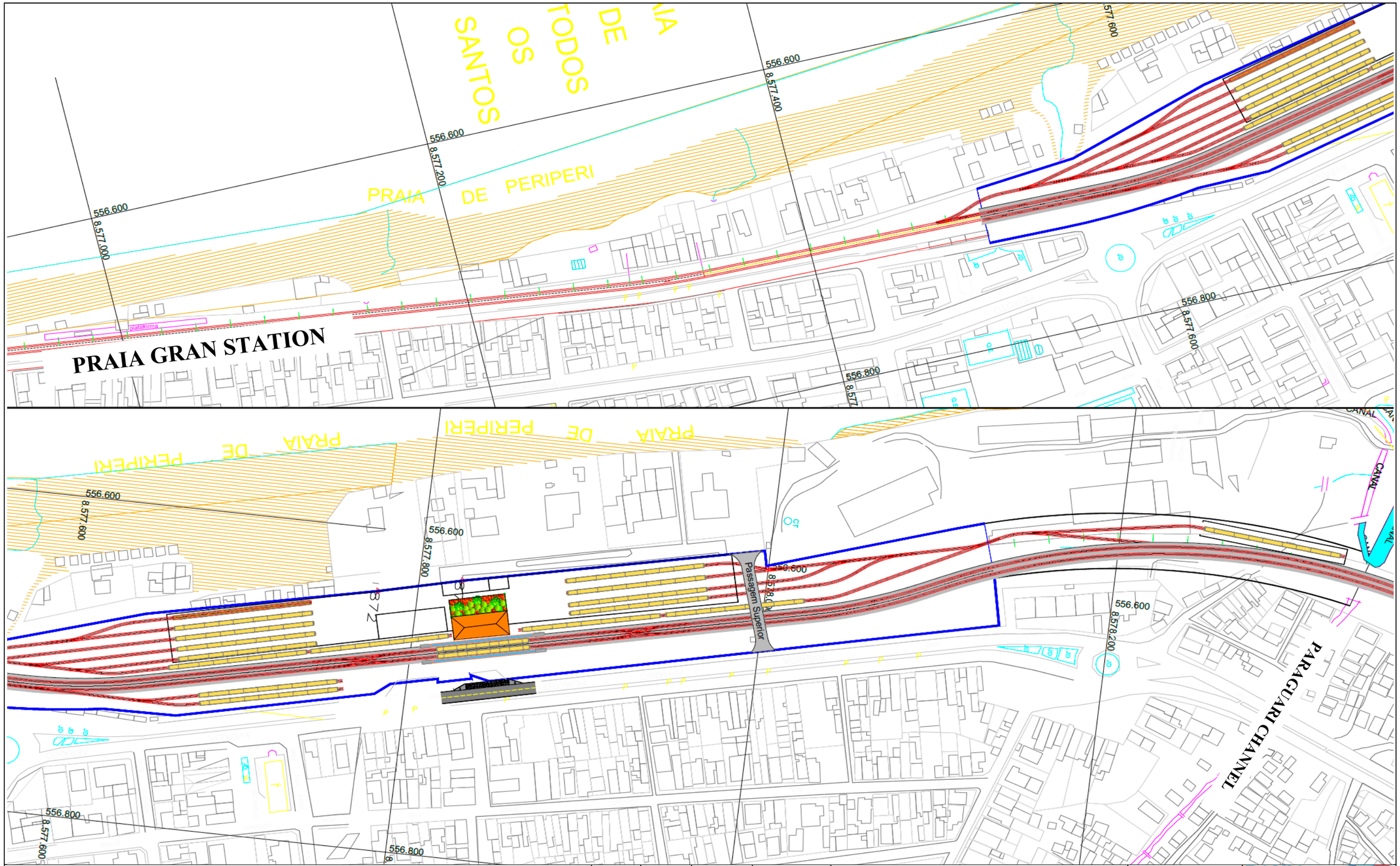
WORK: SECTION - PARIPE - SÃO LUÍS
MUNICIPALITY: SALVADOR
SUBJECT: TOPOGRAPHIC BASE
CONVENTIONAL TOPOGRAPHY

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CJB

LIGHT-RAIL VEHICLE
LRV



CAPTION

			SHEET	
DRAWING		/ /		
CHECKING		/ /	SCALE	
APPROVAL		/ /	H - 1:2,000	
DESIGN	Civil Engineer Robério Ribeiro Bezerra - 3240-D/BA			
DESIGN	Civil Engineer Cynthia Azevedo de Brito -14657-D/BA			
DESIGN	Civil Engineer André Cury Lima - 83992-D/BA			

SECTION – CALÇADA - PARIPE

MUNICIPALITY
SALVADOR

SUBJECT
MAINTENANCE YARD

DEPARTMENT OF URBAN DEVELOPMENT

BAHIA GOVERNO DO ESTADO

CDB

LIGHT-RAIL VEHICLE
LRV