The effect of densification on water and sewer networks

The question many local authorities have, is what the effect of proposed densification would be on the existing engineering infrastructure? The simple answer is that densification has an adverse effect on infrastructure, as the utilisation of capacity is increased. But the question remains how negative this is, as opposed to the benefits that densification could offer. The City of Cape Town recently commissioned a study to determine the effect of densification on water-related services. Through GLS's involvement in the study, as well the company's other experiences of master planning of water and sewer networks throughout South Africa, some light can be shed on this issue

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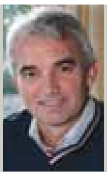

BACKGROUND TO THE CITY OF CAPE TOWN STUDY

Urban densities in the City of Cape Town (CCT) have declined from 1904 through to 2000 even while its population had been rapidly growing. The urban density has, during this period, decreased from 115 persons per hectare to 39 persons per hectare, while the population increased from 265 000 to 3 000 000. If Cape Town had continued to consume land at a rate of 115 persons per hectare (the rate at which it was consuming land in the early 1900s), it would only occupy a footprint of 260 km^2 in contrast to the 774 km^2 that it does today. This affects the ability to retain land for agricultural use, and for scenic and natural biodiversity purposes.

The challenge is to restructure urban settlements so that they are compact, make efficient use of land, are easy to move around in with a clear transport hierarchy, and do not unnecessarily consume peripheral agricultural and rural land.

Increasing densities help to achieve a more sustainable level of development, meet housing targets using less land, and improve the viability and efficiency of amenities and infrastructure services. Currently most South African settlements have an average density of about 12 dwelling units per hectare (du/ha). The aim of densification is to raise these low densities to a level of 25 du/ha in order to increase the overall efficiency and environmental quality of urban settlements.

METHODOLOGY OF STUDY

The methodology for the CCT study was the following:

- Three independent pilot areas were identified as possible densification areas.
- A planning scenario for each area was developed by the City's planners.
- A capacity analysis on the existing networks for each scenario was performed by means of hydraulic modelling.
- Reinforcements to the existing networks, required to accommodate the higher densities, were identified.
- Comparisons between the costs of the three scenarios were drawn in order to determine the most suitable area for densification.

RESULTS OF THE STUDY

The results of the CCT study are the following:

- The unit cost for upgrading the water network beyond the boundaries of the densification area varied between R1 300/du and R5 100/du (excluding VAT) for the three pilot areas.
- The unit cost for upgrading the sewer network beyond the boundaries of

the densification area varied between R900/du and R3 200/du (excluding VAT) for the three pilot areas.

The highest cost of R5 100/du for the water network upgrading was mainly due to a new storage reservoir, which was required, while the highest cost of R3 200/du for the sewer network upgrading was mainly due to reinforcements to the bulk outfall sewer, which were required in the particular densification area.

CONCLUSIONS OF THE STUDY

The general conclusions of the CCT study are the following:

- The costs of new water and sewer services are highly dependent on the availability of bulk infrastructure with sufficient spare capacity. Although this study only investigated 'brownfields' developments, this should even be more relevant for 'greenfields' developments.
- To adequately investigate the feasibility of densification, the status and impacts on the water and sewer services cannot be assessed in isolation. The status and impacts on the other services like roads, stormwater and electricity should also be addressed.
- The availability of an adequate potable water source and sufficient electricity source is a prerequisite for sustainable densification.
- It is seldom, if ever, the case that the water and sewer networks are the determining factors for future densification. These networks can normally be engineered (at a cost which is nominal relative to the total project cost) to acceptable design standards. The factors that would more likely play a substantial role are the planning issues, i.e. environmental issues, political issues, aesthetical issues, possible changing of the character of the suburb, supply and demand forces in the property market, etc.

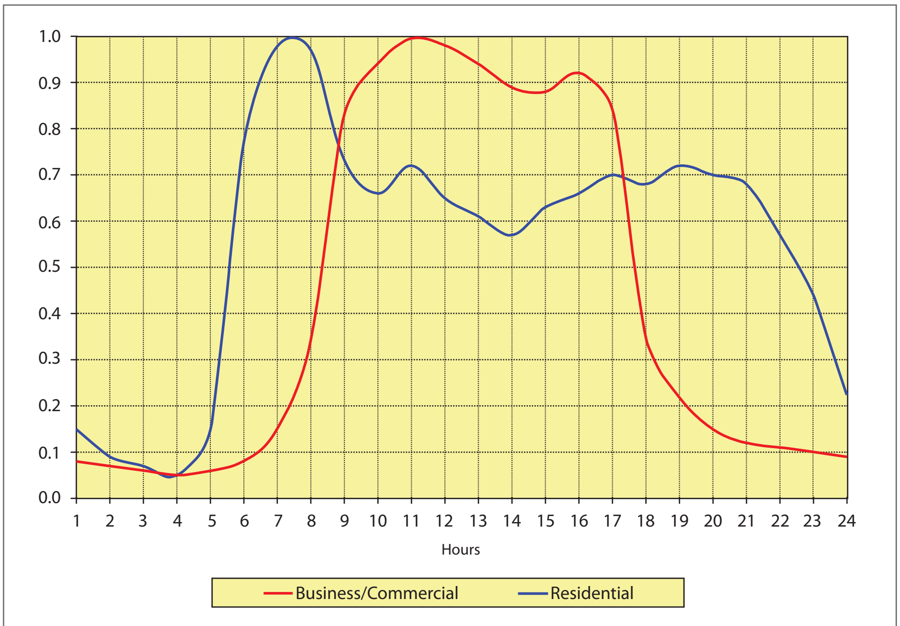

Figure 1: Typical unit hydrographs for sewer flows

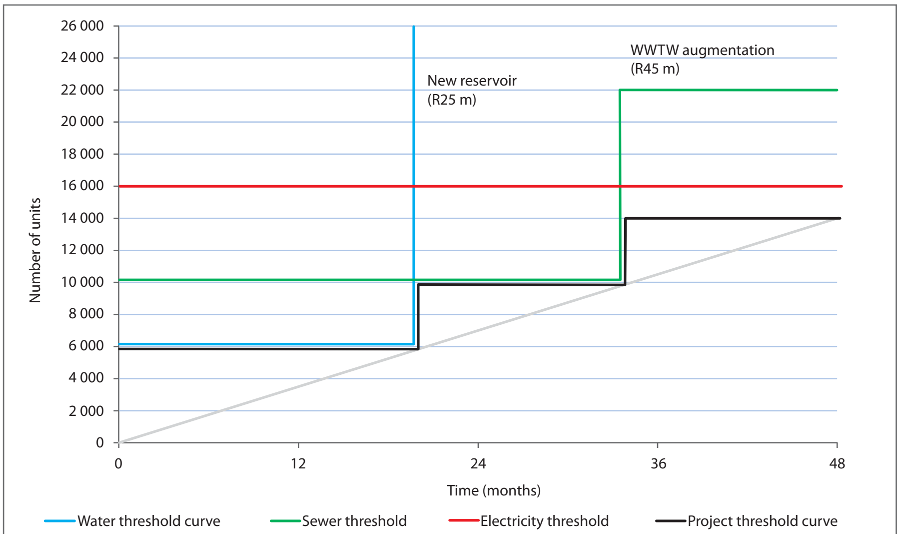

Figure 2: Infrastructure threshold curve for the development of 14 000 units

BROADER RAMIFICATIONS OF DENSIFICATION

The conclusions of the broader impacts of densification on water and sewer networks are as follows:

- It is the generally accepted view that higher population densities over a smaller land area, as opposed to lower densities over a greater land area, lower the cost of providing public services. This is because shorter distances need to be traversed and because of savings derived from economies of scale.
- The degree to which an area is either under- or over-capacitated is relevant to the issue of density and cost effectiveness. If infrastructure in an area has spare capacity, it will be more cost effective to develop that area as opposed to others, but only until infrastructure investment is required to accommodate any further/additional development.
- Infrastructure costs vary with location, according to local land use and environmental conditions. The locations where adverse conditions exist are largely unrelated to distance from the central areas. In fact, the intensely built-up nature of the more central areas (CBD) often makes it relatively more expensive to install additional engineering services.
- A change of land use from residential to business, or vice versa, could create capacity in networks, as the peak water demands and corresponding sewer flows are out of phase – see Figure 1 with sewer hydrograph indicating residential peaks typically around 07h00 and 19h00, while business has a more evenly spread water demand and associated sewer flow with a peak roughly at 11h00.
- Densification would normally require higher fire-fighting requirements, which are likely to impact on the water supply to the area.
- Densification by reducing green areas could have a larger effect on sewer flows than water demands. Where single residential stands are subdivided (or granny flats are added) the garden area is reduced, with associated reduction in irrigation

demands, while the population of the stand is increased with an associated increase in sewer flows.

RECOMMENDATIONS

While assessing the feasibility of densification in a given urban area, the following should be focused upon:

- A similar study whereby the cost implications of each of the required infrastructure components are determined for a particular area should be performed.
- The so called 'big five' infrastructure components, i.e. water, sewer, stormwater, roads (including traffic study and parking requirements) and electricity, should all be considered.
- The bulk infrastructure threshold for each of the 'big five' services should be determined. This threshold is the point which is reached where all the existing spare capacity is taken up and at which point the service is therefore utilised optimally. By assessing the thresholds of each of the five services a density threshold for the area can be decided on. This threshold will then be the density limit after which substantial bulk infrastructure investment will be required in the case of a further increase in density – see infrastructure threshold curve in Figure 2.
- By calculating the unit costs for each density scenario, and performing a sensitivity analysis by increasing or decreasing the density, the impacts of the services costs on the entire project can be assessed.
- Not only infrastructure issues, but also planning issues, i.e. environmental issues, political issues, aesthetical issues, possible changing of the character of the suburb, socio economic issues, property market forces, etc, should be addressed in the process of assessing the feasibility of densification in a particular area.

ACKNOWLEDGEMENT

The author would like to acknowledge the City of Cape Town for their consent to publish the selected contents of the said densification study. □

The challenge is to restructure urban settlements so that they are compact, make efficient use of land, are easy to move around in with a clear transport hierarchy, and do not unnecessarily consume peripheral agricultural and rural land. Increasing densities help to achieve a more sustainable level of development, meet housing targets using less land, and improve the viability and efficiency of amenities and infrastructure services

Source: http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil-Engineering-October/#/0