ANNEXES
ANNEX Nº5. MOBILITY AND TRAFFIC STUDY
Annex nº5. Mobility and traffic study

Contents

1. Introduction and background.................................................................4
2. Field data collection.................................................................................4
   2.1. Manual gauging..................................................................................5
   2.2. Automatic gauging............................................................................6
   2.3. Composition gauging........................................................................9
3. Description of the projected solution..................................................9
4. Offer / demand parameters and traffic simulation parameters.............10
   4.1. Expected road offer.........................................................................10
   4.2. Calculation of the maximum demand...............................................11
      4.2.1. Container terminals..............................................................11
      4.2.2. Prat ZAL.............................................................................13
   4.3. The Barcelona TRANSCAD simulation method..............................14
      4.3.1. Composition and calibration of the model..............................14
5. Results of the load allocation process................................................14
   5.1. Scenario taking into account the connection between Street A and Street 114..................................................15
   5.2. Scenario without taking into account the connection between Street A and Street 114.................................17
6. Calculation of the traffic roundabout functionality.............................19
   6.1. Taking into account the connection between Street A and Street 114.................................................20
   6.2. Without taking into account the connection between Street A and Street 114.................................22
7. Conclusions............................................................................................24
Annex nº5. Mobility and traffic study

1. Introduction and background

Studies that are made for the new road infrastructure enlargement at Port of Barcelona must take into account the repercussions of the traffic generated not only in these infrastructures but also in those that are within the scope of the Port and that their service levels are affected or it is convenient to perform some actions to improve them (fittings, extensions, paving, etc.).

One of these actions is specified in the “Urbanization project of Street 114. Connection between L’Estany del Port Avenue and Street 114 (Port of Barcelona)”, the natural route of arrival to the new Port terminals from the high capacity roads.

Figure 1. Picture of the current temporary traffic roundabout between Street 100 and 114 (source: Esteyco)

2. Field data collection

To characterize the current traffic, a manual gauging of 8 hours in the intersection was done and also some existing information of an automatic gauging of week duration at Street 114 was used.

The manual gauging was held on September 16, 2011 and the automatic one from April 12 to April 18.

The results of the traffic counts were as follows:
2.1. Manual gauging

Figure 2. Movements detected at the intersection of Street 114 and the Mediterranean Sea (source: Esteyco)
Table 1. Results of the manual gauging carried out at the intersection of Street 114 and Street 100 (source: Esteyco)

<table>
<thead>
<tr>
<th>Data:</th>
<th>16 de Setembre</th>
<th>2011</th>
<th>Divendres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punt 5. Carrer 114 - Carrer de l'Estany de Port</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municip:</td>
<td>El Prat de Llobregat (ZAL)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**VOLUM DE TRÀNSIT DE CADA MOVIMENT**

<table>
<thead>
<tr>
<th>Moviment</th>
<th>Coef. M</th>
<th>9 a 14 h.</th>
<th>Coef. T</th>
<th>16 a 19 h.</th>
<th>24 Hores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0,316</td>
<td>419</td>
<td>0,210</td>
<td>305</td>
<td>1,376</td>
</tr>
<tr>
<td>2</td>
<td>0,316</td>
<td>260</td>
<td>0,210</td>
<td>209</td>
<td>0,992</td>
</tr>
<tr>
<td>3</td>
<td>0,316</td>
<td>39</td>
<td>0,210</td>
<td>211</td>
<td>1,141</td>
</tr>
<tr>
<td>4</td>
<td>0,316</td>
<td>370</td>
<td>0,210</td>
<td>353</td>
<td>1,375</td>
</tr>
<tr>
<td>5</td>
<td>0,316</td>
<td>78</td>
<td>0,210</td>
<td>141</td>
<td>0,416</td>
</tr>
<tr>
<td>6</td>
<td>0,316</td>
<td>153</td>
<td>0,210</td>
<td>179</td>
<td>0,631</td>
</tr>
<tr>
<td>7</td>
<td>0,316</td>
<td>236</td>
<td>0,210</td>
<td>216</td>
<td>0,859</td>
</tr>
<tr>
<td>8</td>
<td>0,316</td>
<td>242</td>
<td>0,210</td>
<td>197</td>
<td>0,835</td>
</tr>
<tr>
<td>9</td>
<td>0,316</td>
<td>20</td>
<td>0,210</td>
<td>29</td>
<td>0,93</td>
</tr>
<tr>
<td>10</td>
<td>0,316</td>
<td>59</td>
<td>0,210</td>
<td>45</td>
<td>1,198</td>
</tr>
<tr>
<td>11</td>
<td>0,316</td>
<td>107</td>
<td>0,210</td>
<td>47</td>
<td>2,93</td>
</tr>
<tr>
<td>12</td>
<td>0,316</td>
<td>34</td>
<td>0,210</td>
<td>25</td>
<td>1,12</td>
</tr>
<tr>
<td>13</td>
<td>0,316</td>
<td>45</td>
<td>0,210</td>
<td>28</td>
<td>1,39</td>
</tr>
<tr>
<td>14</td>
<td>0,316</td>
<td>17</td>
<td>0,210</td>
<td>11</td>
<td>0,53</td>
</tr>
</tbody>
</table>

**VOLUM DE TRÀNSIT A CADA SECCIÓ**

<table>
<thead>
<tr>
<th>Secció</th>
<th>Coef. M</th>
<th>9 a 14 h.</th>
<th>Coef. T</th>
<th>16 a 19 h.</th>
<th>24 Hores</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0,316</td>
<td>763</td>
<td>0,210</td>
<td>563</td>
<td>2,521</td>
</tr>
<tr>
<td>B</td>
<td>0,316</td>
<td>137</td>
<td>0,210</td>
<td>191</td>
<td>0,624</td>
</tr>
<tr>
<td>C</td>
<td>0,316</td>
<td>200</td>
<td>0,210</td>
<td>117</td>
<td>0,603</td>
</tr>
<tr>
<td>D</td>
<td>0,316</td>
<td>489</td>
<td>0,210</td>
<td>444</td>
<td>1,774</td>
</tr>
<tr>
<td>E</td>
<td>0,316</td>
<td>515</td>
<td>0,210</td>
<td>453</td>
<td>1,840</td>
</tr>
<tr>
<td>F</td>
<td>0,316</td>
<td>762</td>
<td>0,210</td>
<td>568</td>
<td>2,529</td>
</tr>
<tr>
<td>G</td>
<td>0,316</td>
<td>601</td>
<td>0,210</td>
<td>673</td>
<td>2,422</td>
</tr>
<tr>
<td>H</td>
<td>0,316</td>
<td>691</td>
<td>0,210</td>
<td>603</td>
<td>2,460</td>
</tr>
</tbody>
</table>

From this source it can be seen that 7,400 vehicles drive into the traffic roundabout daily. Through Street 100 drive approximately 5,000 vehicles daily (around 2,500 in each way). From all of them, approximately a 6% reverse their way. From L’Estany del Port Avenue arrive to the traffic roundabout approximately 1,800 vehicles per way. A large amount of them are trucks that have destination the extension works of the Port.

### 2.2. Automatic gauging

Information available from an existing automatic source of information is used. It was done between the 12th and 18th of April 2011 in the Street 114. The automatic sources of information done in the Street 114 give us more reliable information about the evolution of the daily intensity
during the week. It also gives us information about the peak hours and the type of traffic circulating.

![Figure 3. Vehicles entering into the traffic roundabout from Street 114 (source: Esteyco)](image)

**Table 2. Results of the automatic gauging carried out at the Street 114 (source: Esteyco)**

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Total Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-06</td>
<td>2</td>
</tr>
<tr>
<td>06-12</td>
<td>14</td>
</tr>
<tr>
<td>12-18</td>
<td>50</td>
</tr>
<tr>
<td>18-24</td>
<td>8</td>
</tr>
</tbody>
</table>

The peak hour is located between 1 pm and 2 pm, generating about 210 vehicles in one hour.

The average weekday amount is 1,855 vehicles per day, which is approximately 500 vehicles far from the manual gauging. A part of this difference is due to the entry of trucks in the affected extension area of the Port, which now is being carried out through L’Estany del Port Avenue.
Rush hour traffic moves 11.1% of the average daily vehicle entry to the roundabout through the Street 114.

![Figure 4. Vehicles exiting the traffic roundabout from Street 114 (source: Esteyco)](image)

### Table 3. Results of the automatic gauging carried out at the Street 114 (source: Esteyco)

<table>
<thead>
<tr>
<th>Time</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thursday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The peak hour is located between 8 am and 9 am, generating about 188 vehicles in one hour.

The average weekday amount is 2.284 vehicles per day, which is approximately 300 vehicles far from the manual gauging. A part of this difference is due to the exit of trucks in the affected extension area of the Port, which now is being carried out through L'Estany del Port Avenue.
Rush hour traffic moves 11.1% of the average daily vehicle entry to the roundabout through the Street 114.

### 2.3. Composition gauging

The composition gauging shows a high participation of heavy vehicles (64%), mostly the ones with 5 axes (36%).

**Table 4. Results of the composition gauging carried out at the traffic roundabout 100-114 (source: Esteyco)**

![Pie chart showing vehicle types and percentages]

### 3. Description of the projected solution

The project involves the construction of a roundabout that articulates the current intersection and ends with the temporary New Jersey barrier roundabout.

The traffic roundabout, 60 m inner diameter and 70 m outer diameter, 10 meters wide in the central ring and two lanes in the accesses, is dimensioned in order to be functional for the maximum traffic demand that can generate both the ZAL and the expected expanded terminals of the Port of Barcelona in the worst infrastructural scenario case possible.
4. Offer/demand parameters and traffic simulation parameters

4.1. Expected road offer

The existing road offer in the accesses network to the Port is essential to know from where vehicles will reach the intersection.

As in the area there are still doubts about the management of accesses network, capacity calculations have been made taking into account the following infrastructures:
1. Trucks highway (Ministry of Building).
2. North connection to El Port Round.
3. South connection of Street 100 to El Port Round.
4. Remodelling of Streets 114 and 100.
5. New traffic roundabout and flammable’s viaduct.
7. Connection between Streets A and 114.

The connection between Streets A and 114 is an infrastructure that is being studied and its construction is not sure. Having it or not varies significantly both the number and the origins of the vehicles entering the roundabout.

Given the importance of this infrastructure, the functionality of the traffic roundabout has been calculated both if this connection is in service or not.

4.2. Calculation of the maximum demand

4.2.1. Container terminals
For the calculation of the maximum demand generated information available in several previous studies of different companies has been used:

![Diagram](source: Esteyco)

For the calculation of the demand, the following is taken into account:

- A truck equals 2.25 TEU.
- Local traffic is 73.1%.
- An estimated 15% of the mobility of the TEU will be made by train.
- Only 247 working days a year are used.
- The peak hour is 10.4%.
• Total traffic (heavy + light) at rush hour is 15.5% * heavy vehicles IMD.

4.2.2. Prat ZAL

For the calculation of the maximum demand of the ZAL Prat, gauging have been made in their accesses and has been predicted considering the parameters computed in the Special Plan of Port of Barcelona.

![Figure 8. Logistics area (ZAL) of Port of Barcelona (source: Esteyco)](image)

The planned building area reaches almost 900,000 m² of roof. Until now only about 500,000 m² have been developed.

Currently the ZAL Prat is at 56.04% of the parcel development expected in the Special Plan and in turn the activity that takes place is at 71% of its maximum capacity.

If we consider that the ratio of maximum activity is found in the Barcelona ZAL in 2008, with a generation of 8,744 vehicles for a 347,858 m² of building area, we can estimate that the maximum demand for ZAL Prat is 19,853 vehicles per day.

The estimated peak hour for this demand is about 10% of the IMD.
4.3. The Barcelona TRANSCAD simulation method

The traffic study has been developed using the simulation model TRANSCAD. Moreover, the graf road has been used together with the vehicles matrix belonging to the “Prevention, Security and Mobility Area of the City Council of Barcelona”.

The studied area includes the entire accesses network to the Port from the main arteries of metropolitan urban communication and forms a continuum with the city of Barcelona. This allows the analysis of the variation of the truck movements considering new connections, especially the highway truck, which will tend to compact traffic to the port through the corridor formed by A2 / AP-2.

4.3.1. Composition and calibration of the model

The model consists of:

- 511 centroids (points symbolizing the catchment-generation areas of the model, where the demand of vehicles is concentrated (origin and destination of the trips belonging to the traffic matrix)).

- 24,478 arcs (homogeneous sections of roads between intersections) that contain various fields such as the flow direction, the length of the section, the number of lanes, the free stream velocity, the characterization parameters of the functions of delay by traffic density, the existence of bike or BUS lanes, the presence of parking, etc.

- 2,905 radius (it is a virtual network connecting the arcs – road network – and the centroids).

- An internal trip matrix (as a result of self-done interviews and daily mobility in a working day at the metropolitan area of Barcelona. It is also complemented by social and economic data from the City Council of Barcelona).

- The results are compared with available traffic information weighted by its reliability (Permanent gauging stations Ministry of Public Works, Department of Territorial Politics and Public Works of the Generalitat de Catalunya, etc.).

5. Results of the load allocation process
5.1. Scenario taking into account the connection between Street A and Street 114

The results of the load allocation (100% of the activity both at the ZAL and at the Container Terminals) on the future network considering this connection are the following:

At the roundabout between Streets 100 and 114 every day enter around 15,300 vehicles, slightly more than the double that in the current situation. Most arrivals at Port are made through the truck highway and at ZAL through the passage of Street A.

From Street 100 enter the roundabout about 6,000 vehicles per day, being the longitudinal movement the most important, that is to say, the one directed to the new terminals.

The matrix of movements in the planned roundabout would include:
Based on this matrix, capacity calculations are performed and simulated by the AIMSUN traffic micro simulator:
The roundabout would have sufficient capacity to absorb the expected traffic patterns from the macroscopic models. Delays would be a maximum of 20-40 seconds at most per vehicle at peak times and the maximum queues detected do not exceed 7-9 vehicles at any time.

5.2. Scenario without taking into account the connection between Street A and Street 114

The results of the load allocation (100% of the activity both at the ZAL and at the Container Terminals) on the future network without considering this connection are the following:

In this scenario between Streets 100 and 114 each weekday will enter into the roundabout around 23.000 vehicles, more than the triple of the current situation.

A high percentage of the entrances to the Port are via the route that uses the Llevant Round (El Prat de Llobregat). From the Street 100, around 12.100 vehicles reach the roundabout per day, worsening service levels from the previous situation.

Not building the connection of Street A and Street 114 has the following threats:
• From Mercabarna Bridge to the Port's Round there are 3.2 km, the step rate is lost (1 each approximately 1,600 meters).

• Llevant Round undergoes a major traffic increase that is estimated to largely exhaust the capacity of this pathway.

• Street A loses all its traffic on the roundabout of street A with Street 3, an important access area to the Port with capacity problems.

From Street 100 enter the roundabout around 12,000 vehicles per day, being the longitudinal the most important movement (6,500 vehicles / day), that is to say, towards the new terminals.

![Figure 13. aa](source: Esteyco)

The matrix of movements in the planned roundabout would include:

![Figure 14. Matrix of movements in the planned roundabout](source: Esteyco)
Based on this matrix, capacity calculations are performed and simulated by the AIMSUN traffic micro simulator:

![Figure 15. Capacity calculations performed and simulated by AIMSUN traffic micro simulator (source: Esteyco)](image)

Delay times at the entrance of the roundabout from the Street 114 are greater than 60 seconds because of the high intensity of vehicles entering from L’Estany del Port Avenue to the north. This cuts the entrance to the roundabout from this route.

Also the entrance from L’Estany Port Avenue has significant delays between 50-60 seconds because of the high intensity of vehicles accessing the ZAL Prat and bothering this incorporation.

The entrance from Street 100 to the roundabout does not show major problems since no high vehicle intensity interfere with this input flow.

### 6. Calculation of the traffic roundabout functionality

Once quantified the flows of vehicles that will access the future roundabout, it is necessary to verify that the results obtained in the simulations of traffic correspond to the common functionality calculations for roundabouts.
To calculate the saturation indices of a roundabout, empirical methods developed by different institutes specialized in transport are used.

In this case, the CETUR method for calculating roundabouts capacity was used.

The CETUR (Centre d'Etudes des Transports Urbains), today called CERTU, is an agency of the French Ministry of Infrastructure and Transport that is the equivalent to SETRA in the urban environment.

In 1986 it proposed a simplified method for calculating the capacity based on the CETE d'Aix studies (described above). The so-called "method CETUR-86" is a formula to capacity of the entry of a roundabout where the annular flow occurs in a single row and the entrance has a single lane. If these conditions are not met transformations must be used to convert it to an equivalent situation.

The CETUR-86 method is an improvement of the traditional 1500 rule that indicates that in order a traffic roundabout works, the sum of the incoming traffic to the roundabout must be less than 1,500 light vehicles per hour.

6.1. Taking into account the connection between Street A and Street 114

The saturation index of all the accesses is below 50% for rush hour (10.4% of the IMD:}
CÀLCULO DE LA CAPACITAT EN LA GLORIETA ENTRE LES CALLES 100 I 114 CON CONEXIÓ EN LA CALLE A

ROTONDES. MÈTODE CERTU

\[ Q_s = F - f \cdot Q_s \]

\[ Q_f = \text{Intensitat que entra} \]
\[ Q_s = \text{Intensitat que surt} \]
\[ Q_f = \text{Intensitat prioritària que talla la circulació d'entrada (veh/h)} \]
\[ \alpha = \text{Paràmetre geomètric} \]
\[ \beta = \text{Paràmetre geomètric} \]
\[ \delta = \text{Factor de camí d'entrada} \]

<table>
<thead>
<tr>
<th>ENTRADES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>702</td>
<td>426</td>
<td>516</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>490</td>
<td>191</td>
<td>937</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>184</td>
<td>657</td>
<td>183</td>
<td>805</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Fòrmules pel càlcul de paràmetres:

\[ Q_m = \alpha \cdot Q_s + \beta \cdot Q_c \]

\[ I_{cc} = \left( 5 \cdot Q_e + 8/3 \cdot Q_m \right) / 1600 \]

<table>
<thead>
<tr>
<th>ENTRADES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qm</td>
<td>253</td>
<td>508</td>
<td>363</td>
<td>591</td>
</tr>
<tr>
<td>I_{cc}(%)</td>
<td>Saturació</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percentatge de saturació:

\[ S = H_{100} \]

<table>
<thead>
<tr>
<th>ENTRADES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>45%</td>
<td>49%</td>
<td>44%</td>
<td>38%</td>
<td></td>
</tr>
</tbody>
</table>
6.2. Without taking into account the connection between Street A and Street 114

The saturation index of all the accesses is less than 75% for the rush hour (10.4% of the IMD:}
CÀLCULO DE LA CAPACITAT EN LA GLORIETA ENTRE LES CALLES 100 Y 114 SIN CONEXIÓN EN LA CALLE A

ROTONDES. MÉTODO CERTU

\[ q_{e} = F - f \cdot q_{e} \]

on:

\[ q_{e} = \text{Intensitat que entra} \]
\[ q_{s} = \text{Intensitat que surt} \]
\[ q_{e} = \text{Intensitat prioritaria que talla la circulació d'entrada (veh/h)} \]
\[ \alpha = \text{Parâmetre geomètric} \]
\[ \beta = \text{Parâmetre geomètric} \]
\[ \delta = \text{Factor de carrils d'entrada} \]

<table>
<thead>
<tr>
<th>ENTRADES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>( q_{e} )</td>
<td>1263</td>
<td>532</td>
<td>496</td>
<td>30</td>
</tr>
<tr>
<td>( q_{s} )</td>
<td>997</td>
<td>631</td>
<td>680</td>
<td>13</td>
</tr>
<tr>
<td>( q_{e} )</td>
<td>43</td>
<td>674</td>
<td>526</td>
<td>1010</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.95</td>
</tr>
<tr>
<td>( \delta )</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>1</td>
</tr>
</tbody>
</table>

Fórmules pel càlcul de paràmetres:

\[ Q_{m} = \alpha \cdot Q_{s} + \beta \cdot Q_{c} \]
\[ I_{cc} = (\delta \cdot Q_{e} + 8/9 \cdot Q_{m}) / 1600 \]

on:

\[ Q_{m} \text{ (veh/h)} \quad \text{Trànsit molest} \]
\[ I_{cc} \% \quad \text{Saturació} \]

<table>
<thead>
<tr>
<th>ENTRADES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_{m} )</td>
<td>279</td>
<td>629</td>
<td>538</td>
<td>962</td>
</tr>
</tbody>
</table>

Percentatge de saturació: \( H_{100} \)

<table>
<thead>
<tr>
<th>ENTRADES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \delta )</td>
<td>71%</td>
<td>60%</td>
<td>53%</td>
<td>59%</td>
</tr>
</tbody>
</table>
7. Conclusions

The roundabout planned for the intersection of Street 100 and 114 is sufficient to ensure good levels of service during peak hours and for the worst possible infrastructural scenario.
ANNEX Nº6. FIRMS AND PAVEMENTS
Annex nº6. Firms and pavements

Contents

1. Introduction.................................................................................................................. 27
2. Applicable regulations................................................................................................. 27
3. Traffic class.................................................................................................................. 27
4. Esplanade...................................................................................................................... 29
5. Firm section of the vials............................................................................................... 30
   5.1. Materials for the firm section.................................................................................. 30
6. Sidewalks and bike path.............................................................................................. 31
Annex nº6. Firms and pavements

1. Introduction

In the current annex the firms employed on the vials of the “Urbanization project of Street 114. Connection between L’Estany del Port Avenue and Street 114 (Port of Barcelona)” are defined and justified.

2. Applicable regulations

For the firms dimensioning, the norm applied was “Pavement sections. Instruction 6.1-IC”. The reason for applying this norm is the traffic type that the vials would need to absorb. Therefore, the projected firm section is justified by the proposed methodology given by this norm.

3. Traffic class

A firm structural section depends on the expected traffic action, concretely the heaviest one. Therefore, the first variable to determine would be the expected Average Daily Intensity of heavy Vehicles (IMDₚ) on the projected lane.

In the annex 5 (“Mobility and traffic study”), not included in this project, the traffic supported by the traffic roundabout is studied. Two different scenarios will be analyzed:

- Without contemplating the connection between Street A and Street 114.
- Contemplating the connection between Street A and Street 114.

From the simulation carried out, the following average daily intensity of vehicles were obtained on the most loaded area of the traffic roundabout:

- Without contemplating the connection between Street A and Street 114 = 12,500 veh/day.
- Contemplating the connection between Street A and Street 114 = 10,000 veh/day.

The percentage of heavy vehicles is 64%, obtaining therefore the following Average Daily Intensity of heavy Vehicles (IMDₚ):
• Without contemplating the connection between Street A and Street 114 = 8,000 veh/day.

• Contemplating the connection between Street A and Street 114 = 6,400 veh/day.

These two IMDP are classified as the type of heavy traffic T00, , according to the Table 1.A of the instruction 6.1-IC.

**Table 5. Types of traffic according to the Table 1.A of the instruction 6.1-IC (source: Esteyco)**

<table>
<thead>
<tr>
<th>Type of heavy traffic</th>
<th>T00</th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADIp (heavy vehicles/day)</td>
<td>&gt;4,000</td>
<td>&lt;4,000</td>
<td>&lt;2,000</td>
<td>&lt;800</td>
</tr>
<tr>
<td></td>
<td>&gt;4,000</td>
<td>&gt;2,000</td>
<td>&gt;800</td>
<td>&gt;200</td>
</tr>
</tbody>
</table>

Given that the traffic roundabout of the current project is located in L’Estany del Port Avenue, the coordination with the “Urbanization Project of the Street 100” must be kept coordinated. For that purpose, it also must be considered that in this project the type of heavy traffic obtained in the Street 100 is T00.

In conclusion, the type of traffic that will be used to dimension the section is T00. According to the norm, the following sections can be admitted:

![Figure 16. Sections admitted on the firms dimensioning (source: Esteyco)](image)

**Legend:**

MB: Asphalt mix.
ZA: Artificial sand.
4. Esplanade

When defining the firm structure, there exists another parameter to determine: the esplanade category. The norm shows there exist three different categories: E1, E2 and E3. They are determined by their compressibility modulus in the second loading cycle $E_{v2}$. Formation of the necessary esplanade given the firm section required according to the heavy vehicles traffic depends on the soil grading type or subjacent earthworks, and also on the characteristics and thicknesses of the materials available.

The geological study done in the affected area allows us to classify the type of soil as tolerable (0). Therefore, the formation of the esplanade will be as following:

![Figure 17. Formation of the esplanade (source: Esteyco)](image)

Legend:
0: Tolerable soil.
1: Adequate soil.
2: Selected soil.
S-EST: In-situ stabilized soil.

Given that the intention is to obtain an E3 esplanade above the tolerable ground, from the two options given in the existing norms, it is decided to arrange 30 cm of stabilized S-EST3 in situ ground above the 30 cm of selected ground.

5. Firm section of the vials

Taking into account that the type of heavy traffic is T00 and that the esplanade will be E3, from all the sections defined in the norm 6.1-IC, it is considered as the most suitable one the 0031 section, for its low degree of difficulty execution and because the artificial sand used implies a better finishing. Moreover, it maintains the continuity with the firm defined for Street 100 in the “Urbanization Project of the Street 100”.

Finally, the firm pack selected is the following:

![Firm pack selected](source: Esteyco)

5.1. Materials for the firm section

In this chapter the asphalt mix layers and their corresponding thicknesses are dimensioned.

Following the indications of the “Norm 6.1-IC”, a non-plastic material primer irrigation will be applied to the granular layer that will receive the asphalt mix – in our case the artificial sand –. This primer irrigation will eventually be natural or crushing sand, with a sand equivalent always higher than 40.
Taking into account the 35 cm thickness of the asphalt mix, the type of traffic T00 and the average summer thermal zone location of the works done, the layers forming the asphalt mix will be the following:

<table>
<thead>
<tr>
<th>Firm (section 0031)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt hot mix</td>
<td>35 cm</td>
</tr>
<tr>
<td>Discontinuous asphalt mix AC16 surf BM-3c D</td>
<td>5 cm</td>
</tr>
<tr>
<td>Modified adhesion irrigation ECR-2d-m (minimum amount 500 g/m$^2$)</td>
<td></td>
</tr>
<tr>
<td>Semi dense asphalt mix AC22 bin B60/70 S</td>
<td>8 cm</td>
</tr>
<tr>
<td>Adhesion irrigation ECR-1d (minimum amount 500 g/m$^2$)</td>
<td></td>
</tr>
<tr>
<td>Semi dense asphalt mix AC32 bin B60/70 G</td>
<td>10 cm</td>
</tr>
<tr>
<td>Adhesion irrigation ECR-1d (minimum amount 500 g/m$^2$)</td>
<td></td>
</tr>
<tr>
<td>Semi dense asphalt mix AC32 bin B60/70 G</td>
<td>12 cm</td>
</tr>
<tr>
<td>Primer irrigation ECI (minimum amount 1.000 g/m$^2$)</td>
<td></td>
</tr>
<tr>
<td>Base of artificial sand</td>
<td>25 cm</td>
</tr>
<tr>
<td>Cured irrigation ECR-1d with a minimum binder amount of 500 g/m$^2$</td>
<td></td>
</tr>
</tbody>
</table>

As it can be seen in Table 6, the appropriate adherence irrigation will be applied between two asphalt mix layers.

It must be marked that the dense asphalt mix AC16 surf D was selected as a surface layer, contrary to what the norm recommends for heavy traffic type T00. That is because, as Port of Barcelona is in the rainfall zone 5, defined dry, and as there is slow traffic and heavy truck maneuvering, heavy loads will be applied on the firm top layer, and in consequence a draining asphalt mix does not ensure the durability required. Therefore, an AC16 surf D asphalt mix was chosen because it satisfies the necessary requirements of resistance and durability and at the same time is not very expensive.

6. Sidewalks and bike path

For the dimensioning of the sidewalks and the bike path, it was decided to use the already existing typology, following at the same time the reference rules for the urbanization works in the service area of Port of Barcelona. It will be composed of an hydraulic tile of 0.20 x 0.20 size of 4 tablets and 4 cm thickness above a 3 cm mortar layer. Below them, a 15 cm fck 15 N/mm$^2$ concrete layer will be placed for a leveling and cleaning purpose above a 20 cm artificial gravel layer (esplanade). Below the artificial gravel, a 40 cm selected soil layer will be placed.
The curb to be placed will be made by a BR1 type 30 x 20 cm precast concrete in vertical position.
ANNEX Nº7. CLIMATOLOGY, HYDROLOGY AND DRAINAGE
Annex nº7. Climatology, hydrology and drainage

Contents

1. Introduction..................................................................................................................35
   1.1. Background..............................................................................................................35
2. Climatology and pluviometry......................................................................................39
3. Sewer network design..................................................................................................40
4. Hydraulic testing of the projected manifolds..............................................................42
Annex nº7. Climatology, hydrology and drainage

1. Introduction

The current document describes, justifies and develops the sewerage storm water network of the "Urbanization project of Street 114. Connection between L'Estany del Port Avenue and Street 114 (Port of Barcelona)". The action consists, basically, in the execution of a traffic roundabout substituting the existing intersection.

Given that the project is developed in an area belonging to the City Council of El Prat de Llobregat and to the Port of Barcelona (Intermodal Logistics Center S.A. – El Prat ZAL), the general parameters fixed by the City Council of El Prat de Llobregat will be taken into account when designing the network. However, they will be adapted to the recommendations suggested by the public company Clavegueram de Barcelona, S.A. (CLABSA) for the South Extension of Port of Barcelona.

The designed sewer system will solve and ensure the runoff drainage of the new urbanized area by projecting an inlet network that will substitute or extend the existing one. Moreover, this network will be adjusted to the connection of the existing networks. For that purpose, the documents defining previous actions in the area were consulted, and described in the following paragraph.

1.1. Background

For the development of the Project, apart from the data collection and the field works executed, information collected in the following Projects was taken into account:

- *Modification number 2 of the canalization project of the Llobregat River from The Mercabarna Bridge to the Sea (Agència Catalana de l'Aigua, May 2004)*. Concerning the scope of the current project, in the existing intersection of Streets 114 and L'Estany del Port Avenue (old Street 100), runs the interceptor sewer projected from the Avenue, and it is composed by a bi cellular concrete drawer of dimensions 2,00 x 3,50 x 1,5 m.

**All the runoff collected by the projected drainage system will be connected to this bi cellular concrete drawer**, in order to be able to analyze in the appropriate purifying plant the water collected during the first 10 minutes of rainfall along all the scope of the project.

The following figure shows the situation of the existing bi cellular concrete drawer:
• **As-Built Project of the urbanization and extension of the logistics zone of Port of Barcelona, phases 1 and 2** (COPISA, March 2003 and October 2005). This project was requested by Centro Intermodal de Logística S.A. (CILSA). Its purpose was to describe and assess the works done corresponding to the urbanization of the first and second stages of the Logistics Area (ZAL) extension of Port of Barcelona.

The actions described in the As-Built do not belong to the strict scope of the current project. However, in this project is stated (as a connection network) the frame system belonging to the City Council of El Prat.

• **As-Built of the reshuffle project of the sewer system of the Industrial area of El Prat de Llobregat** (EGI, Enginyeria i Gestió d'Infraestructures, December 2005). This project
was written after a request from the City Council of El Prat de Llobregat. The sewerage network in the Street 114 is formed by a unicellular frame of 2.50 m base and 1.50 m height, from which the inlets located every 20 m in the northeast sidewalk of the Street 114 are successively connected. This network will be totally maintained, except the two inlets located at the southwest part that are affected both by the new flush and the new order.

The following figure shows a scheme of the existing network:

![Figure 20. Scheme of the existing drainage network in the northeast part of Street 114 (source: Esteyco)](image)

- Reshuffling project of Streets 110/114 of the Pratec Industrial area in the perimeter zones of the Baix Llobregat purifying plant at El Prat de Llobregat (EGI, October 2007). The information extracted from this project gives useful data with respect to the connection to the storm water network projected at the South-West part of the Street 100. After the topographic map and the field works that were carried out, it was checked that the wells 2-1 were alienated.

The following figure shows a scheme of the existing network:
Figure 21. Scheme of the existing drainage network in the southeast part of Street 114 (source: Esteyco)

- **Urbanization project of Street 100** (Esteyco, March 2009). On March 2009, the Port Authority of Barcelona requested Esteyco the adaptation of the urbanization project of Street 100 to the new service requirements and geometric actions that would allow the Street to fit with the new access road network to the new terminals.

  According to the projected drainage and the scope of the current action, the two sewer networks will not overlap; they are not connected to each other. Therefore, they only have one drainage element in common: the bi-cellular framework that works as an interceptor and that was described above.

- **Urbanization project of the south extension accesses – Phase I** (PROINTEC, 2006). On April 13th, 2006, the Port Authority of Barcelona bid for this project as part of the urbanization works of the new accesses to “Terminal Prat”. It is included in the actions considered in the Director Plan of Port of Barcelona, which at the same time are part of the so-called “Plan Delta”. The purpose of the project was to define the access vials to the Prat quay (1st phase), as well as their urbanization and their extension to the Sea next to the Prat Polygon drainage, Logistics Area 2 (ZAL 2) and part of Prat quay. In particular, this project considered the urbanization of Streets 100 and 114 in their final
width, the execution of the Prat Vial and the non-lit connection between Streets 100 and 114 – and their connections with existing and future vials –.

After the topographic study and the in-situ inspections, some inconsistencies were detected both in the projected network at the traffic roundabout and in the Northeast alienation of Street 114. Therefore, the information related to this project has not been taken into account.

2. Climatology and pluviometry

For the design and justification of the drainage network, the recommendations from CLABSA have been followed, using therefore the designed rainfall defined in the Special Sewer Plan of Barcelona with a 10 years return period.

The histogram was done by the alternating blocks system after determining the IDF curves (intensity – duration – frequency), attached here:

![Figure 22. Barcelona – Fabra IDF curve (1927-1993 series) (source: Esteyco)](image-url)
As it can be observed, for a 10 years return period, the rainfall intensity of a 5 minutes duration is 212.40 mm/h. This value is will be used to calculate the volume of water circulating in the new manifold network.

3. Sewer network design

For the sewer network design, the following criteria were taken into account:
• A minimum slope of 0.3% due to the possible limitations of the existing services, and velocities between 0.5 and 6 m/s (CLABSA requirements).

• PVC tubes will be used, and they will be covered by concrete following CLABSA requirements.

• An inlet will be placed at least every 180 m$^2$ of drainage area. The dimensions of the inlet will be 70x30 cm. This decision is justified by CLABSA criteria and by the following table, which shows the inlets density criteria in Barcelona. The density of inlets to be placed in Barcelona is expressed in terms of the tax area (m$^2$) per unit of inlet. It is determined as a function of the longitudinal slope and the type of inlet according to the following table:

<table>
<thead>
<tr>
<th>Pendiente longitudinal ($i$) (%)</th>
<th>Reja Barcelona 1</th>
<th>Reja CIVE 70</th>
<th>Reja Meridiana</th>
<th>Reja Barcelona</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>180</td>
<td>175</td>
<td>170</td>
<td>275</td>
</tr>
<tr>
<td>1</td>
<td>190</td>
<td>185</td>
<td>180</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>195</td>
<td>190</td>
<td>325</td>
</tr>
<tr>
<td>3</td>
<td>205</td>
<td>205</td>
<td>195</td>
<td>340</td>
</tr>
<tr>
<td>4</td>
<td>205</td>
<td>210</td>
<td>200</td>
<td>350</td>
</tr>
<tr>
<td>5</td>
<td>185</td>
<td>185</td>
<td>175</td>
<td>310</td>
</tr>
<tr>
<td>6</td>
<td>160</td>
<td>160</td>
<td>150</td>
<td>265</td>
</tr>
<tr>
<td>7</td>
<td>140</td>
<td>135</td>
<td>130</td>
<td>225</td>
</tr>
<tr>
<td>8</td>
<td>125</td>
<td>120</td>
<td>120</td>
<td>200</td>
</tr>
<tr>
<td>9</td>
<td>110</td>
<td>110</td>
<td>105</td>
<td>180</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>160</td>
</tr>
<tr>
<td>11</td>
<td>95</td>
<td>90</td>
<td>90</td>
<td>150</td>
</tr>
<tr>
<td>12</td>
<td>85</td>
<td>85</td>
<td>80</td>
<td>140</td>
</tr>
<tr>
<td>13</td>
<td>80</td>
<td>80</td>
<td>75</td>
<td>130</td>
</tr>
<tr>
<td>14</td>
<td>75</td>
<td>75</td>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>15</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>110</td>
</tr>
</tbody>
</table>

The type of inlet to be placed will be Barcelona1. The maximum distance between two consecutive inlets will be 15 m. Two consecutive inlets will be able to be connected by tubes of minimum 300 mm diameter and 3% longitudinal slope.

• In some cases, such as in the lowest points of the outline, double inlets will be placed in order to improve their drainage capacity.
• The connections between inlets and manifolds will be done directly to the base of the manifold, without the necessity of building a well. These connections will be carried out by 500 mm minimum diameter tubes, and on the same way of the water flow.

• In the green zone near the traffic roundabout, it is expected to collect the rainfall and irrigation water by a sub drainage network, in order to avoid damages to the new vial’s esplanade due to the water infiltration. These sub drainages will have a 160 mm diameter, and they will be wrapped in a package of gravels and protected by a geotextile material that will be connected to a 300 mm diameter manifold, that will transport the water collected to the existing interceptor.

• The manholes to be built will have 1 m diameter with eccentric conical reductions in order to place the 65 x 60 cm covers. These covers will be alienated with the center of the traffic lane, avoiding vehicles to pass over them. Therefore, the covers’ axes will always coincide with the traffic lane axis.

• The water collecting bars at the parcel entrances will be auto cleanable 30 cm wide with a minimum slope of 2.5%, F250MF type from ULMA or similar.

• The manholes will provide a sandbox when water collected from the projected sub drains network is connected to them. This is to avoid the entrance of sediments to the manhole.

• All the new projected manholes’ covers will be alienated to the lane axis in order to avoid them to be trodden by the driving vehicles.

4. Hydraulic testing of the projected manifolds

The hydro meteorological methods will be employed to calculate the discharges. Given that the times of concentration are relatively short, these methods are based on the application of an average rainfall intensity to the surface of the basin through an estimation of its runoff. Therefore, the maximum discharges will be determined applying the rational method according to the “Instruction 5.2 I.C – Superficial drainage”, by the following expression:

$$Q = C \cdot I \cdot A / K$$

Where:

• C: Runoff coefficient of the drained surface.
• I: Average rainfall intensity (mm/h).
• A: Drained surface area (m²).
- K: Coefficient that includes an increment of a 20% of the discharge in order to take into account the peak precipitation moments. It will be considered K = 3.000.000.
- Q: Discharge (m$^3$/s).

Concerning the runoff coefficient (C), and depending on the pavement type of the new urbanization, the following values have been estimated:

- Urban pavements: $C_1 = 0.99$.
- Gardened surfaces: $C_2 = 0.40$.

According to the following scheme, the water discharge collected by the projected manifolds can be determined applying the data above:

Table 8. Discharge calculation table of the manholes connecting to the existing bi cellular drawer (source: own-source)

<table>
<thead>
<tr>
<th>Surface A (m$^2$)</th>
<th>Intensity I (mm/h)</th>
<th>Runoff coefficient (C)</th>
<th>Discharge Q (m$^3$/s)</th>
<th>Accumulated discharge Q' (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manhole 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban pavements</td>
<td>536,82</td>
<td>212,4</td>
<td>0,99</td>
<td>0,038</td>
</tr>
<tr>
<td>Gardened surfaces</td>
<td>812,35</td>
<td>212,4</td>
<td>0,40</td>
<td>0,023</td>
</tr>
<tr>
<td>Manhole 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban pavements</td>
<td>633,09</td>
<td>212,4</td>
<td>0,99</td>
<td>0,044</td>
</tr>
<tr>
<td>Gardened surfaces</td>
<td>299,39</td>
<td>212,4</td>
<td>0,40</td>
<td>0,008</td>
</tr>
<tr>
<td>Manhole 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban pavements</td>
<td>438,43</td>
<td>212,4</td>
<td>0,99</td>
<td>0,031</td>
</tr>
<tr>
<td>Gardened surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manhole 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban pavements</td>
<td>596,09</td>
<td>212,4</td>
<td>0,99</td>
<td>0,042</td>
</tr>
<tr>
<td>Gardened surfaces</td>
<td>847,09</td>
<td>212,4</td>
<td>0,40</td>
<td>0,024</td>
</tr>
<tr>
<td>Manhole 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>593,27</td>
<td>212,4</td>
<td>0,99</td>
<td>0,042</td>
</tr>
</tbody>
</table>
Starting from the value of the maximum discharge circulating through each of the projected tubes, the hydraulic capacity of them is tested by using the Manning formula:

\[ Q = S \cdot R^{2/3} \cdot J^{1/2} / n \]

Where:

- **Q**: Discharge (m³/s).
- **S**: Wet surface of the drainage element (m²).
- **P**: Wet perimeter (m).
- **J**: Slope (m/m).
- **N**: Manning's rugosity coefficient. It will be considered \( n = 0.012 \) for all the elements coated by PVC.

The relationship between the discharge and the depth associated to it for the minimum slope (3%) (most unfavourable case) is represented in the curve below. The hydraulic calculus has been done with the interior measure of the PCV tube diameter (around 476 mm).

<table>
<thead>
<tr>
<th>pavements</th>
<th>150,80</th>
<th>212,4</th>
<th>0,40</th>
<th>0,004</th>
<th>45,854</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gardened surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For the calculation of the obtained discharges and with the parameters previously defined, it can be observed how the tube presents an approximate depth of 18 cm. The velocity is approximately 1 m/s.

Figure 26. Relationship between the depth (mm) and the discharge (l/s) for a minimum slope of 0.3% (source: Esteyco)
ANNEX Nº8. AFFECTED SERVICES
Annex nº8. Affected services

Contents

1. Introduction................................................................................................................................48
2. Development of works.................................................................................................................48
3. Contacts with organisations and service companies.................................................................48
4. Sewerage network......................................................................................................................49
   4.1. Storm water network ............................................................................................................50
   4.2. Sewage network ..................................................................................................................51
5. Water supply network...............................................................................................................52
6. Regenerated water network......................................................................................................53
7. Gas Natural...............................................................................................................................56
8. FECSA – Endesa ......................................................................................................................58
9. Telefónica network....................................................................................................................59
Annex nº8. Affected services

1. Introduction

This annex concerns the definition of the necessary work for the realization of protection, diversions and replacement of services affected by the completion of the work defined in the “Urbanization project of Street 114. Connection between L’Estany del Port Avenue and Street 114 (Port of Barcelona)".

Before starting the work, the contractor will have to update the affectations by contacting the affected companies and make all the necessary to find the exact locations of the existing services.

2. Development of works

The research about the definition of the existing installations and services consisted basically in:

- Topographic map and inspection on site of all the visible installations and services, identifying each type of service and the possible owning company.

- Contrasting the field data collected with the available information from the Port Authority of Barcelona.

- Request to the affected companies about the recent available data of the services located in the area affected by the current project.

- Proposal of the temporary deviations, protections and/or replenishments to the affected companies.

- Contacting the affected companies, requesting the respective proposal of replenishment and/or protection.

Now a description of the different service networks, the respective type of affectation and the replenishment proposal is done.

3. Contacts with organisations and service companies
During the course of the works, contacts with the following companies and public organisations were considered:

- Empresa Metropolitana de Sanejament S.A. – EMSSA.
- City Council of El Prat de Llobregat.
- FECSA – Endesa.
- Gas Natural.
- Telefónica.
- Aigües del Prat.

The affected services by the current project and the planned actions for each of them are described in the following lines.

4. **Sewerage network**

Currently, there exist two sewer networks in the area affected by the project and in the streets that connect with it, belonging to the City Council of El Prat de Llobregat and to “Entitat Metropolitana de Serveis Hidràulics I Tractament de Residus (EMSHTR)”, all managed by “Empresa Metropolitana de Sanejament (EMSSA)”.
4.1. Storm water network

In the area affected by the project, we first encounter a manifold which discourses through Street 114, and consists in a drawer of dimensions 2,50 x 1,50 m. This manifold collects the water from the inlets placed on the vial, and evacuates it to the manifold discoursing through L’Estany del Port Avenue, which consists of two bi-cellular drawers of dimensions 2,0 x 3,5 x 1,5 m, belonging to the City Council of El Prat.

These manifolds are located around 50 cm below the ground level, which does not differ practically from the projected ones. This fact conditions significantly the potential installation of services in the area due to the possible intersections with them.

The only affectation considered about the manifold is the one produced near the access of machinery to the bi-cellular drawer that discourses through L’Estany del Port Avenue. In this place heavy vehicles drive over the existing manifold cover, therefore producing the deformation of the metal fence and the sinking of some of the concrete slabs.
The actions projected will modify slightly the elevation of the ground at this point, and in consequence the metal fence and the concrete slabs will not be affected by the heavy vehicles driving over them as much as before. In order to avoid future possible problems similar to this one, it is decided that the heavy vehicles will go through the traffic roundabout interior, avoiding them to drive over the manifold and also avoiding them to create any inconvenience when carrying out the maintenance works in the manifold.

4.2. Sewage network

To the sewage network belongs the interceptor of Street A – type NT1715 –, belonging to the “Entitat Metropolitana de Serveis Hidràulics I Tractament de Residus (EMSHTR)”. The affected section discourses through the future extension area of Street 114 and through L’Estany del Port Avenue until its connection to the treatment plant.
This manifold is always below the lower bound of the esplanade, therefore it will not be affected by the construction works. The only thing that must be taken into account is the alienation of the covers with the new flush.

5. Water supply network

In the area affected by the project there exists a water supply network, belonging to “Aigües del Prat”. 
On the one hand there are two supply lines that discourse through both edges of L’Estany del Port Avenue. They are formed by a $\phi 250$ mm melting pipeline on the right side of the Avenue and a $\phi 200$ mm polyethylene pipeline on the left side. On the other hand, another $\phi 250$ mm melting pipeline discourses through the existing sidewalk of Street 114.

The projected actions do not affect directly any of these supply lines, but they do affect the location of their mechanical equipment (suckers, shutoff valves, etc.). The replacement proposal of all this mechanical equipment has been done by “Aigües del Prat” and consists basically in the installation of $\phi 250$ mm gate valves on the sidewalks, an underground $\phi 100$ mm hydrant and a 2” sucker for the $\phi 250$ mm supply lines.

6. Regenerated water network

In the area affected by the project there exist two regenerated water lines managed by the “Empresa Metropolitana de Sanejament EMSSA”.

![Figure 30. Scheme of the existing water supply network (source: Esteyco)](image-url)
Figure 31. Scheme of the existing sewerage network and the regenerated water network (source: Esteyco)

From the tertiary treatment zone of the purifying plant to the Street 114 discourse a φ400 mm line that transports regenerated water to the Montjuïc Park in Barcelona. In almost all its path it passes by the interior of the purifying plant parcel until reaching the existing electrical panel located next to its entrance. From this place the line is located below the existing sidewalk at L’Estany del Port Avenue until reaching Street 114. Before reaching Street 114, the line affects the scope of the project. However, the upper bound of the pipeline is at 2,20 m, still much lower than the lower bound of the esplanade to execute, and therefore any affectation to the pipeline is expected.

In addition, in order to avoid possible affectations to one of the manifolds existing in the Street 114, a connection branch from the traffic roundabout to the Street 114 was projected in order this manifold to be located outside the roadway.
The other existing regenerated water line consists in a $\phi 500$ mm line discoursing through Street 114. This line aims to feed some injection wells that contribute with water to the Llobregat River in order to decrease the intrusion of Sea water to it.

This line discourses at a depth higher than 2,0 m, and none of the projected actions affect it. Moreover, the connection branch from the traffic roundabout to the Street 114 was projected so the manifold of the existing injection well was located in the middle zone of the roadway (avoiding its affectation).
7. Gas Natural

A high pressure gas conduit belonging to Gas Natural discourses through the Sea side of Street 114.
The projected action will affect the canalization and its signalling, so it will be necessary to replace it.

![Figure 35. View of the signal of the affected Gas Natural conduit (source: Esteyco)](image)

The replacement proposal of all the necessary mechanical works was done by Gas Natural. The solution consists basically in:

- Installation of a new DN-6" MOP-16 bar steel pipe branch of 53.0 m.

- 31.0 m protection of the existing conduit by DN-10" medium canes of 6.35 mm thickness.

- Protection of the steel pipe branch section on the existing manifold section by a DN-10" steel protection tube of 6.35 mm thickness and a concrete slab.

- Protection of the opencast steel pipe branch section by a DN-10" steel protection tube of 6.35 mm thickness and 25.0 m long.

- Execution of 2 provisional steel DN-6" MOP-16 bar by-passes of 13.0 and 17.0 m long.
8. FECSA – Endesa

In the area affected by the project, as well as in the connection streets to it, there exist different underground canalizations of MV and LV belonging to Fecsa-Endesa. The following figure shows the existing MV and LV network in the area affected by the project:

![Figure 36. Existing MV and LV network belonging to Fecsa-Endesa in the area affected by the project (source: Esteyco)](image)

The projected actions will affect the underground canalizations of MV belonging to Fecsa-Endesa. Therefore, it will be necessary to replace them.

The replacement proposal was done by Fecsa-Endesa. The solution consists basically in a deviated branch of the MV canalizations affected by the project. In this replacement proposal, together with its economic valuation, it is planned to carry out some civil works (canalizations) that will be done by the main contractor. Therefore, the contractor will execute the crossing opencast expected actions in L’Estany del Port Avenue and in the Street 114.

In the executed crossing at L’Estany del Port Avenue, it will be executed as well a 3,0 m width and 1,20 m depth canalization. This canalization includes the execution of an HM-20 concrete prism with 8 PVC corrugated tubes, an 8 mm thickness steel plate, a PVC signalling sheet and the replacement of the existing pavement.
In the executed crossing in the Street 114, it will be executed as well a 1.60 m width and 1.20 m depth canalization. This canalization includes the execution of an HM-20 concrete prism with 4 PVC corrugated tubes, an 8 mm thickness steel plate, a PVC signalling sheet and the replacement of the existing pavement.

9. Telefónica network

In the area affected by the project, there exist some underground telecommunications canalizations and an aerial telephone line belonging to Telefónica. These canalizations discourse through the left margin of L’Estany del Port Avenue and through the existing sidewalk in the Street 114. Simultaneously, an aerial telephone conduit on wood supports discourses through the Sea side of Street 114.

The projected actions will affect the 8 conduit canalization that discourses through L’Estany del Port Avenue in its crossing with Street 114, the aerial telephone conduit and the 4 conduit prism that discourses in parallel to Street 114.
The replacement proposal was done by Telefónica. The solution consists basically in the underground relocation of the aerial telephone conduit and in the deviation of the underground affected canalizations, with all the necessary modifications of the existing manifolds and recording chambers.

Figure 38. Scheme of the existing Telefónica network *(source: Esteyco)*

Figure 39. View of the existing support at the aerial – underground connection *(source: Esteyco)*
ANNEX Nº9. SIGNALLING, BEACONING AND ROAD SAFETY
Annex nº9. Signalling, beaconsing and road safety

Contents

1. Signalling, beaconsing and defence ................................................. 63
2. Horizontal signaling .......................................................................... 63
3. Vertical signaling ............................................................................... 63
4. Works signaling ................................................................................ 64
Annex nº9. Signalling beaconing and road safety

1. Signalling, beaconing and defence

The current document describes, justifies and develops the signalling, beaconing and road safety of the vials defined in the “Urbanization project of Street 114. Connection between L’Estany del Port Avenue and Street 114 (Port of Barcelona)”.

The network has been designed according to the general parameters given by the existing Norms and Recommendations.

Given that the project area is characterized by a heavy vehicles high level traffic, signalling and beaconing system to develop will solve and give fluency to the road traffic expected to exist and converge in the urbanization area.

2. Horizontal signalling

The horizontal signalling was designed according to the Norm 8.2-I.C given by the “Roads Instruction” and also according to the “Manual of urban signalling in the city of Barcelona”.

The signalling proposed for the vials contemplated in this project is composed by the placement of a painting in stripes of 2 m x 0,1 m to separate lanes, with a separation between them of 5,5 m (D-1 type), reduced to 2 m at the traffic roundabout entrance (D-2 type).

The continuous line to separate lanes will be 0,1 m wide (D-11 type). The parking discontinuous lines will be 1 m length and the separation between them will be 1 m (D-21 type). Shoulders less than 1,5 m width will be delimited by a continuous line 0,1 m width (D-33 type).

Concerning the stopping lines, the E-2 type 0,4 m thickness will be employed for yielding.

Finally, each stripe will be painted by hot and reflective thermoplastic painting including glass microspheres. For crosswalks and letters acrylic painting will be used.

3. Vertical signalling

The vertical signalling was designed according to the Norm 8.1-I.C given by the “Roads Instruction”. Signage was designed according to the Port of Barcelona Specifications.
Given that the roads affected by the project belong to a heavy traffic high level area, in terms of signalling it has been decided to consider the area as a conventional road without sidewalks, despite being an industrial urbanized zone.

Therefore, triangular signals of 90 cm side, circular signals of 60 cm diameter, octagonal signals of 60 cm and square signals of 60 x 60 cm will be placed. They will be enough high to ensure that the difference between the lower bound of the signal and the pavement is 1,5 m. Moreover, and according to the Table 7 of the Norm 8.1-I.C, they will have a reflectance level II.

The defence components employed in the current project are reduced to a simple BMSNA 2/C metal barrier located at the right margin of the provisional branch of the traffic roundabout exit to Street 114.

4. Works signalling

Provisional works signalling will satisfy the requirements given by the “Roads Instruction 8.3-I.C – Works signalling”, the “Manual of fixed works signalling examples”(Ministerio de Fomento) and the “Quality manual of the City Council of Barcelona works”.

64
ANNEX Nº10. PROGRAMMING WORKS
Annex nº10. Programming works

Contents

1. Introduction ................................................................................................................................. 67
Annex nº10. Programming works

1. Introduction

The bar chart is accompanied with the time schedule of works.

Execution time is six months (6 months).

Obtaining the total execution time of the works listed in this project is based on the following premises:

- The works have been ordered in units or groups of activity.

- The efficiencies used are the ones indicated in the justification of prices, or a multiple of them.

- Eight-hour days and months of twenty two working days have been considered.

The timing diagram is scheduled summarizing activities as work units grouped by blocks of joint implementation.
ANNEX Nº11. INSTALLATIONS
Annex nº11. Installations

Contents

1. Lighting .............................................................................................................................70
   1.1. Introduction ..................................................................................................................70
   1.2. Projected lighting .........................................................................................................70
      1.2.1. Projected luminaries .............................................................................................71
   1.3. Civil works ..................................................................................................................73
      1.3.1. Pipes ......................................................................................................................73
      1.3.2. Manholes ..............................................................................................................75
      1.3.3. Lighting columns ..................................................................................................76
   1.4. Electrical installation .................................................................................................76
      1.4.1. Cabling ..................................................................................................................76
      1.4.2. Calculation of conductor section .........................................................................76
      1.4.3. Dashboards and protection ..................................................................................78
      1.4.4. Electrical installation of the luminaries .................................................................78
      1.4.5. Protection of the installation ...............................................................................79
      1.4.6. Installation of the ground network .......................................................................79
   1.5. Mandatory rules .........................................................................................................79
   1.6. Energy qualification of the installation ......................................................................80
      1.6.1. Energetic efficiency ..............................................................................................80
      1.6.2. Energetic qualification ..........................................................................................82
2. Telecommunications network. Port Authority of Barcelona ........................................83
3. Irrigation network and gardening ..................................................................................85
   3.1. Irrigation network .......................................................................................................85
      3.1.1. Overview ...............................................................................................................86
      3.1.2. Description of the network ..................................................................................86
      3.1.3. Sizing of the primary and secondary irrigation network tubes and feeding of sprinkler and diffuser areas ........................................................................................................88
   3.2. Gardening ...................................................................................................................88
      3.2.1. Trees .....................................................................................................................88
      3.2.2. Grass .....................................................................................................................89
Annex nº11. Installations

1. Lighting

1.1. Introduction

The present document describes and justifies the public lighting of the “Urbanization project of Street 114. Connection between L’Estany del Port Avenue and Street 114 (Port of Barcelona)”. These basic works refer to the distribution of public lighting service from the existing control box today on L’Estany del Port Avenue (Street 100) to consumption points such as lighting points installed.

It has been tried to standardize as maximum as possible the lighting elements by using columns of similar heights and powers in roads and sidewalks.

The designed lighting network is composed by the existing command center, from which some lighting circuits are derived (L-1 to L-4). Initially, the possibility of connecting the projected lighting to these circuits was considered. However, the high voltage drops produced and the necessity of modifying the existing cables’ section in the already executed stretches, forced to discard this option. It was preferred then to use the reserve circuits L-5 and L-6, available in the existing command center, in order to carry out the connection of the projected lighting.

The chosen outline is a consequence of the necessity to connect all the spotlights to this network, trying to make the path as minimum as possible, and taking into account the other installations operating in each place.

The cross sections of the projected canalization are drawn in maps depending on the number, diameter, position and finality of conduits.

The lighting is planned to be executed by 9 m height lampposts, with a 40,0 m distance separation between them, and with a luminaire power of 250 W. All this in order to satisfy all the restrictions of the new norm (energetic optimization).

1.2. Projected lighting

When selecting the lighting level, the singular characteristics of the selected stretch analyzed were taken into account. As said before, the public lighting design was done following the indications of the norms referring to the urbanization works inside the service area of Port of
Barcelona, which specify the following lighting level for roadways (hypothesis: lighting class ME₁ comparable to CE₁):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Class CE₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average luminance $E_m$ (lux)</td>
<td>30</td>
</tr>
<tr>
<td>Minimum luminance (lux)</td>
<td>12-15</td>
</tr>
<tr>
<td>Average uniformity coefficient $U_m$</td>
<td>0,40-0,50</td>
</tr>
</tbody>
</table>

**1.2.1. Projected luminaries**

Concerning the luminaries’ election, their location was taken into account in order to respect the lighting requirements. The selected luminary is the Euro-7 type, which presents the following characteristics:

- High light output (a high percentage of the flux given by the lamp is reflected on the roadway).
- Good photometric curve (the flux is distributed properly).
- Good dazzling control.
- Mechanical and electric properties that ensure a medium – long term life of the installation.
- Resistant to a possible vandalism.

The luminaire shall be weather resistant and closed (protection grade IP66 and IP44 for optical assembly, IP64 optionally for the rest), with the reflector independent from the housing. It will be capable of operating with high pressure sodium lamps, metal halide or steam mercury up to 750W of power. The luminaire will incorporate the power equipment in a housing intended for that purpose, and the optical assembly will remain closed when the equipment is handled. The luminaire shall be suitable for mounting on pole or column.
The luminaire and equipment will have the same manufacturer. Also, wiring and equipment installation will be performed by the manufacturer to ensure proper quality.

The housing will consist of two parts (cover and lower case), both casting aluminum alloy injected at high pressure. The alloy to be used will be low copper, less than 4%, for good corrosion resistance.

These pieces will be painted with polyester powder paint applied electrostatically and oven cured. The finish shall verify that, subjected to accelerated aging of a thousand hours, according to the UNE 48024-80, 48059-82 and 48099-85, the following specifications:

- The brightness will not be less than 60% of initial brightness, according to UNE 48059.
- Initial testing of graph, according to the standards UNE 48024 and UNE 48099 shall be zero degree, and after aging shall not exceed grade two.
- The color change according to UNE 48059 shall not exceed the degree 3.N.BS.

The optical assembly shall consist of a reflector, tempered glass sealed reflector with silicone, a neck die cast aluminum alloy and support plastic socket with high temperature resistance. The tempered glass must be resistant to thermal and mechanical shock. It will be a curved shape for its perfect adjustment with the reflector and its internal housing. The aluminum reflector is in one piece and faceting. Its finishing will be achieved through anodizing and sealing. With this method of protecting the illuminating surface is anodized and sealed with a minimum layer thickness. The neck die cast aluminum will be rigidly connected to it.
Over the lamp holder, shall be mounted a silicone gasket for ensure the sealing with the reflector neck. The assembly will be secure and safe from incidental operations detachments during maintenance. Its basic features are:

- The molecular structure will be made by closed cells.
- Water absorption according to the test method ASTM-D-1056, or the NF-R-99211, with 127mm of mercury, and after three minutes, would not exceed 10%.
- The compression permanent strain of the seal according to UNE 53511-74 will not be greater than 65%.

For the election of the lamp, the following specifications have been considered:

- That with the chosen power approaches high light levels with high efficiency.
- That the generated luminous flux is distributed properly.

The type of lamppost used will be the type NAV-T 250 W. The lighting characteristics are the following:

<table>
<thead>
<tr>
<th>Roadway (flux)</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37.04</td>
<td>19.00</td>
<td>73.51</td>
</tr>
</tbody>
</table>

1.3. Civil works

1.3.1. Pipes

The lighting canalizations will be formed by 4 tubes of 110 mm diameter that will be registered in the adequate manholes. These canalizations will be concreted with HM-25 concrete for a better protection.
Figure 41. Detailed ditch on sidewalk (source: Esteyco)

The execution of the prism will be done as following: once excavated the prism ditch, a cleaning concrete layer will be executed. The tubes will be placed on this layer and separators between tubes will be installed to ensure that concrete penetrates in all the holes, with a minimum concrete covering of 0,03 m between tubes and 0,08 m with respect to the bottom of the excavation and gables.

Abrupt variations in the vertical and horizontal of the prism will be avoided. The maximum depth of pipes may vary, always respecting the points of the crossings, proximities and parallelisms. The ideal would be to not get low points in the sections between manholes, ensuring that the manholes are the lowest points in order to avoid water retention in inaccessible points.

The bare copper wire is placed once the excavation of the trench pipeline is finished and it will be positioned so as to ensure its function is well performed.

Both for the manholes of 40 x 40 cm and for the prism in general, the minimum depth of the cable will be 40 cm for the upper base and 60 cm for the lower base.

The depths of manholes and prism are limited; if due to depth needs manholes exceed the stipulated, chests of 60 x 60 cm will be placed. If it is necessary to run the prism deeper than the established, it will be notified to the Construction Management before starting the works.

As long as possible, in crossings with wires and vias, the crossing will be perpendicular to the axis of the vial. In these crossings and also when there is a change of direction, manholes of 60 x 60 cm will be executed.

In crossings with vias, the depth of the prism will be higher to allow the development of all the layers of the pavement. That is why the manholes of 60 x 60 cm will be deeper.

Although pipes are cased and concreted, a warning tape warning of the existence of the prism must be placed.
1.3.2. Manholes

Their interior dimensions will be 35 x 35 cm (frame dimensions 40 x 40 cm), with a maximum depth of 60 cm. For depths larger than 60 cm, as well as in the intersections, points and manholes located in roadways, the interior dimensions of the manholes will be 55 x 55 cm (frame dimensions 60 x 60 cm).

Figure 42. Manholes projected, type 1 (source: Esteyco)

Figure 43. Manholes projected, type 2 (source: Esteyco)
Manholes can be made by prefabricated concrete or by solid brick. In both cases, the existing space between the excavation and the manholes’ walls will be filled completely by HM-25 concrete. A manhole will be placed next to each spotlight.

In all manholes a drain that allows the evacuation of water will be executed. An excavation of the existing soil will be made and a geotextile and a bed of gravel about 20 cm thick will be placed on the seat of manholes. Gravels must be covered by the geotextile so as to ensure the proper functioning of the drain. The base of the manhole shall slope to an overture located in its center. This overture will allow the water drainage.

The drain will be performed just after excavation and before running the manhole; therefore proper functionality is ensured.

The frames of the lids must be well subjected; besides the manholes will be delivered without debris, well finished, with tubes cut properly

1.3.3. **Lighting columns**

The lighting columns projected to the vials will have a truncated shape of 9 m height, a galvanized steel sheet of at least 3 mm thickness and a covering of 450 g/m² of Zinc, tip diameter of 60 mm, and they will provide a flushed registration door interiorly reinforced.

1.4. **Electrical installation**

1.4.1. **Cabling**

The cables will be RV-K 0,6/1 KV in all the sections of the underground installation. They have been calculated in order the voltage drop not to be higher than 3% of the admitted by the luminaries components and 5% of the admitted by the rest of the components (as provided by REBT).

These lines have been calculated in accordance with the increase in power considered in REBT (80% of the base power of the lamp) in order to predict the starting peak points produced during the ignition phase.

1.4.2. **Calculation of conductor section**

To calculate the power and the conductor section the Low Voltage Electro technical Regulations currently operating have been followed. Also the Interpretation pages of the Ministry of Industry have been taken into account.
For the calculation of the conductors sections the following steps were followed:

- Calculation of the intensity of the circuit through the following formulas:
  - Phase circuit:
    \[ S = \frac{P \times L}{\sigma \times V \times e} \]
  - Tri-phase circuit:
    \[ S = \frac{2 \times P \times L}{\sigma \times V \times e} \]

Where \( I \) is the Intensity (A), \( P \) is the Power (W), \( U \) is the voltage between phase and neutral (V), \( V \) is the voltage between phases (V) and \( \phi \) is the angle between voltage and intensity.

Once known the current in amperes, the conductor was chosen using Table I of the Instruction MI BT 017 and Table V of the Instruction MI BT 004.

It has been taken into account if the cable is unipolar or hose, if the circuit is phase or tri-phase, the insulation material, the type of installation and the correction factors due to groups of cables.

- For calculating the sections due to voltage drop of the same conductor, the following formulas have been used:
  - Phase circuit:
    \[ I = \frac{P}{U \times \cos \phi} \]
  - Tri-phase circuit:
    \[ I = \frac{P}{V \times \sqrt{3} \times \cos \phi} \]
Where $S$ is the section of the cable (mm$^2$), $L$ is the length of the conductor (m), $e$ is the voltage drop (V), $P$ is the Power (W), $U$ is the voltage between phase and neutral (V), $V$ is the voltage between phases (V) and $\sigma$ is the conductivity of the conductor (m/$\Omega \times$ mm$^2$).

1.4.3. Dashboards and protection

The dashboard used will be the existing one (Port Authority of Barcelona), located in L’Estany del Port Avenue (old Street 100). This scorecard has two reserve circuits (C-5 and C-6), and a maximum admissible power of 13.85 kW. The current installed power is 6.900 W. It allows serving the demanded power of 4.000 W.

1.4.4. Electrical installation of the luminaires

Metal columns will have an opening access for handling their protection elements, at a minimum height above ground of 0.30 m, and equipped with a closing door, with degree of protection IP44 according to UNE 20.324 (EN 60529) and IK10 according to UNE-EN 50.102. The door can be opened by using special tools.

The support of luminaires for exterior lighting will comply with the existing regulations (in case they are made by steel they must satisfy the requirements given by the RD 2642/85, RD 401/89 and OM 16/5/89).

The electrical installation will comply with the following minimum requirements:

- Drivers will be made by copper and with a minimum section of 2.5 mm$^2$. Their assigned voltage will be at least 0.6 / 1 KV; and there will be no connections within the supports.

- In the entry points of cables inside the supports, cables will have an additional protection made by insulating material extending through the tube or another system to guarantee it.

- Connection to terminals will be executed so that no traction effort is applied to conductors. For the connection of the network conductors with the support ones, all the necessary protection elements will be used.

The electrical equipment of the luminaires used in this installation will be high factor power.
When luminaires are Class I, they must be connected to the ground network by unipolar insulated cable of assigned voltage 450 / 750V with yellow-green coating colour and a minimum cross section of 16 mm$^2$ copper.

1.4.5. Protection of the installation

To protect the electrical installation against overcurrent and short-circuits, magneto-thermal automatic circuit breakers will be installed. Their nominal intensity will be adequate to the maximum intensity supported and will depend on the section.

These magneto-thermal switches will be installed in the main electrical panel of the installation.

For connection of conductors, in each point of light there will be a box with fuse bases that will protect the internal equipment of each of the columns.

1.4.6. Installation of the ground network

Instruction ITC-BT-09 of this Regulation requires that the columns and other accessible equipment supported by those supporting a luminaire installation of street lighting, must be attached to the general ground network if they are metallic. This is in order to limit as minimum as possible the voltage with respect to ground that the metal frames of the electrical system may present, and also to ensure the performance of protections.

Each point of light will have a welded ground plate by a "Cadwell" welding to a bare copper wire 35 mm$^2$ nominal section.

The numerical value of the overall resistance to ground of this general point will not be bigger than 30 ohms as indicated by the ITC-BT-09.

The conductor that connects each bracket with the plate or ground network will be a unipolar insulated cable of assigned voltage 450/750 V, with yellow-green coating colour and a minimum cross section of 16 mm$^2$ copper.

All ground circuit connections of will be done by pressure terminals and a screw, ensuring a constant contact and a good corrosion protection.

1.5. Mandatory rules

Electricity installations:


• Administrative procedure for the application of the Low Voltage Electro technical Regulation. Instruction 7/2003, 9th September.

• Certificate about the accomplishment of regulatory work distances and electric lines constructions. 04/11/1988 Resolution (DOCG 30/11/1988).

• Regulation on technical conditions and safety guarantees in electrical plant and transformer centres. RD 3275/82 (BOE: 01/12/82).

• Standards for ventilation and access to certain processing centres. 19/06/84 Resolution (BOE: 26/06/84).

• Transportation, distribution, marketing, supply activities and authorization procedures of electric power installations. RD 1955/2000 (BOE: 27/12/2000)

Lighting installations:


• Standard regulations for urbanization works in the Port of Barcelona area.

• CIE Recommendations, gathered on the “Technical Guide of Energetic Lighting Efficiency”.

1.6. Energy qualification of the installation

1.6.1. Energetic efficiency

The energetic efficiency of an outdoors lighting installation is defined as the relation between the product of the illuminated surface and the average luminance in service divided by the total active power installed:

\[ \varepsilon = \frac{S \times E_M}{P} \]
Where:

- \( \varepsilon = \) Energetic efficiency of the outdoors lighting installation \( (m^2 \times \text{lux} / \text{W}) \).
- \( E_M = \) Average luminance in service of the installation, considering the maintenance (lux).
- \( S = \) Reference roadway illuminated surface \( (m^2) \).
- \( P = \) Total active installed power (W).

The minimum requirements established by the real decree 1890/2008 on November 14th 2008 are used for the functional and ambient vial lighting and are determined by ITC-EA-01 in the following tables:

**Table 9. Minimum energetic efficiency requirements in functional street lighting installations (source: Esteyco)**

<table>
<thead>
<tr>
<th>ILUMINANCIA MEDIA</th>
<th>( E_M (\text{Lux}) )</th>
<th>( \varepsilon )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \geq 30 )</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>( \leq 7.5 )</td>
<td>9.5</td>
<td></td>
</tr>
</tbody>
</table>

*Nota – Para los valores de iluminancia media comprendidos entre los valores indicados en la tabla, la eficiencia energética de referencia se obtendrá por interpolación lineal.*

**Table 10. Minimum energetic efficiency requirements in environmental street lighting installations (source: Esteyco)**

<table>
<thead>
<tr>
<th>ILUMINANCIA MEDIA</th>
<th>( E_M (\text{Lux}) )</th>
<th>EFICIENCIA ENERGÉTICA REF. (( \varepsilon_R ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \geq 20 )</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>7,5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>( \leq 5 )</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

*Nota – Para los valores de iluminancia media proyectada comprendidos entre los valores indicados en la tabla, la eficiencia energética de referencia se obtendrá por interpolación lineal.*

The given reference values are compared with those obtained in the installation to be treated. These reference values for functional and environmental street lighting are:
Table 11. Energetic efficiency reference values *(source: Esteyco)*

<table>
<thead>
<tr>
<th>Iluminancia media en servicio projectada</th>
<th>Eficiencia energética de referencia $E_m$ (lux)</th>
<th>Iluminancia media en servicio projectada</th>
<th>Eficiencia energética de referencia $E_m$ (lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\geq 30$</td>
<td>$32$</td>
<td>$\geq 20$</td>
<td>$13$</td>
</tr>
<tr>
<td>$25$</td>
<td>$29$</td>
<td>$20$</td>
<td>$15$</td>
</tr>
<tr>
<td>$15$</td>
<td>$23$</td>
<td>$10$</td>
<td>$9$</td>
</tr>
<tr>
<td>$10$</td>
<td>$18$</td>
<td>$7,5$</td>
<td>$7$</td>
</tr>
<tr>
<td>$\leq 7,5$</td>
<td>$14$</td>
<td>$\leq 5$</td>
<td>$5$</td>
</tr>
</tbody>
</table>

Nota - Para valores de iluminancia media projectada comprendidos entre los valores indicados en la tabla, la eficiencia energética de referencia se obtendrán por interpolación lineal.

The energetic qualification is determined by comparing the values obtained from the installation analyzed with the following table.

The obtained results in the projected installation are acceptable according to the real decree 1890/2008, and are the following:

<table>
<thead>
<tr>
<th>Studied area</th>
<th>Illuminated surface (m²)</th>
<th>$E_m$ (lux)</th>
<th>Total active installed power (W)</th>
<th>$\varepsilon$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic roundabout</td>
<td>3.060</td>
<td>37.04</td>
<td>4.000</td>
<td>28.33</td>
</tr>
</tbody>
</table>

### 1.6.2. Energetic qualification

The outdoors lighting installations, except Christmas lighting and illuminated signs, will be qualified according to their energetic efficiency index ($\varepsilon$).

$\varepsilon$ is defined as the quotient between the energetic efficiency of the installation ($\varepsilon$) and the reference energetic efficiency ($\varepsilon_R$), which is a function of the average luminance in service projected. $\varepsilon_R$ is indicated in the real decree 1890/2008, ITC-EA-01.

To facilitate the interpretation of the energy qualification of the lighting installation and in accordance with other regulations, a label characterizing the energy consumption of the installation is defined. This label is on a scale of letters going from A (most efficient) to G (least efficient). The index used to scale the letters is the energy consumption index $ICE$ that is equal to the inverse of $\varepsilon$. This qualification is determined in the following table, belonging to the Royal Decree ITC-EA-01:
### Table 12. Energetic qualification *(source: Esteyco)*

<table>
<thead>
<tr>
<th>CALIFICACIÓN ENERGÉTICA</th>
<th>ICE</th>
<th>$I_\varepsilon$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$ICE &lt; 0.91$</td>
<td>$I_\varepsilon &gt; 1.1$</td>
</tr>
<tr>
<td>B</td>
<td>$0.91 \leq ICE &lt; 1.09$</td>
<td>$1.1 \geq I_\varepsilon &gt; 0.92$</td>
</tr>
<tr>
<td>C</td>
<td>$1.09 \leq ICE &lt; 1.35$</td>
<td>$0.92 \geq I_\varepsilon &gt; 0.74$</td>
</tr>
<tr>
<td>D</td>
<td>$1.05 \leq ICE &lt; 1.79$</td>
<td>$0.74 \geq I_\varepsilon &gt; 0.56$</td>
</tr>
<tr>
<td>E</td>
<td>$1.79 \leq ICE &lt; 2.63$</td>
<td>$0.56 \geq I_\varepsilon &gt; 0.38$</td>
</tr>
<tr>
<td>F</td>
<td>$2.63 \leq ICE &lt; 5.00$</td>
<td>$0.38 \geq I_\varepsilon &gt; 0.20$</td>
</tr>
<tr>
<td>G</td>
<td>$ICE \geq 5.00$</td>
<td>$I_\varepsilon \leq 0.20$</td>
</tr>
</tbody>
</table>

The projected installation has the following energetic qualification:

<table>
<thead>
<tr>
<th>Studied area</th>
<th>$I_\varepsilon$</th>
<th>Energetic qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic roundabout</td>
<td>2,17</td>
<td>A</td>
</tr>
</tbody>
</table>

### 2. Telecommunications network. Port Authority of Barcelona

The actions described in this chapter belong to the prescribed actions to execute at the telecommunications network belonging to the Port Authority of Barcelona in the "Urbanization project of Street 114. Connection between L’Estany del Port Avenue and Street 114 (Port of Barcelona)".

The projected actions pretend to allow in the future the closure of the Port Authority of Barcelona telecommunications network, once the extension works of Street 114 are over.

The projected action will consist basically in the execution of a telecommunications prism of 9 conduits, including in the last 3 tritubes $\phi 40$ PE, that once intersects l’Estany del Port Avenue, discourses through the sidewalk until the connection with Street 114.
The planned pipeline will consist of an HM-20 concrete prism with 9 polyethylene tubes of diameter 125 mm, including in the last 3 a Ø 40 PE tritube according to the following section:
Figure 45. Canalization cross section of the telecommunications prism between L’Estany del Port Avenue and Street 114 (source: Esteyco)

The telecommunications network will provide manholes every 50,0 m and wherever there is a reversal point. These manholes will be made by prefabricated concrete or solid brick of dimensions 140 x 70 x 1,0 m approximately.

All manholes shall have a final height not exceeding 1,10 m. The height of these manholes can vary when the special characteristics of site require so, or when crosses or other situations constrain the depth of the pipeline.

The drain will be executed just after excavation and before running the manhole.

The cover frames must be well subjected. The lids must be for a breaking load of minimum 70 tones. The space between the excavation and the walls of the manhole will be filled completely with HM-25 concrete.

3. Irrigation network and gardening

3.1. Irrigation network

In the irrigation network of the current project there exist two different kinds of irrigation: sprinkling irrigation and dripping trees irrigation.
3.1.1. Overview

The irrigation hydraulic installations will be made by low density polyethylene pipelines for diameters smaller than 75 mm and by low or medium density polyethylene pipelines for diameters smaller than 90 mm. All the conduits and installation accessories will use a minimum working pressure of 10 atm., and according to the existing official norms.

The hydraulic conduits will discourse preferably through land areas, avoiding as much as possible paved areas.

In areas of hard pavements such as sidewalks rigid tubes will be placed. Their inside diameter will be twice the outside diameter of pipes. They will have 0.60 x 0.60 x 0.60 m manholes every 40 m at maximum.

In areas of soft pavements with drainage systems made by gravels or other materials pipes will discourse above them as long as there is a minimum thickness of 40 cm of soil. If the thickness of soil is less than 40 cm, installations will be drawn between the tubular drainage with inside diameter twice the diameter of the pipes.

When hydraulic installations have to discourse through the street, tubular materials with 0.60 x 0.60 x 0.60 m manholes will be placed on both sides of the roadway at the sidewalks.

Within the same irrigation sector, the different water distribution systems cannot be mixed.

3.1.2. Description of the network

The irrigation network to be executed is projected as an extension of the existing one in L’Estany del Port Avenue. Therefore, the secondary dripping irrigation network for the road trees in the existing sidewalks will be extended. On the other hand, both in the middle of L’Estany del Port Avenue and in the traffic roundabout, an extension of the primary and secondary networks is projected in order to feed the existing hydrants and sprinklers.

To sum up, the projected irrigation network is divided into different primary and/or secondary networks, which will be described in the following chapters.

Primary irrigation network:

This network starts from the existing manifold at the gardened middle part of L’Estany del Port Avenue and brings the irrigation water to the existing sectorial by-passes of the different secondary networks. In parallel to this network, a PE 60 mm conduit carrying the necessary
electric cables (1 KV 4 x 2.5 mm² cable) will discourse in order to drive all the sectorial by-passes' solenoids of the existing secondary networks.

This primary irrigation network will be done by a PE BD pipeline of diameter 75 mm and nominal pressure 10 atm.

The existing hydrants hang from this primary irrigation network. These hydrants are bayonet quick coupling, type SR-2310 and SR-2350, bought from Euro-Rain or similar. They will be fed exclusively by drinking water. The hydrants will be placed in land accessible areas for the maintenance staff, and they are separated between them a maximum distance of 50 m. This distance will be shorter wherever there are difficulties and it will not be taken into account wherever irrigation is no needed through a hydrant.

This primary hydrant network will be done by a PE BD pipeline of diameter 50 mm and nominal pressure 10 atm.

**Secondary sprinkling irrigation networks:**

These networks start from the different sectorial “by-passes” distributed through the project area. Through these networks all the land areas with grass or similar flora less than 20 cm height and more than 4 m width will be irrigated. These networks’ design was done by zoning the sprinkling irrigation surfaces as a function of the counter capacity and trying to reduce as much as possible the number and length of necessary tubes.

This secondary sprinkling irrigation network will be done by a PE BD pipeline of diameter 50 mm and nominal pressure 10 atm. The branches connecting this secondary network with the sprinklers will be done by a PE BD pipeline of diameter 25 mm and nominal pressure 10 atm.

The installed sprinklers will be the PGP model from the brand Hunter or similar. The radius and angle of inclination will be fixed depending on each particular case, having in total a maximum coverage radius of 10.4 m.

**Secondary dripping trees irrigation networks:**

These networks start from the different sectorial “by-passes” distributed through the project area. Through these networks all the trees located in paved areas will be irrigated by drip rings. The trees located in green areas will be irrigated by the sprinkling/diffusion irrigation networks or by the land areas dripping irrigation networks.
The drip rings will be open with 7 droppers of approximately 3.5 l/h inserted every 30 cm. They will be protected by a drain tube of diameter 50 mm at an approximately 20 cm depth.

These networks are independent from the sprinkling irrigation networks. Therefore, the consumption of water of these networks will be much less than the sprinkling irrigation networks.

### 3.1.3. Sizing of the primary and secondary irrigation network tubes and feeding of sprinkler and diffuser areas

Hunter sprinklers are initially used, with a radius of maximum scope 10.4 meters; 10cm elevation and adjustable and interchangeable angle.

To design primary irrigation network, irrigated areas will be zoned limiting the flow of each of them at 6300 m$^3$/h (maximum of the existing flow measured at L’Estany the Port Avenue).

According to data provided by the manufacturer, for the proper functioning of the sprinklers, a pressure of 2.1 atm is required.

### 3.2. Gardening

#### 3.2.1. Trees

The new wooded, alignments and species are defined as a function of the design criteria for the public area where the project is developed.

The existing alignments will be extended in L’Estany del Port Avenue, where the plantation of the “Populus Nigra” is suggested. These trees will be planted with a portage of 2 m height so their adaptation to the environment and their success is assured.

An irrigation of 50 l/unit will be done. During the 5 warmest months of the year 5 irrigations of 20 l/unit are expected depending on their adaptation and exposition.

Alignment trees will be planted every 5 meters, which allows their proper growth without interfering with the other elements of the new sidewalk. A rectangular zone made by precast concrete is suggested (100x100cm) in order to generate a clean and tidy sidewalk and also in order to leave the largest possible space for comfortable movement pedestrians and bicycles.

The completion of the hole will be executed by a machine or manually with a minimum dimension of 0.8x0.8 m so that the organic wrap is ensured and thus its proper behaviour.
When performing the plantation, a 50% of the soil removed will be replaced by a mixture of 40% of sand and 60% of topsoil.

Maintenance of the first year will include irrigation, pruning and pesticide treatments.

Frequencies of automatic irrigation will be determined once the facility is in operation and will be concretized by the gardens maintenance staff of Port of Barcelona, as they will be responsible for future exploitation.

3.2.2. Grass

The type of grass to be planted, following the “Parcs i Jardins” criteria, will be the C-4. This type of grass has the quality to improve its resistance to droughts and, therefore, less irrigation water will be required. Moreover, this specie shows a good behaviour to hot and cold weather.
ANNEX Nº12. PRICES JUSTIFICATION
Annex nº12. Prices justification

Contents

1. Adopted criteria...........................................................................................................................................92
Annex nº12. Prices justification

1. Adopted criteria

For the realization of this annex about the prices justification of the “Urbanization project of Street 114. Connection between L’Estany del Port Avenue and Street 114 (Port of Barcelona)”, GISA prices base for Civil Works (2010) and Port of Barcelona base (2011) was used.