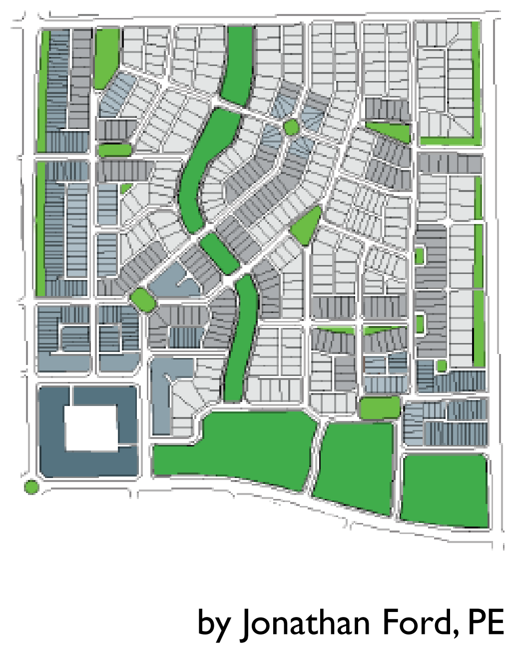
Smart Growth & Conventional Suburban Development

An infrastructure case study completed for the EPA



initial design by Swift & Associates

by Jonathan Ford, PE

January 13, 2010

MORRIS BEACON design
CIVIL ENGINEERING.
PLANNING.
URBAN DESIGN.
implementing community vision

Material is adapted from "Comparative Infrastructure & Material Analysis" under EPA contract EP-W-05-25 and appears in the working publication "Smart Growth: The Business Opportunity for Developers and Production Builders" under the same contract.

INTRODUCTION

Since World War II and especially in the last 25 years, Conventional Suburban Development (CSD) was the path of least resistance for the majority of builders. Zoning codes favored CSD, the market was understood, the risks were clear, and the planning, design, and permitting process had been repeated time and time again. However, the development climate has now changed. Developers and builders are looking for ways to cut costs. Municipalities face a steadily growing burden of infrastructure maintenance costs. Energy efficiency is a high priority as the supply of oil and other natural resources are dwindling. Countering the effects of climate change has become a priority worldwide. At the same time, demand for urban, walkable communities is steadily increasing, and supply has not kept up: market studies show a demand gap of one-third.[1]

Given these realities, there has been increasing interest in Traditional Neighborhood Development (TND) as an alternative to CSD. To further TND's position as a compelling alternative, developers need to become more comfortable with the methodology and costs associated with building compact communities. A crucial component of this process involves quantifying the cost of TND infrastructure as it compares to the known costs of conventional development practices.

Morris Beacon Design recently completed two case study projects for the EPA comparing CSD and TND infrastructure cost. Several CSD and TND development alternatives were prepared for the two case study sites, and then the total infrastructure costs were calculated. Variables that drive infrastructure cost including lot size, product type, residential density, thoroughfare cross section, and thoroughfare network pattern were studied in order to quantify and compare the impact on the total infrastructure cost.

Reductions in infrastructure costs due to TND development patterns ranged from 32% to 47%.

When comparing CSD scenarios to alternative TND designs, the study found that infrastructure costs for the TND scenarios were consistently less than CSD. Reductions in infrastructure costs due to TND development patterns ranged from 32 to 47%, with the extent of TND cost savings based principally on density.

It is important to note that these infrastructure cost studies analyzed one piece of the development bottom line: the cost of infrastructure materials and construction. Costs for design and engineering, vertical construction, price premiums, market demands, and many other local-area market factors influence decisions to design and build using certain design principles.

1 EPA White Paper: Where Will Everbody Live? Arthur C. "Chris" Nelson, Virginia Tech, 2007.

Conventional Suburban Development (CSD)

Dover Kohl & Associates

CSD development usually reflects the following characteristics:

1. Dispersed form with no distinct edge, disturbing the majority of the site's buildable land;
2. Single-use pods, containing one kind of lot and building type in each (e.g. office parks, residential subdivisions, and strip shopping centers);
3. One way in and out of each pod;
4. Garage doors and garbage pickup facing the street;
5. Large blocks with irregular shapes and cul-de-sacs;
6. Open space in the residual "left-over" land between pods and around regulated wetlands; and
7. Strip shopping centers with big box retail and large parking lots between buildings and the street.

CSD & TND characteristics adapted from Dover Kohl & Associates

Smart Growth & Traditional Neighborhood Development (TND)

Dover Kohl & Associates

New Urbanism and TND take advantage of Smart Growth regional development principles by implementing specific urban design techniques including:

1. Compact form with a distinct edge yielding large contiguous preserved open space;
2. Mixing of land uses;
3. Complete neighborhoods proportioned generally according to 5 minutes walking distance;
4. Grid network of interconnected streets with short, walkable blocks and multiple route choices;
5. Alleys with garage access and rear garbage pickup;
6. On street parking & shared parking strategies to reduce parking lot size; and
7. Community parks, squares, and open spaces faced by the fronts of buildings and located within walking distance of residential homes.

I: CASE STUDY BACKGROUND

Morris Beacon Design completed two infrastructure case study analyses for the EPA's Business Case for Smart Growth Publication. Input from a committee of TND and CSD developers and builders was used to establish benchmarks and guide methodology and design assumptions to ensure the case study development scenarios modeled actual development practices as closely as possible.

Case Study 1: Belle Hall

The "Belle Hall" study compared five TND and CSD development alternatives for a 750-acre site in Mount Pleasant, South Carolina. The total development (residential units and commercial/industrial development) for each case study scenario was held constant in order to facilitate accurate comparisons of infrastructure cost. Scenarios A, B, and C were designed with 800 residential units, and Scenarios D and E were designed with 1,410 residential units.

Although the case study comparison was completed for all five Belle Hall scenarios, the builder and developer peer review team determined that Smaller-Lot CSD C and Smaller-Lot CSD Buildout E are not market feasible. It was felt that the lot sizes are too small for typical CSD buyers and that developers would not seek zoning changes to build CSD using smaller lots when the Original CSD B scenario buildout would be by right.

Scenario	Commercial Dev. (sf)	Industrial Dev. (sf)	Residential Units	SF Lot Size (sf)	Developed Area (ac)	Res. Density* (du/ac)	Gross Density** (du/ac)
BH TND A	285,000	420,000	800	5,000	253	4.6	3.2
BH CSD B	285,000	420,000	800	20,000	601	2.1	1.3
BH CSD C	285,000	420,000	800	5,500	384	4.6	2.1
BH TND D	285,000	420,000	1,410	varies	253	8.0	5.6
BH CSD E	285,000	420,000	1,410	5,500	525	4.5	2.7
DVR TND	906,000	-	3,236	varies	558	10.1	5.8
DVR CSD	-	-	1,479	7,000	582	3.0	2.5

Summary of Case Study Scenarios

* units per land devoted to residential use (i.e. residential area including thoroughfares, mixed-use areas, and civic/open space)
** units per developed area

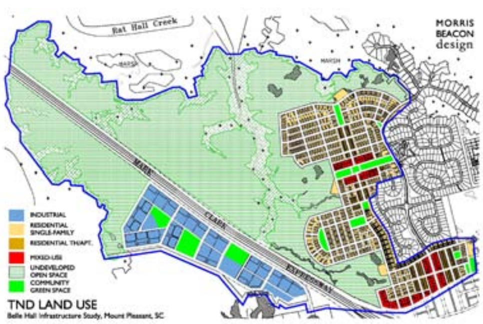
Case Study 2: Dove Valley Ranch (DVR)

For the Dove Valley Ranch (DVR) case study, an existing 575-acre CSD built north of Phoenix was compared to a hypothetical TND redesign at the same site. The DVR CSD buildout scenario was purely single-family residential; however, the DVR TND scenario includes a diverse mix of residential product types, more than twice the total number of residential units than the CSD alternative, a variety of community open spaces, and several mixed-use town centers.

Dove Valley Ranch CSD (partial)

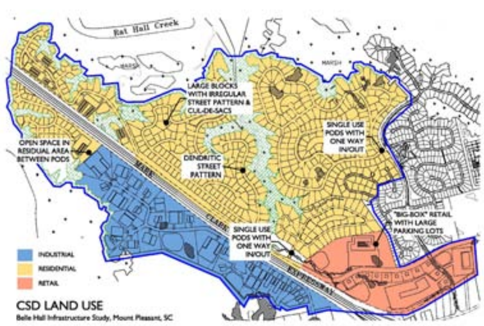

Dove Valley Ranch TND (partial)

initial design by Swift & Associates



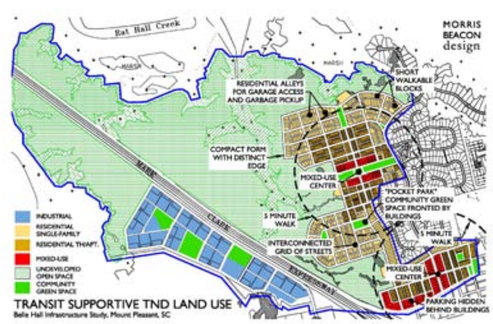
initial design by Dover Kohl

Belle Hall TND A



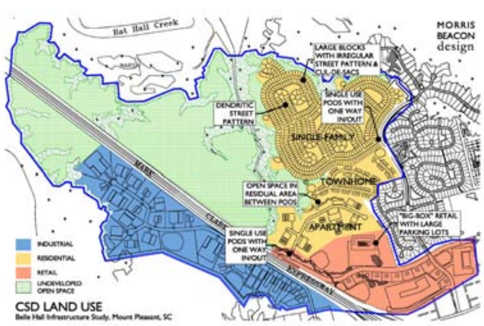
initial design by Dover Kohl

Belle Hall CSD B

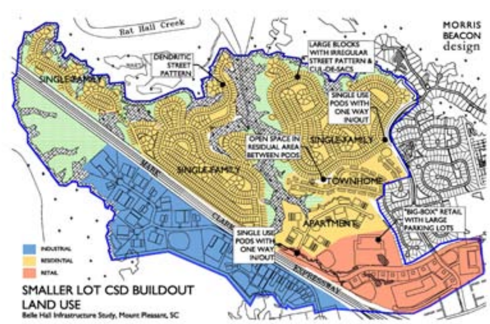


initial design by Dover Kohl

Belle Hall Transit Supportive TND D



Belle Hall Smaller-Lot CSD C



Belle Hall Smaller-Lot Buildout CSD E

Comparative Analysis: Overview

Each development scenario was engineered at a schematic level including thoroughfare typology analysis, streetscape design, parking analysis, and utility design. The engineering design ended at the building footprints – building foundations and cost of vertical construction were not part of this study.[2] Once an estimate of infrastructure quantities was compiled for each development scenario, material quantities were multiplied by industry standard unit cost data and adjusted to account for regional cost variations. Design and engineering fees were not included.

Land Costs

Land costs were not factored into the analysis due to the desire to keep infrastructure cost comparisons distinct from land costs, which vary greatly and could disproportionately affect infrastructure conclusions. However, development configuration obviously has a significant effect on land costs. Utilization of lower density CSD development patterns requires additional land acquisition spending compared to a compact TND with the same development program.

> *Utilization of lower density CSD development patterns requires additional land acquisition spending compared to a compact TND with the same development program.*

For example, if the total residential development proposed by the Belle Hall and DVR TND scenarios were built at the density of the Belle Hall and DVR CSDs, an additional 417 and 550 acres of land, respectively, would be required. This is more than twice as much land, even before taking into account the TND mixed-use areas where the same infrastructure is serving double-duty for commercial uses with residential units above. Higher residential density featuring interconnected street grids, mixing of uses, and parking efficiencies all lead to less land required for TND development.

II: COST RESULTS

Overview

Although numerous CSD and TND case study examples were evaluated, the following three direct comparisons were selected for presentation in this paper to isolate the effects of specific development variables.[3]

- Belle Hall TND A vs. Belle Hall Large-Lot CSD B
  Using the same development program, a comparison of TND vs. Large-Lot sprawl.

- Belle Hall TND D vs. Belle Hall Smaller Lot Buildout CSD E
  Using the same development program, a comparison of transit supportive TND vs. CSD using smaller residential lot sizes comparable to that of TND.

- Dove Valley Ranch TND vs. Dove Valley Ranch CSD
  A comparison of built CSD single-family residential with a hypothetical TND demonstrating the land's potential.

In order to directly compare development scenarios with different development buildout, results presented in this paper were divided by the scenario's number of residential units to provide per-unit metrics. Belle Hall industrial areas were not included in the bottom line, since in each case study scenario they could be easily isolated. Infrastructure serving mixed-use areas of the Belle Hall and Dove Valley Ranch TND scenarios was counted as residential infrastructure so as not to unfairly benefit TND scenarios in the comparisons. Therefore, commercial development above residential can be considered a TND "bonus" where the same infrastructure serves multiple uses.

As mentioned previously, both Belle Hall Smaller-Lot scenarios (C & E) were determined to not be market feasible. Although CSD Scenario C did result in a lower per-unit infrastructure cost than TND Scenario A, the direct comparison of TND D with CSD E is reproduced in this paper. The Belle Hall D/E comparison presents the buildout of transit supportive program over the entire Belle Hall buildable area, which was felt to be a more valuable illustration and comparative analysis from a market perspective due to the more appropriate TND density as discussed below.

Density

TND scenarios designed according to Smart Growth and New Urbanist principles with smaller lot sizes, compact urban form, a variety of multi-family housing types, and a mix of land uses results in infrastructure systems that serve more development in proportion to their cost to construct. In comparison, typical lower density CSD alternatives require far-reaching infrastructure systems to serve lower-density development, with higher costs to build. The case studies showed a clear reduction in infrastructure cost for scenarios with higher density.[4]

> *The same TND infrastructure framework can support much higher densities due to the interconnected transportation network, mixing of uses, and parking efficiencies.*

For example, directly comparing two scenarios with the same total development but different residential density demonstrated the cost premium for Large-Lot CSD infrastructure. Belle Hall TND A and CSD B scenarios have the same total development, but the CSD B scenario single-family residential lot size is approximately four times as large as that of TND A. The TND scenario results in a 35% per unit infrastructure cost savings compared to the Large-Lot CSD B scenario.

It is important to note that the same TND infrastructure framework can support much higher densities, such as that of the DVR TND and more, due to the interconnected transportation network, mixing of uses, and

---

2 Vertical construction presents a new set of architecture and market variables, and vertical construction costs are typically a separate element in a developer's pro-forma.

3 Contact Morris Beacon Design or visit www.epa.gov/dced to obtain a copy of the full report completed for the EPA.

4 Seven residential units per acre (gross) is often cited as the minimum density to support public transportation. Those who argue for complete living neighborhoods as the building blocks for TND design and implementation would likely consider the Belle Hall TND A residential density of 4.5 units per acre, and perhaps even the Belle Hall TND D residential density of 7.9 units per acre, inadequate to support a healthy, complete, walkable neighborhood, especially if the study's residential densities were converted to gross densities.

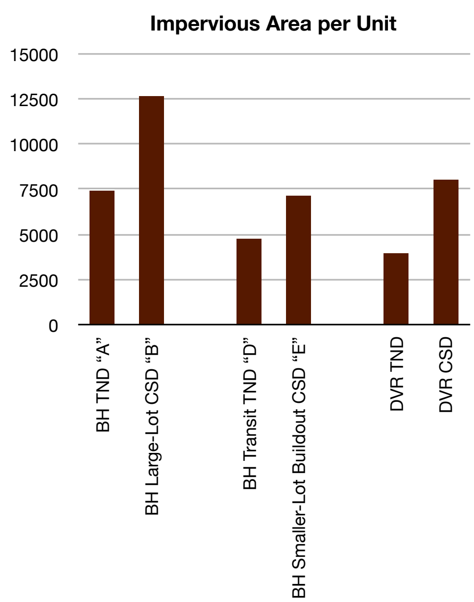
parking efficiencies. For example, density was added to the original Belle Hall TND framework simply by changing lot sizes and adding vertical floors. CSD land use patterns cannot adequately accommodate higher densities due to segregated land uses and dendritic transportation systems like that of the Belle Hall Buildout CSD E scenario.

Urban Form

The infrastructure construction cost premium commanded by CSD large-lot sprawl in comparison to compact TND is significant. However, many developers and builders interviewed for the EPA studies are using CSD development patterns (separated land uses, residential product type pods, disconnected auto-focused transportation systems) but with smaller lot sizes comparable to those of TND projects. Directly comparing scenarios with the same total development, similar residential lot size, and vastly different urban form, Belle Hall TND D compared with Smaller-Lot Buildout CSD E showed a 32% cost savings per unit for the TND scenario, and the Dove Valley Ranch TND resulted in a 47% cost savings per unit compared to the built CSD.[5]

Impervious Area

Impervious area correlates strongly with both environmental impact and infrastructure cost. Antiquated zoning codes often require additional pavement, walks, driveways, and other impervious surfaces. In addition to the additional material cost for construction of impervious surfaces, more impervious area increases stormwater runoff volume and degrades water quality. As a result, higher costs are needed for more extensive stormwater management systems.



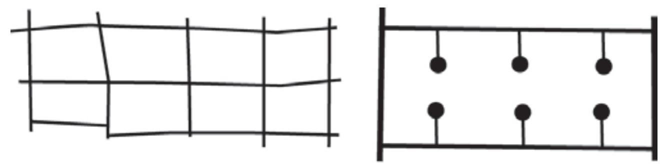
As shown above, compact TND forms of development result in far less impervious area per residential unit. These findings corroborate studies previously conducted by the EPA and others showing reduced impervious area for compact and interconnected Smart Growth and TND development patterns.[6] Morris Beacon Design's research for the EPA showed that TND alternatives resulted in an average of 42% less impervious area per unit than CSD alternatives.

5 These savings do not take into account the "bonus" TND commercial uses supported by the same infrastructure.

6 Protecting Water Resources with Higher Density Development, US EPA, January 2007.

Thoroughfares, Alleys, & Driveways

A myth exists that a TND network of thoroughfares is inherently more costly than a disconnected CSD local/collector/arterial system due to the greater total length required for a grid system. Conceptually, the TND interconnected network includes thoroughfares on all four sides of a block, where a dendritic system of local streets, collectors, and arterials typically includes thoroughfares on only three sides (a collector with two cul-de-sacs). This oversimplified comparison is difficult to clearly resolve due to the myriad of variables involved, such as streetscape cost per linear foot of street, block size and configuration, land use patterns, and density. The TND grid network is usually part of a more efficient compact development pattern that provides for greater density, and the TND network also enables narrower thoroughfares and alleys utilizing less pavement per linear foot.



Myth: an oversimplification of grid vs. arterial/collector/local length comparison

The infrastructure studies did show a greater total length in the TND systems when compared to CSD systems, with TND alleys essentially balanced by CSD driveways.[7] For example, for the same total development there is a similar total thoroughfare length for the Belle Hall TND A scenario and the Large-Lot Belle Hall CSD B scenario, even though the developed area for the Large-Lot CSD B scenario is more than double that of the TND A scenario.

However, total length is only the first step towards the bottom line infrastructure cost. Potential savings gained by the reduced total thoroughfare length for CSD systems are in large part offset by the

image credit: Chuck Bohl

Typical streetscapes, TND (left) and CSD (right)

higher cost of wider CSD pavement sections. The TND compact and interconnected grid allows for more appropriate pavement widths and a greater variety of thoroughfare types. This is not possible in the CSD dendritic arterial/collector/local transportation model for several reasons:

- The CSD system funnels traffic to a small number of collectors and arterials, which typically require additional lanes to accommodate much higher demand.

- CSD thoroughfares are often required to be wider because they serve as the only route for emergency responders. The interconnected TND network allows for simple route adjustments through the grid if any one path is blocked.

7 Although residential driveways are typically not included as part of a developer's infrastructure cost, they were included as part of these studies to balance the cost of TND alleys and provide a fair comparison.

Parking

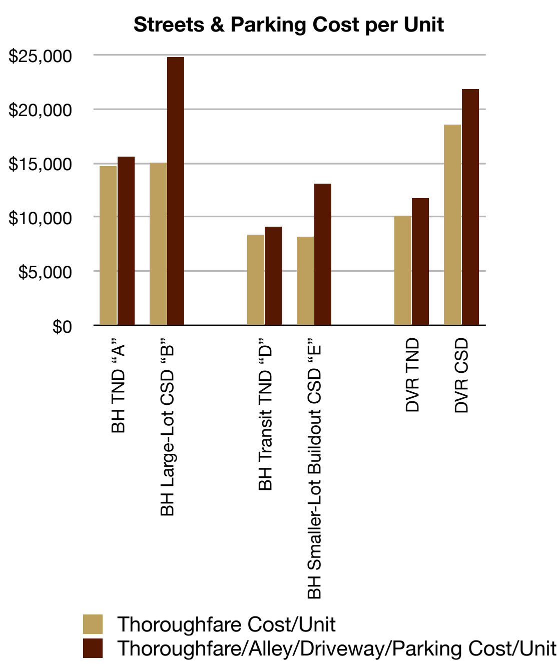
Even with narrower widths, TND thoroughfares satisfy a large percentage of parking demand with on-street parking. Reduced parking requirements and shared parking strategies due to mixing of uses and compact urban form also contribute to reduce parking requirements in TND developments by as much as 40-60 percent. CSD requires

Regents of the University of Minnesota
Used with permission of Metropolitan Design Center

Chuck Bohl

Auto-only CSD land use patterns (above) require construction of additional parking, while TND main streets (below) reduce parking requirements with on-street parking, shared parking, and mixing of uses

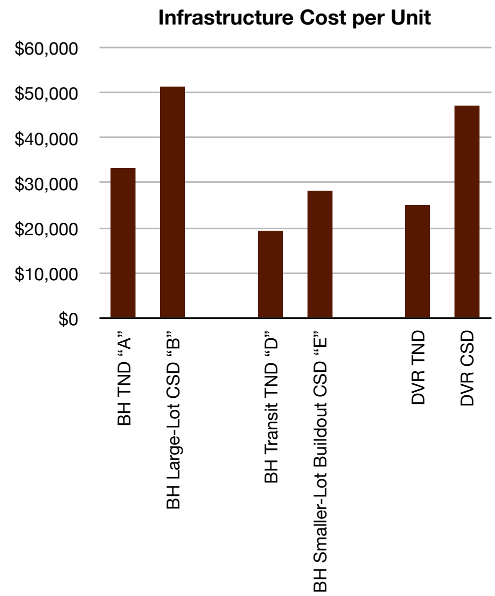
far greater investment in parking lots to serve single-use buildings in automobile only transportation networks. The figure below summarizes the total street and associated non-street costs (parking lots, residential driveways, and residential walks and patios) for each scenario.[8]



To summarize, TND scenarios generally require greater total thoroughfare length per residential unit in comparison to CSD scenarios with similar density. However, after adding the higher cost for wider CSD thoroughfares and for additional parking requirements, the comparisons change dramatically. The Belle Hall and Dove Valley studies found the total TND thoroughfares and parking cost per residential unit to be 30-46% less than that of CSD.

Summary

The bottom line results of the EPA comparative infrastructure cost study are reproduced in the figure below. The variables discussed in the EPA report including density, urban form, and impervious area led to a clear cost savings for TND infrastructure when compared with that of CSD.



Since every development team has a list of internal motivations and external guiding forces affecting the form of development, the intent of this study is not to imply that the comparative cost savings found here would necessarily be replicable in every situation. However, the EPA study demonstrated that the costs can always be measured and compared, and the results showed far greater TND infrastructure cost savings than expected when compared to conventional suburban infrastructure costs.

Infill and Redevelopment

The most sustainable and cost-effective infrastructure solution is reuse of what has already been built. Infill development and reuse of underutilized buildings provides the lowest infrastructure construction and long-term infrastructure maintenance costs, and as importantly, redevelopment projects typically do not cause additional loss of natural resources. This study is not meant to state otherwise. However, experts predict 34 million new housing units will be built by 2030, and it is unrealistic to expect that a large percentage of these will be built within the existing urban framework. If a widespread move towards sustainable development is to happen, developers and high-production builders must consider both greenfield TND and infill as a desirable alternative to CSD.

8 The DVR CSD scenario was entirely single-family residential, therefore there were no parking costs.

III: ADDITIONAL TND BENEFITS

The infrastructure case study completed for the EPA isolated the cost to construct infrastructure for TND and CSD buildout scenarios. Several additional benefits of TND development patterns were not factored into the analysis in order to keep the focus on infrastructure and density. Section III provides a qualitative discussion of these additional benefits.

Open Space

Park landscaping costs (TND) and municipal parks fees (CSD) were included in the infrastructure cost analysis but set equal so that they did not have an impact on the comparative total cost analysis. However, there is a significant difference between open space used for community benefit such as plazas and parks, undeveloped and protected open space (natural resource areas), and residual open space. Open space for community use is an important feature of TND land planning, where small parks and squares fronted by buildings are located within walking distance of homes. This type of open space increases property values and internalizes that value to the developer. Undeveloped open space is natural area left untouched by development. In addition to the benefits contiguous undeveloped open space provides for environmental, habitat, and viewshed protection, it could also potentially be converted into a community amenity by introducing carefully designed low-impact walking trails. Residual open space is leftover naturalized or landscaped areas with little use to the community, such as buffer zones between CSD land use pods or landscaped areas between apartment buildings.

> *TND developers emphasized the clear increase in property values generated by protecting natural resource areas and internalizing open space with small parks and squares for community benefit.*

Although not quantified in this study, TND developer peer reviewers strongly emphasized the clear increase in property values generated by protecting natural resource areas and internalizing open space with small parks and squares for community benefit, in contrast to the residual open spaces and municipal parks fee payments typical of CSD. Repeated studies over the years have confirmed that people prefer to buy homes close to parks, and will pay premiums to do so.[9]

Phasing and Risk Management

The infrastructure cost breakdowns for each of the development scenarios is helpful to evaluate the impact of various planning and design decisions on cost; however, it does not necessarily address developers' implementation strategy. In addition to evaluation of the overall infrastructure cost, development phasing and risk management is a crucial component of the CSD/TND infrastructure comparison. Due to the compact nature of TND development and the inherent mix of uses, far less land and infrastructure is required to bring all residential and commercial products to market in a single phase. This translates into less carrying cost and shorter risk horizon per phase. If adjustments to the residential product mix are necessary due to a changing market, adjustments can be made incrementally. Due to the pod-like segregation of residential product types and sprawling infrastructure, CSD development patterns are far less flexible and require greater initial investment and risk.

> *Due to the pod-like segregation of residential product types and sprawling infrastructure, CSD development patterns are far less flexible and require greater initial investment and risk.*

For example, analysis of the land required to bring all Belle Hall residential/commercial product to market in one phase highlights the phasing advantages of TND land use patterns. Almost 200 more acres would be required to bring all product to market in one phase for the CSD A scenario, and 64 more acres for the smaller-lot CSD C scenario.

Stormwater management

Sustainable stormwater management strategies strive to minimize the impact of development on a site's natural hydrology by utilizing small-scale, decentralized measures that slow, treat, and infiltrate runoff at its source. Whereas in the traditional "curb and gutter" approach, all runoff is collected and conveyed to a centralized detention/treatment facility and discharged offsite.

Sustainable stormwater management practices were not incorporated into the cost study. It was determined that while strongly supported by the EPA and Morris Beacon Design, incorporating innovative sustainable stormwater management strategies into the methodology would unnecessarily shift attention from the primary focus of this study: density and arrangement of infrastructure. Although the engineering industry continues to adopt innovative stormwater management techniques as an alternative recommended practice, sustainable stormwater management techniques are not yet universally utilized as standard engineering practice and therefore were not utilized in this study.

The case studies completed for the EPA found that even though urban stormwater management techniques are sometimes more costly than those for suburban development patterns, reductions in impervious area per unit for TND scenarios led to far less total runoff, and therefore less total cost for mitigation of runoff rate, runoff volume, and stormwater quality.

Additional study of the connection between compact development and watershed health can be found in the following section.

Acknowledgements

Special thanks to Dover Kohl & Partners for generously providing Belle Hall project site information including the initial CSD & TND scenario plans, William Gietema, Arcadia Development Company, for providing valuable developer review and feedback, Scott Durbin, PE, for his review input and contributions to the text, and Peter Swift, PE, for his initial design of the Dove Valley Ranch TND.

9 Sherer, Paul. "The Benefits of Parks." The Trust for Public Land, 2006.

IV: WATERSHED IMPACT

The fact that our water resources have been negatively impacted by development is well documented. By paving over our land we alter the natural water balance – reducing infiltration and evapotranspiration, and increasing the volume and peak flow of runoff. This change in runoff increases pollutant loadings, erosive flows, and water temperatures at the receiving waters, which impairs their quality and degrades the overall health of the watershed.

Whereas traditional stormwater flow-control regulations have focused on peak flows, current regulations are beginning to recognize the importance of maintaining the natural hydrologic balance in the watershed and are moving toward reduction of both peak flows and runoff volumes. This has led to the increasing adoption of Low Impact Development (LID) Best Management Practices (BMPs) as the preferred stormwater management strategy. LID BMPs such as bioretention, water quality swales, and permeable pavement, utilize natural processes to infiltrate, detain, and filter runoff as close to its source as possible, thereby approximating pre-development hydrologic patterns.

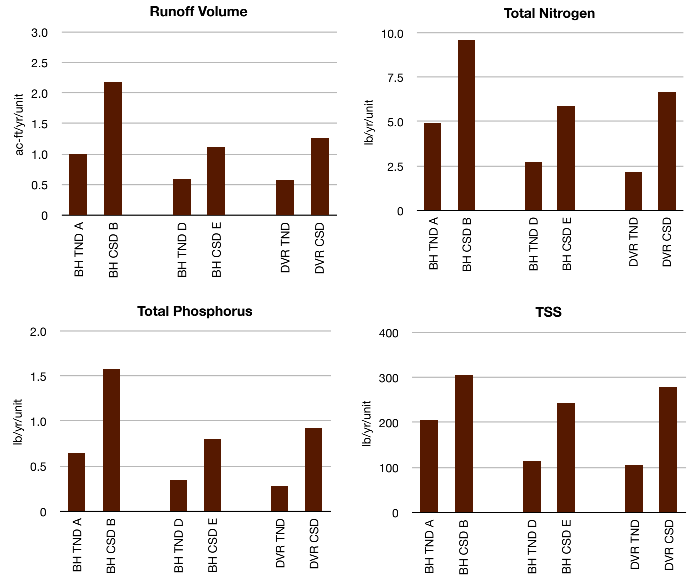
Research has shown that LID practices mimic predevelopment hydrology more effectively than traditional pipe-and-pond BMP strategies, while reducing overall lifecycle costs and providing improved aesthetics.[10] However, this research also recognizes that prior to implementing treatment BMPs, the ultimate stormwater management technique is to utilize source control measures to prevent runoff from being generated in the first place. One of the foremost source control methods is land use planning on a watershed scale to reduce impervious area, protect environmentally sensitive areas, and conserve natural open space.

TND alternatives generated an average of 55% less runoff per unit than comparable CSD alternatives - before the introduction of engineered BMPs.

TND's compact development with access to multiple modes of transportation reduces the amount of impervious area in the built environment while simultaneously conserving more natural areas. Studies are beginning to show that TND's compact land use patterns provide significant reductions in runoff volume and pollutant loadings on a per capita basis.[11] The findings are further corroborated by our study, which found that the TND alternatives generated an average of 55% less runoff per unit than comparable CSD alternatives – all this before the introduction of innovative BMPs.

Directly comparing pollutant loadings from scenarios with equivalent residential densities and commercial programs also demonstrated the benefits of compact development and TND land use patterns. TND scenarios generated an average of 57% less total nitrogen, 61% total phosphorus, and 57% total suspended solids (TSS) per unit than comparable CSD scenarios.

Going one step further, it is possible to compare the benefits of



compact development with those of engineered sustainable BMPs. For example, walkable Belle Hall TND Scenario A without any structural BMPs generated 15 percent less total nitrogen than CSD Scenario B including engineered nitrogen reduction BMPs[12], and Belle Hall TND Scenario D without structural BMPs generated 23 percent less total nitrogen than CSD Scenario D including engineered nitrogen reduction BMPs. In other words, for directly comparable case study scenarios, compact land use patterns had more of a beneficial effect on nitrogen loading than structural BMPs.

Compact land use patterns had more of a beneficial effect on nitrogen loading than structural BMPs.

Compact development reduces per capita watershed impact while innovative engineered stormwater BMPs naturally filter and infiltrate. (Providence, RI)

When the relative impact of density and neighborhood design principles are more fully understood and quantified, it is expected that TND and New Urbanism will be established as effective solutions to reduce watershed impacts. This data is crucial to the justification of efforts to design walkable places in balance with nature.

10 Reducing Stormwater Costs through LID Strategies and Practices, US EPA, December 2007.

11 Studies include: "Is Denser Greener? An Evaluation of Higher Density Development as Urban Stormwater Quality BMP" by John Jacob & Ricardo Lopez, "Using Smart Growth Techniques as Stormwater BMPs" by Lisa Nisenson.

12 A 40 percent BMP nitrogen reduction was assumed.

MORRIS
BEACON
design

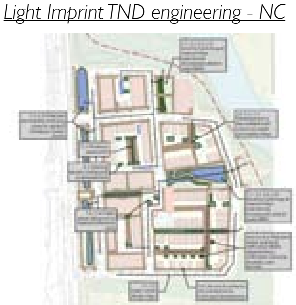
CIVIL ENGINEERING. PLANNING. URBAN DESIGN. implementing community vision

Cottage Court site design - RI

Green parking retrofit - Providence, RI

masterplan by Civitech

Light Imprint TND engineering - NC



Form-based codes & stormwater ordinances

TOD planning & engineering - Attleboro, MA

With unique dedication to the principles of Traditional Neighborhood Design, Smart Growth, and New Urbanism, Morris Beacon Design integrates sustainable neighborhood design with civil engineering detail.

Walkable Street Design Morris Beacon Design implements Smart Growth by providing context sensitive thoroughfare analysis, network layout, and detailed streetscape design to facilitate neighborhood connections both physical and social.

Sustainable Infrastructure Morris Beacon Design produces reports, plans, and calculations to incorporate eco-sensitive neighborhood design principles and sustainable site engineering best practices into projects of all sizes.

Master Planning Morris Beacon Design works side by side with the design team's architects, urban designers, and town planners to develop plans that are feasible and constructible.

Charrette Support During the planning and design of new projects, Morris Beacon Design serves as a liaison between the charrette team and local engineers, planners, and the general public while serving as a design resource during plan development.

Implementation A consensus master plan is too often compromised when it comes time for detailed engineering & construction. Morris Beacon Design provides integrated site layout, grading, and utility design services to develop construction documents for New Urbanist & TND projects without sacrificing the intent of the master plan, and can also liaison with local engineers to ensure proper execution.

Form-based Codes and Stormwater Ordinances MBD develops watershed-based codes & stormwater ordinances to support compact development, including stormwater design manuals and design guidelines. Great places in balance with nature.