UTILITY NETWORKS IN URBAN PLANNING PLANS: EVOLUTION OF ITS GRAPHIC REPRESENTATION

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ABSTRACT:
Usually, the plans of the utility network have been incorporated into planning documents as basic diagrams that establish a design and principle of estimated dimensions, principle that will later be developed technically and with absolute precision in a document not pertaining to the actual urban planning document, often drafted by specialized engineers and not by urban planning technicians. However, increasingly stringent conditioning factors, both in terms of how space should be occupied and the quantity and quality in the design of these utility networks, force us to deal with this as another factor determining urban planning and not, as used to happen, as a simple annex that can developed "a posteriori". The present article studies and reflects on the evolution of the graphic representation of utility networks in urban planning plans. It is based on the analysis of a significant enough sample performed under scientific criteria from assumable field work, sufficiently indicative and representative and which spans a significant period in time.

Key-words: *Urban mapping, utility networks, city planning, graphic representation, urban drawing.*

1. INTRODUCTION

One of the disciplinary boundaries that is difficult to establish clearly regarding some points is the one that separates urban planning and civil engineering, as the latter is commonly understood. One may think that the function of each of the two disciplines is very clear, however, both have common areas or fields that clearly overlap. Civil engineering mainly covers the design and construction of infrastructures of all kinds, and, without any doubt, certain especially technological areas of architecture and urban planning.

The fact is that historically, architects have always felt that the inclusion of infrastructures into the planning that they had designed used to be a most secondary part of the whole project process. A task that could be carried out without too much trouble once the conceptual task of urban planning design had terminated. Work in which it was not always necessary to resort to "special sensitivity" and "essential knowledge"; a lesser task. If we spoke in "CAD jargon", it could be symbolized as the last layer of the drawing that needs completing in order to finish the job. And in this case, many of the architects understood the concept of "last" not in the purely temporal sense, though as well, but in the strict value in the order of importance. Perhaps this "slightly overlooking" the study of infrastructures has been caused by some kind of instrumental and disciplinary subdivision that, generally speaking and particularly in some countries, has established a clear separation between the process of urban design, the classification and grading of land, also

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including all of the legal aspects involved, from the more "technical-constructive" process of adapting the land via the required urbanization works.

It should be pointed out, moreover, that the bibliography regarding this matter is scarce indeed. Normally, the authors who have dealt with this, such as Herce and Magrinyà (2002), Jude and Matkin (1983) or Santamera (1998), for example, have done so from the technical and design perspective of utility networks and not from the graphic point of view of their representation. It is also especially interesting to be able to see how academics of the history of urban planning and of the development of cities often include examples of plans of urban utility networks in their publications. This is the case of such authors as Bosma and Hellinga (1997), Boyer (1986), Bosselmann (1997), Peterson (2003) and Scott (1995).

Only French authorities such as the “Conseil National de l'Information Géographique. Groupe de travail -Informatisation PLU-“(2011) or the “Conseil National de l'Information Géographique. Groupe de travail -Numérisation des PLU-“ (2011), have worked on the approach of graphic solutions based on semiological and visual perception studies which optimizes the solutions applicable to planning drawings, and among them, to the representation of utility networks.

2. RESEARCH METHODOLOGY

The essential purpose of any scientific paper is to convey the results of research, ideas and debates clearly, concisely and accurately. However, even if this task is tackled with enthusiasm and effort, it is not always achieved with sufficient fidelity, since what is written is usually vaguer than what is thought. This is often a tricky obstacle to overcome, especially if the writer is primarily technically trained. And the difficulty increases yet further if both the subject matter of the research and the data and results obtained from it are not, as is the case, purely scientific in nature. The subject of graphic expression and its realization is, in most cases, based on observations and data provided by the senses, data that often have more to do with perceptions and feelings rather than with totally reliable data. So, assuming this difficulty from the outset, it is necessary to pose with sufficient clarity the initial questions to be solved, as well as the limits and constraints of the research framework.

In the case in hand, the lack of specific and concrete literature as well as research or articles published on the subject in question requires the production of a series of data from the fusion and interpretation of themes bordering with the body and the background of the present work. The problem of graphic encoding has been dealt with by relating and commenting on the documents it has been possible to find of the graphic representation of service networks on planning drawings. A sufficiently significant number of planning drawings was collected and observed, and then the different graphic features used in their representation were identified and classified.

So, and first of all, planning drawings published in various books or articles were collected that are significant of the different periods, techniques, methods of representation, reproduction or printing, etc. This first collection of drawings was carried out mainly from a qualitative aspect, considering a more global geographic scope. The collection of

drawings and the establishment of the sample under scientific criteria were carried out via manageable, sufficiently indicative and representative fieldwork that spans a sufficiently significant period of time. The collection and cataloguing of planning documents begins systematically from 1980 and extends to 2005. The fieldwork consisted of the observation, photography and analysis of a sample of drawings from specific planning documents. The sample includes different types of drawings that show approved plans of small or medium-sized towns in Catalonia. The definition and selection of the sample was done on the basis of probabilistic criteria and forming a significant sample.

From the data obtained, we proceed with a detailed analysis of the evolution of the graphic aspects examined, establishing a time thread in the transformation and evolution of the graphic parameters and resources used in the graphic representation of service networks. The final cataloguing of the results and variables must be done from the analysis of the graphic resources used to draw the service networks, with special emphasis on data collection relating to the types of graphic resources used to realize them, and that includes the study of the characteristics of the lines, the use of patterns and textures, the texts, the techniques of reproduction and delineation techniques, etc.

3. THE GRAPHIC REPRESENTATION OF UTILITY NETWORKS

Usually, the plans of the utility network have been incorporated into planning documents as basic diagrams that establish a design and principle of estimated dimensions, principle that will later be developed technically and with absolute precision in a document not pertaining to the actual urban planning document, often drafted by specialized engineers and not by urban planning technicians. However, increasingly stringent conditioning factors, both in terms of how space should be occupied and the quantity and quality in the design of these utility networks, force us to deal with this as another factor determining urban planning and not, as used to happen, as a simple annex that can developed "a posteriori".

3.1 The early times

Since the industrial revolution, when human densification increased significantly, due to the need for concentrated manpower to work in the new factories, the cities' health and sanitation conditions became especially necessary. The drinking water supply networks and sewage systems were beginning to require sufficiently careful studies in order to meet the demands of the new areas for developing. At the same time, public lighting, first with a gas grid and then electricity, the supply of electricity to houses later on, as well as other services such as the early telephone networks, would have to superpose the public spaces -streets- and occupy a part of them, whether at pavement level -aerially-, or beneath -underground-.

While the water supply and sewage networks have much older historical backgrounds, the public lighting, electricity supply and communications networks were developed during the nineteenth century. More properly we could speak of the second half of the nineteenth century (see **Fig. 1**) and the early twentieth century.

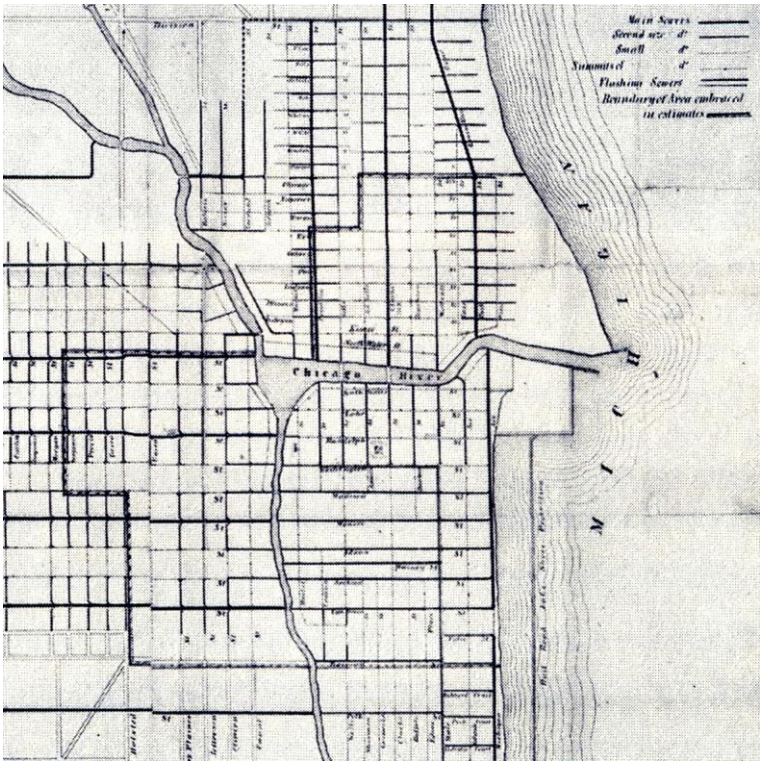

Fig. 1 Portion of the Plan of the sewerage system of the city of Chicago (Illinois, USA)[3] (Peterson, 2003: p.37).

It was during this period that some plans began to appear showing utility networks. And, of course, it is in the cases in which the design of the networks has the need for a more accurate system of calculation that leads to the emergence of infrastructure plans that clearly illustrated the proposed network on the city map.

In essence, these were ink drawings on a base plan of the city, reproduced primarily using the etching technique. In some cases, we can also find original plans made with no prior printing of a base plan. These plans were primarily drawn by teams of cartographers, with the sole purpose of representing the necessary features that the technical team required to carry out the project.

[3] *Plan of the sewerage system of the city of Chicago (Illinois, USA). Project dated 1855 by the engineer Ellis Sylvester Chesbrough (1813-1886). In 1855, Chicago was a growing city and had many problems with its water supply and sewage disposal. After a dysentery epidemic, Ellis Sylvester Chesbrough, the designer of the water distribution system in Boston (USA), was commissioned, solving the city's public health problem. Chesbrough, a self-taught engineer, designed and supervised the construction of the first comprehensive sewer system in the American nation, allowing the city to continue to grow. The system planned by Chesbrough was based on gravitational flow, but the centres of the streets were too low to drain into the river. The sewers were constructed on the existing ground level and then covered, increasing the level of the city, in some places by up to 10 metres.*

Therefore, the plan ended up adding the solutions contributed by the project. Both types of plans are in monochrome, exclusively in black and white. In this case, the thickness of the elements represented is what gives the necessary value to the line and categorizes the importance of elements drawn, as shown in **Fig. 2.**

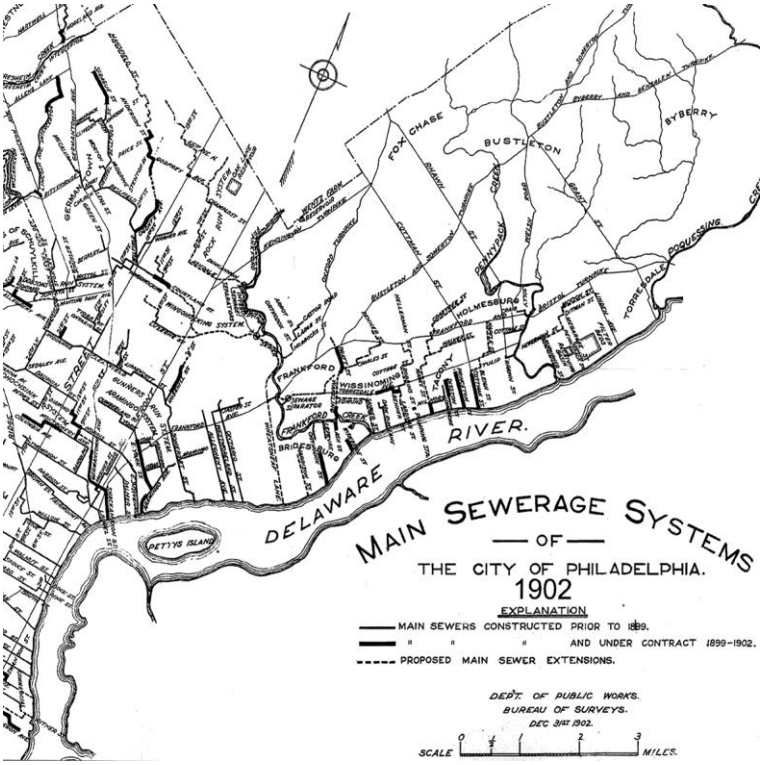

Fig. 2 Portion of the plan of the main sewerage network in the city of Philadelphia (Pennsylvania, USA) in 1902 [4] (Levine, 2011).

It is known that during the first half of the twentieth century the use of colour was a fundamental tool of representation applied to urban plans. While the difficulties of the production and reproduction of colour plans were substantial, the benefits of applying colours were especially significant. It is also evident that planning drawing has always been well ahead of purely architectural or industrial drawing in respect of the application of colour in its representations. Thus, despite the considerable difficulty of finding plans of utility networks in the periods spanning from the second half of the nineteenth century until approximately the end of the Second World War, it is even harder to locate plans that breathe this graphic style brought by the application of colour.

[4] *Plan of the main sewerage network in the city of Philadelphia (Pennsylvania, USA), in 1902. The plan shows the main sewage collectors categorized according to three different periods: the first refers to collectors that existed before 1899, the second illustrates the collectors built or under construction during the period 1899-1902, and finally, the third, using discontinuous lines, represents the new collectors proposed by the city's public works department.*

A style which, used in the representation of utility networks, also becomes rather a useful visual mechanism. However, it should be remembered that colour can be used in all applicable graphic elements, but it is on surfaces that their implementation is most efficient. Indeed, colour differences are more noticeable on surfaces, and if the coloured elements are dots or lines, very different and contrasting colours should be used to avoid confusion. Since, except in very rare circumstances, utility networks are located in public spaces, the plans that present their delineation are configured from base plans where the representation of the road network and public spaces is the main element. They are relatively light plans insofar as the graphic density they display. Generally, in many cases some issues are omitted such as the categorization of the land, boundaries, the surrounding perimeters of buildings, parcelling, etc., or are drawn on a second level of importance (see **Fig. 3**). It should be said, however, that this is not always so, and it depends, in general, on the particular choice by the technician when setting the graphic priorities to be reflected in the base plan on which the designed infrastructure will be represented. Priority is given, therefore, to the representation of elements of the planned utility network and the definition of the public space in which it runs.

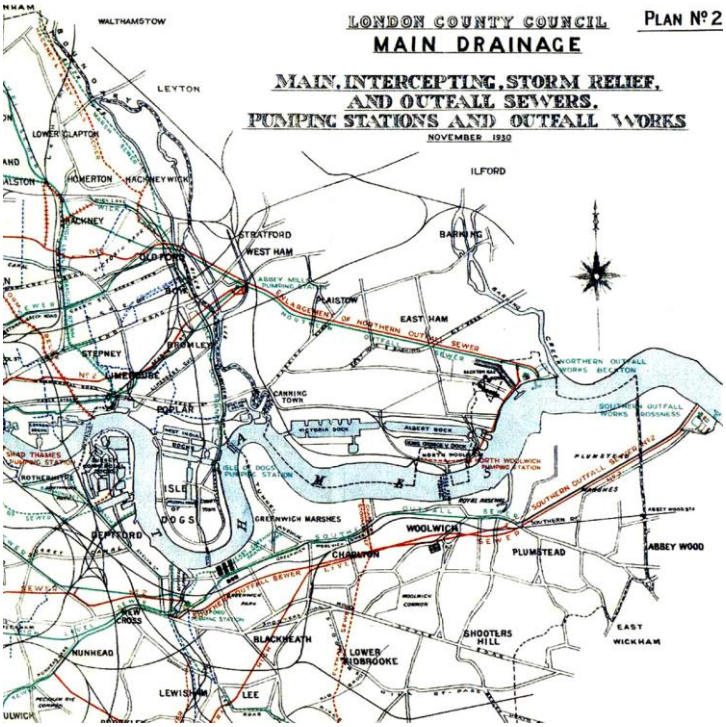

Fig. 3 Part of the Plan of the main sewerage network of the city of London (England) dated 1930[5] (Schladweiler, 2011).

[5] *Plan of the main sewerage network of the city of London (England) dated 1930. In the drawing the main rainwater and wastewater collectors, pumping stations and overflows are represented. The network is illustrated in colour on a map of the city on which all that remains drawn are the city's major roads and, of course ,the River Thames. Ink of various colours and wash on paper.*

This is a feature that has been observed in most of the plans reviewed, which constitute a significant enough sample performed under scientific criteria from assumable field work, sufficiently indicative and representative and which spans a significant period in time. In any of the periods, and more or less pronounced depending on the possibilities of copying and reproduction techniques available in each era, in the preparation of plans the priority has been the clear representation of the roads and public space above other elements.

3.2 The changes 1980/2005

Thus, the different planned utility networks have been superimposed on these characteristic base plans taking into account that, in most cases, a small collection of thematic plans that usually appear on a plan for each type infrastructure or service has been created. It should be pointed out, however, that in some projects of the sample, certain infrastructures, of an analogous theme though conceptually different, share the same plan. They tend to be relatively isolated cases and in fact there are two highly significant ones: sewage systems when they are deal with waste separation, which can be seen as being more than reasonable since in the end they are a part of the same concept of infrastructure, and the electricity networks which sometimes use the same plan to represent the low voltage distribution network and the public lighting network. However, telecommunications, gas and drinking water supply networks usually have their own plan.

If we focus on the purely graphic characteristics of representation it can be seen how in the first two periods (1980-1989 and 1990-1999) of the sample variations are little significant, as shown in **Fig. 4** and **Fig. 5**. The graphic criteria of representation are maintained, slightly changing the thicknesses and fonts applied. One element that also undergoes a variation, also seen in the aspects discussed above, is the delineation technique. During the second period, the use of CAD tools began to prevail, although not absolutely clearly and definitely. Otherwise, the illustration of utility networks is usually done using lines, mainly semi-thick, with variations of line and dot, without discarding some cases in which use is made of continuous lines or discontinuous lines.

Main characteristics from period 1980-1989

Lines
Predominant thickness: 0.3 mm.
Range of thicknesses: Group 0.8/1.2
Types of lines used: Variants of line and dot
Colour: Black and white
Patterns and textures: Not available
Text
Predominant thickness: 0.2 mm.
Font: ISO
Colour: Black and white
Reproduction technique: Heliographic
Delineation technique: Manual
Standardized symbols: NO

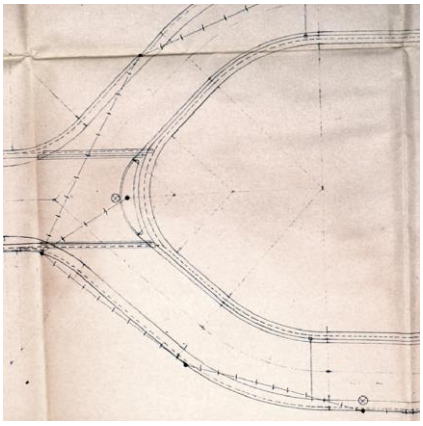

Fig. 4 Typological example graph from period 1980-1989.

Main characteristics from period 1990-1999

Lines
Predominant thickness: 0.2 mm.
Range of thicknesses: Group 0.3/0.5
Types of lines used: Variants of line and dot
Colour: Black and white
Patterns and textures: Not available
Text
Predominant thickness: 0.2 mm.
Font: ROMAN
Colour: Black and white
Reproduction technique: Heliographic
Delineation technique: CAD tools
Standardized symbols: NO

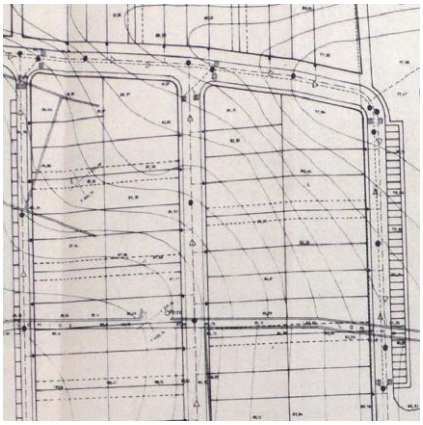

Fig. 5 Typological example graph from period 1990-1999.

Now, it is during the third period (2000-2005) that we can see a more substantial change in the illustration of utility networks. First, the introduction and use of CAD tools allows technicians to carry out a "made-to-measure" plan to be able to clearly represent the planned networks. The immediate possibility to enhance or highlight one aspect of the plan over another enables quickly establishing a base plan adapted to the representative needs required by the illustration of the utility networks.

Second, during this third period, the emergence of colour became particularly significant in the representation of infrastructures (see **Fig. 6**). As already mentioned, it is known that during the first half of the twentieth century colour was a crucial tool for the representation of urbanism, however, at the same time, its application was still practically irrelevant when representing utility networks; and so it has remained, in this case determined by the plan reproduction techniques that were available until the late twentieth century.

Main characteristics from period 2000-2005

Lines
Predominant thickness: 0.3 mm.
Range of thicknesses: Group 0.3/0.5
Types of lines used: Variants of line and dot
Colour: YES
Patterns and textures: Not available
Text
Predominant thickness: 0.1 mm.
Font: ROMAN
Colour: Black and white
Reproduction technique: Printing of originals
Delineation technique: CAD tools
Standardized symbols: NO

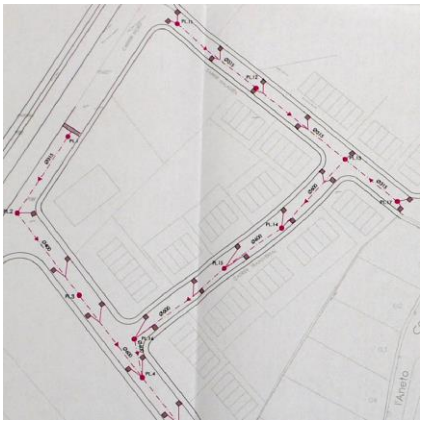

Fig. 6 Typological example graph from period 2000-2005.

However, in the period 2000-2005 the plans of the sample often used colour profusely, and the representation of the networks does not escape this trend. A trend which, on the other hand, greatly facilitates the understanding of what is being represented. To dispose of base plan in black and white, representing what the technician deems necessary in order of importance, on which the layout and symbolic elements that represent the designed infrastructure are drawn "in colour", becomes an especially useful "graphic-visual" mechanism for the observer, and one which the technician, usually with good reason, is not willing to renounce.

3.3 Recent tendencies

If we look at the new trends that can be observed, it must be stated that, with regard to this aspect in particular, there are few graphic changes or novelties, if any. The common mechanism of drawing is usually the use of a base plan, mainly in black and white or in shades of grey, where lines are illustrated in colour that symbolize the facilities to be represented, as shown in **Fig. 7**. These lines, of a sufficiently significant thickness, are usually drawn with dashes, mainly line and dot variants or variants of lines. Overall, it is a very useful mechanism since, immediately, the most relevant information on the plan stands out visually. The observer is able to identify and distinguish, at first glance, what the technician aims to highlight in addition to the most generic information that is provided by a municipal plan.

Fig. 7 Part of the plan of the main drinking water network in the town of "Dieu-sur-Mer" [6] –France- dated 2007 (ESpace &TERritoires, 2007).

[6] *Part of the plan of the main drinking water network in the town of "Dieu-sur-Mer" –France- dated 2007. The main drinking water network is drawn in blue and discontinuous line and dot, on the base plan that was ordered to proceed with the review of the "Local urban planning plan". Authors "ESpace & TERritoires" –urban planning consultants-.*

Another times, the use of colour on the plan is more pronounced. And so are the references and the data it contains. These are plans on which the representation of the network is more accurate and, consequently, probably, so is its design. This is a problem that generally arises on plans that represent the infrastructures in planning work.

Are they simply schematic drawings of what is or will be the network of services represented? Or, in contrast, is it that they are plans that result from a precise and realistic design process? In most of the documentation consulted on urban plans the former of the two options has been detected as being the most common. The plans typically show estimated dimensions or diagrams that serve as guidelines for the utility networks, without the documentation actually being able at a first glance to reveal a careful process of calculation and dimensions. Probably in the process of design and urban development, the drafting of a more typical civil engineering document is left to a second stage in order to develop precisely the different conditions of the utility networks to be included or modified according to the approved planning. In this case, these plans can often end up, without losing their technical rigour, having a more descriptive aspect, as they incorporate into their graphic design a new aspect of capital importance regarding services, that is their clear and translucent representation to facilitate their maintenance (see **Fig. 8**).

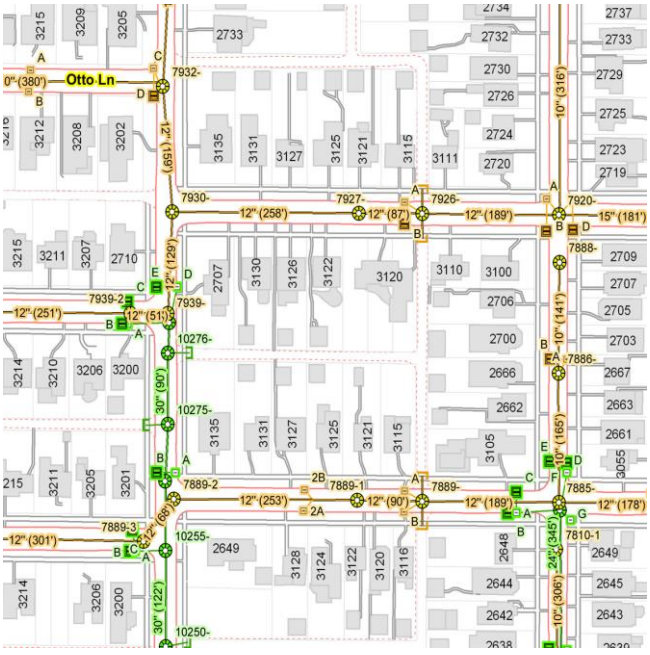

Fig. 8 Part of the plan of the sewerage system of the city of "Evanston"[7] –Illinois, United States- (City of Evanston, 2011).

[7] *Part of the plan of the sewerage system of the city of "Evanston" –Illinois, United States-. The plan shows the sewerage and rainwater network, updated in 2008. It uses several colours and clear signage provides the locations of wells, manholes, overflows, diameters and lengths of sections, as*

Such maintenance cannot or must not only consist of the necessary repair tasks but also take into account the possibility of their extension or modification. It should be pointed out, though, that in this respect, the making of graphically and technically accurate drawings to facilitate "a posteriori" the maintenance of the installation has generally been ignored or despised by urban planning architects, as they are generally considered a mechanical, unimportant task, closer to the work of the "council maintenance team" than an honest, proper task of town planning and civil engineering.

Finally, it should also be said that the use of CAD tools and, consequently, the easy incorporation of colour to plans, has enabled categorizing and separating different elements of a network with ease. Indeed, what the exclusive use of black and white and heliographics forced, distinguishing through the subtle use of the thickness of the lines and their typologies, combining lines of varying continuity and significantly different thicknesses for the same installation, is now done with the incorporation of colour in habitually continuous lines that represent different features or aspects of the same network of services.

The plan that can be seen in **Fig. 9** shows utility networks in which the use of colour enables a more rotund means of representation insofar as the thickness of the lines, since the colour means that they do not interfere with the drawing of the base plan. At the same time, the use of different colours makes distinguishing between sections which, though part of the same network or infrastructure, the technician has believed appropriate to distinguish due to their singular features.

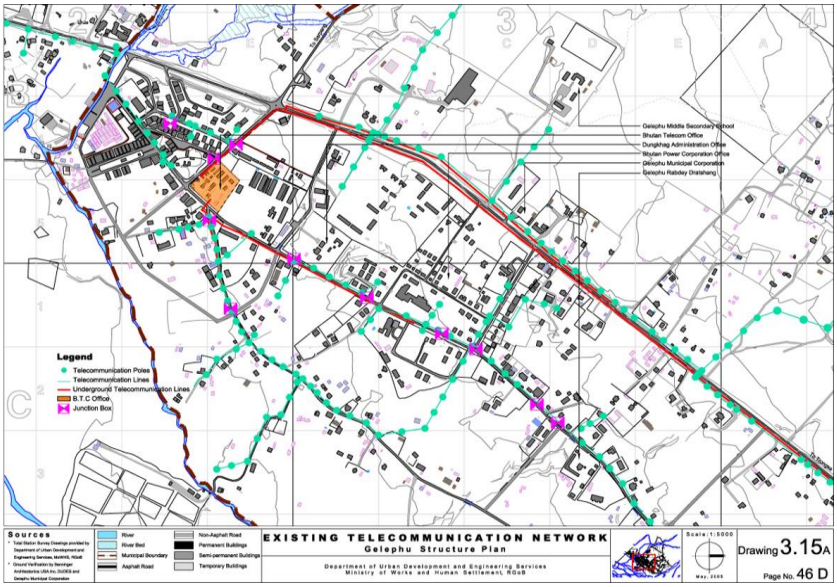

Fig. 9 Plan dating from, of the telecommunications network of the municipality of "Gelephu" –Bhutan-, located near the border with India [8] (Gelephu Municipal Corporation, 2005).

well as the approximate routes of connections to dwellings existing on the network in order to facilitate their location and maintenance.

[8] *Department of Urban Development & Esgineering Services, Ministry of Works &Human Settlement. Bhutan. Telecommunications network. Gelephu municipal corporation.*

4. CONCLUSION

The journey along this historical process has to be rigorous but, when doing so from a purely graphic point of view, we must adopt a sufficient distance in order to achieve a global appreciation of the subject, allowing ourselves not to be over-fussy in each and every one of the small changes that, though significant, might cause us to dwell on issues that are graphically too superfluous and more in keeping with the historical evolution of cities and urban planning rather than their representation.

Thus, a more integral, less detailed vision of the specific historical circumstances that have been involved in the transformation of cities and their utility networks enables, quite straightforwardly, to establish a process of sufficiently indicative and notable graphic incidences, and thus ascertain which are the mechanisms and resources that have been used to represent them, and what was the cause of and the reason behind their implementation.

The influence of what might generically be called instrumental techniques, which include both delineation and drawing techniques –including the materials (inks and physical format) and tools-, and printing and/or reproduction techniques, have been key factors in the development of the model of representation of planning and of the resulting plans, as is the case of utility network plans.

These changes in instrumental techniques that have come about historically have taken place in parallel with certain conceptual changes, such as, for example, the gradual importance gained by the proper dimensioning or number of utility networks incorporated in order to supply an increasingly modern and more sustainable population. Despite everything, the majority is concentrated at the end of the process and those occurring as of the second half of the 20th century, when the graphic representation of town planning underwent little conceptual variation, are particularly notable.

It would seem, therefore, that the graphic evolution undergone by the representation of the city and its utility networks follows a development over time which could be established, in a highly simplified manner, from the elementary representation of the minimal utility networks in the beginning, and subsequently, the introduction of several changes in the instrumental techniques and in the number and importance attributed, by the end of the 20th century, to utility networks. This introduction of changes in instrumental techniques does not seem to have ended. At present, the substitution of plans on paper by the computerized representation of current planning as well as the use of photoplans is likely to bring about new changes to the graphic approach of new town planning documents.

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