WIDER COSTS OF MEDIUM DENSITY DEVELOPMENT

REPORT
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Prepared for
Department of Planning, Lands and Heritage (DPLH)

Independent insight.

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EXECUTIVE SUMMARY

The Department of Planning, Lands and Heritage (DPLH) is currently developing a suite of policy reforms to improve outcomes in medium density housing development. These reforms would be applied to a range of medium density dwelling forms, from mircolots to grouped dwellings, and smaller apartments projects.

To help understand the case for reform, DPLH has commissioned SGS to provide advice on the broader community and society costs this type of development has when it is not done well. This analysis can also be viewed as the possible benefits on offer from a policy which would successfully address these identified issues.

Case study development

SGS has created a case study development, of a typical suburban triplex subdivision (illustrated below), to identify some of the characteristics of this development which would create costs to the broader community.

FIGURE 1: CASE STUDY DEVELOPMENT OUTCOME

Source: Nearmap

Informed by the example identified above and typical development outcomes, SGS has assumed that the development is characterised by:

- A loss of existing established trees and little opportunity for additional tree planting.
- An increase in impermeable surfaces in the form of hardscaping, such as driveways, as well as structures, such as roofs.
- High site coverage with the site primarily taken up by dwelling footprint, garage, and driveways.
- Little opportunity for passive heating and cooling with narrow eaves and poor solar orientation.
- A reduction in private open space. Post development, private open space is primarily limited to small paved and covered courtyards.
- Poor quality building materials with high embodied energy costs.

Societal costs

The case study development results in a range of costs to the broader community and society in general. The quantified costs on a per dwelling basis are outlined in the table below. These can be interpreted as the costs to society of sub-optimal outcomes resulting from a single newly developed, business-as-usual medium density dwelling. That is, for every new business-as-usual dwelling there is an additional $29,200 of costs borne by the wider community.

TABLE 1: COSTS PER DWELLING

Impact	Cost (capitalised)
Storm water runoff	$4,400
Loss of private open space	$5,800
Loss of trees	$7,300
Active heating and cooling	$600
Urban heat island effect	$8,000
Embodied energy	$1,600
Social isolation	$1,500
Total	*$29,200*

Source: SGS Economics and Planning

Extrapolating these costs to a WA wide level, new medium density housing could be creating $117 million in additional costs to society every year if there is no change in the planning, design and development of medium density housing. Over a decade this accumulates to a cost of $1.17 billion.

These are substantial costs to the community which require further investigation and possible government action. The quantum of these costs provides an indication of the possible benefits on offer for any policy which addresses the identified issues.[1]

[1] Noting that benefits depend on the specific policies chosen and net benefits would also need to also account for the costs of the policy change.

1. PROJECT BACKGROUND

1.1 Introduction

The Department of Planning, Lands and Heritage (DPLH) is currently developing a suite of policy reforms to improve outcomes in medium density housing development. These reforms would be applied to a range of medium density dwelling forms, from microlots, to grouped dwellings, townhouses, and smaller apartments projects.

To help understand the case for reform, DPLH has commissioned SGS Economics and Planning (SGS) to provide advice on the broader community and societal costs this type of development can have when it is not done well.

Housing densification in Australian cities has brought many benefits and is well justified by urban planning and economic principles. Denser cities encourage more efficient provision of infrastructure, including the viable operation of mass public transport. It also reduces the need for an ever-expanding urban fringe while still allowing for an increase in housing supply in well serviced areas, providing wider access to amenity and economic opportunity. However, densification needs to be done well. New developments must be good quality as a place to live, as well as not detracting to the communities they are appearing in, nor creating undue costs to society more broadly.

The ongoing COVID-19 pandemic has increased the time we are spending at home and how we use this space. This has highlighted the importance of good residential design outcomes, including energy efficiency, access to nature, as well as enabling social connection. This increased reliance on our homes further strengthens the case for ensuring the houses built for Western Australian's are good quality.

1.2 Project method

Urban development in Perth in recent decades has seen a trend towards densification, but the housing delivered is typically far from best practice. This can result in poor outcomes for residents of this housing as well as the wider community. DPLH is interested in the costs to the broader community of this type of development to help inform a policy to improve housing outcomes.

This report seeks to identify and quantify the community and societal costs of a typical middle ring medium density development in WA. We create a case study development, selecting a typical suburban triplex subdivision. We identify some of the characteristics of this development which would create costs to the broader community. We quantify these costs and present a view on what these costs could be in aggregate, at a state wide scale. SGS notes that while the chosen case study is from Perth, which sees the vast majority of medium density development in WA, the implications readily apply to any context in WA where medium density development is happening.

SGS notes that this work is intended as a research piece to help DPLH understand the quantum of costs to society which may not be fully considered in private market development. It is not intended to be a detailed financial feasibility analysis, nor a cost benefit analysis. SGS recommends DPLH undertakes a detailed cost benefit analysis of a particular package of reforms once its details are settled.

2. DEVELOPMENT CASE STUDY

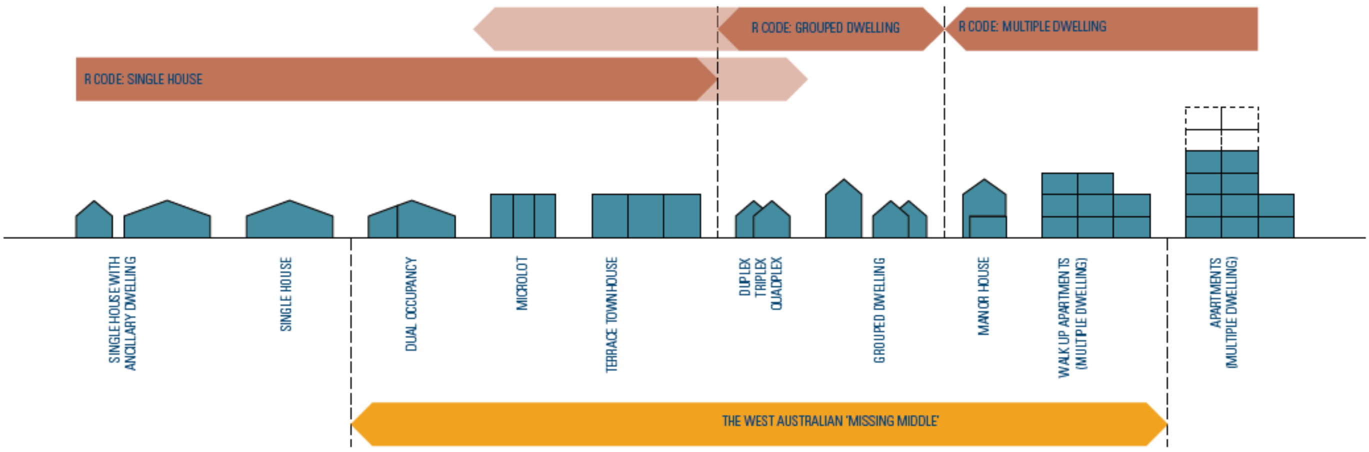
This section identifies a case study development of a typical suburban triplex subdivision. The characteristics of this development which would create costs to the broader community are also outlined.

2.1 Definition

This analysis takes a 'typical' medium density development as a case study to understand societal costs. Medium density dwellings in Western Australia broadly refers to the typologies such as dual occupancy, microlot, terrace townhouse, duplex, triplex, quadplex, qrouped dwellings, and walk up apartments.[2]

As shown in the figure below, this definition of medium density is broader than the grouped dwelling category in the R Code, and includes some typologies in the Single House category and Multiple Dwelling category.

FIGURE 2: DEFINITION OF MEDIUM DENSITY



Source: David Barr Architects, 2019

2.2 Medium density developments trends

Supply and spatial distribution

Medium density dwellings account for the majority of new housing supply in many of Perth's middle ring suburbs.[3] Sales data covering 2010 to 2019 show that of the 23,444 newly built medium density dwellings sold in Perth, an average of approximately 2,300 dwellings a year. Of this supply, 11,800 (or 50%) were in the middle ring suburbs.[4]

As shown in the figure below, key middle ring suburbs with high levels of medium density developments include suburbs north of the river such as Balga, Nollamara, and Morley.

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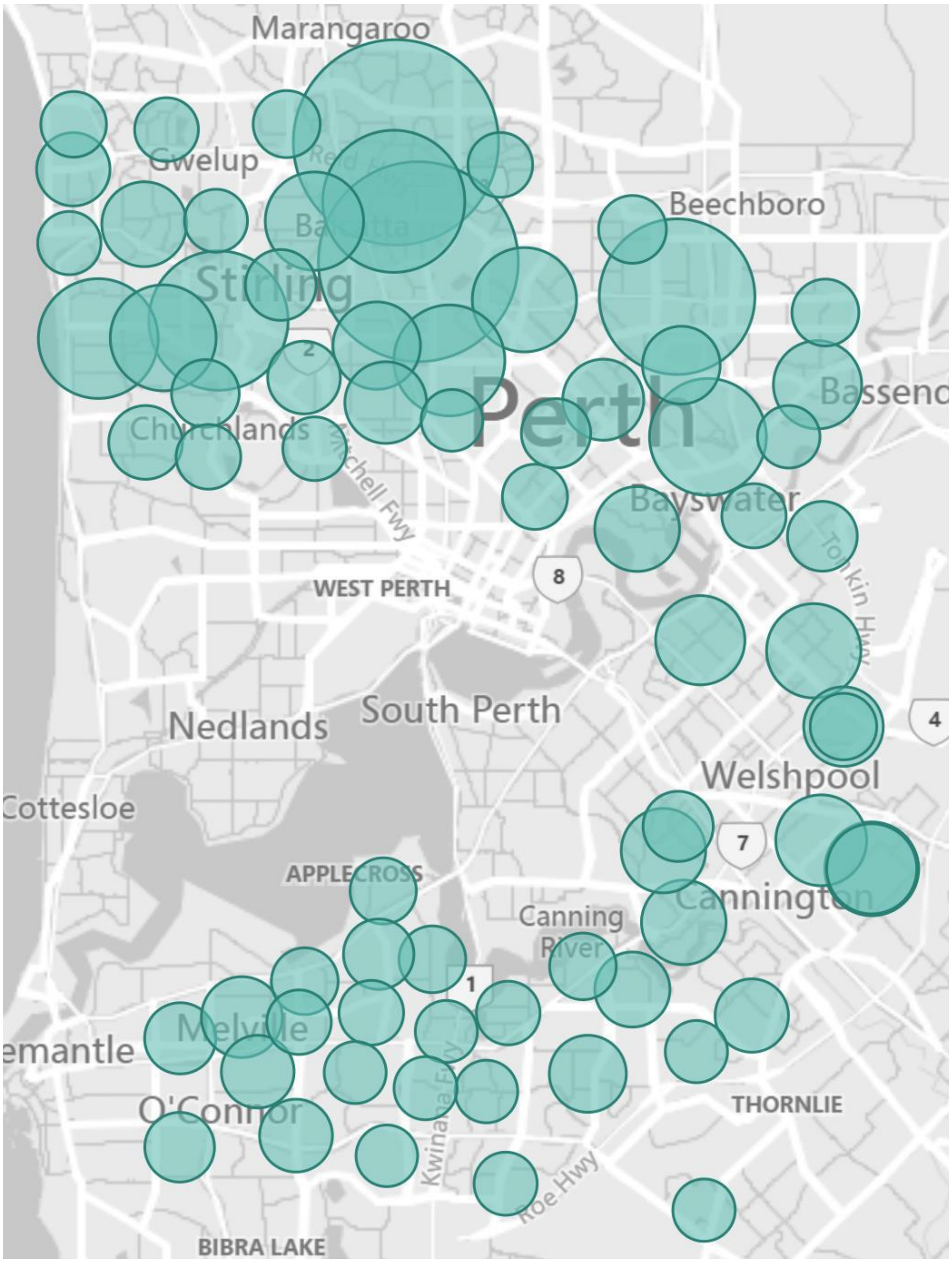
[2] David Barr Architects (2019) *Medium Density Typology Research*
[3] Urbis (2019) *Medium Density Definition and Market Conditions*
[4] Urbis (2019) *Medium Density Definition and Market Conditions*

FIGURE 3: MEDIUM DENSITY HOUSING SALES SINCE 2010



Source: Urbis, 2019

Development type

Typical medium density developments in WA are two, three, or four dwellings, single storey, and on one block. They can be either side by side or battle-axe style (or split on a corner block) and detached or attached. Duplex (as well as triplex and quad) developments make up the bulk of recent infill medium density development in Western Australia.

Analysis by Urbis found that in 2018, 61% of sales were either duplex, triplex or quadruplex, as shown in the table below.

TABLE 2: 2018 MEDIUM DENSITY HOUSING SUPPLY BY TYPOLOGY

Housing Typology	Sales	%	Average Lots	Median lot size
Triplex	309	27%	3.0	260
Group House	253	22%	8.5	227
Quadruplex	204	18%	4.0	224
Duplex	186	16%	2.0	375
House	112	10%	3.4	375
Villa House	30	3%	17.9	194
Town House	24	2%	12.2	225

Source: Urbis, 2019

Battle-axe splitting of larger suburban blocks means that existing houses can be built behind or demolished and rebuilt as part of a duplex/triplex development, as shown in the figure below. This attempts to maintain neighbourhood character, from the perspective of the street, while allowing for increased density.

FIGURE 4: WESTMINSTER IN 2009

Source: Nearmap

FIGURE 5: WESTMINSTER IN 2020

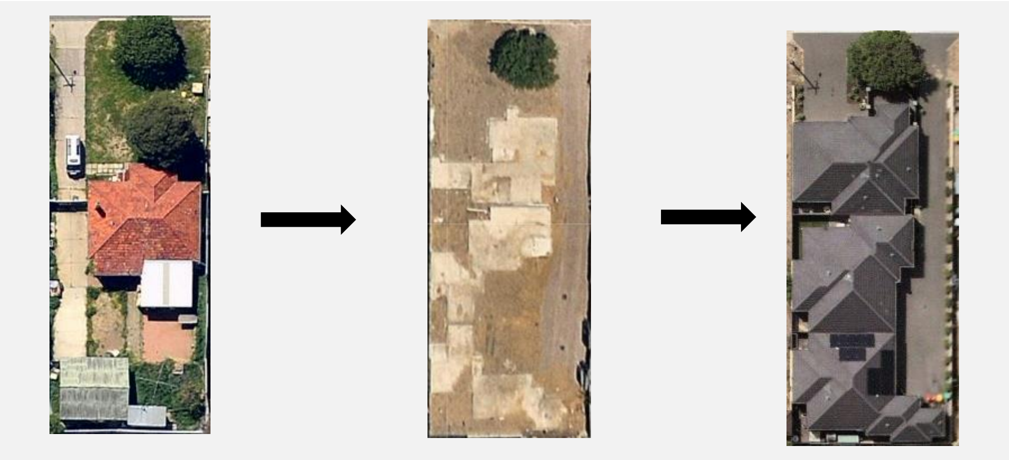
Source: Nearmap

2.3 Case study

For our analysis, SGS has selected a triplex as the case study to help understand the broader societal impacts of a typical medium density development in WA. A single-storey triplex is a common development form and it sits roughly in the middle of medium density housing typologies. It is therefore a reasonable 'average' development to choose as a case study.

The case study is largely based on the example development illustrated in the figure below. The development sees a freestanding house in a middle ring Perth suburb demolished and replaced with three dwellings.

FIGURE 6: CASE STUDY DEVELOPMENT OUTCOME



Source: Nearmap

Site parameters

The size of the site is 800 sqm with the private open space accounting for around 45% of the site in its predeveloped state. Following development, private open space is reduced to around 12% of the site. Accordingly, site coverage increases from 55% to 88%.

Following development gross realisation value of the site more than triples, from around $350,000 to $1,200,000. This indicates there is reasonable profit to be made from this type of development and underlines the property economics rationale for development.

TABLE 3: CASE STUDY ASSUMPTIONS

	Predevelopment	Developed
Dwellings (no.)	1	3
Land size (sqm)	800	800
Internal area (sqm)	190	330
Driveway (sqm)	160	250
Garage (sqm)	80	120
Private open space (sqm)	370	100
Gross Realisation Value ($)	$350,000 (approx.)	$1,200,000 (approx. $400,000 per dwelling)

Source: Approximated using Nearmap and real estate listing for similar dwellings

FIGURE 7: CASE STUDY IMAGES – FOLLOWING DEVELOPMENT

Source: Realestate.com.au based on a typical development

Development outcomes

Informed by the example identified above and typical development outcomes, SGS has assumed that the development is characterised by:

- A loss of existing established trees and little opportunity for additional tree planting.
- An increase in impermeable surfaces in the form of hardscaping, such as driveways, as well as structures, such as roofs.
- High site coverage with the site primarily taken up by dwelling footprint, garage, and driveways.
- Little opportunity for passive heating and cooling with narrow eaves and poor solar orientation.
- A reduction in private open space. Post development, private open space is primarily limited to small paved and covered courtyards.
- Poor quality building materials with high embodied energy costs.

The flow on implications of these characteristics are quantified in the following chapter.

Note, SGS has focused on the undesirable development outcomes which result in costs to the community. We do not mean to single out any specific development as being particularly bad. Rather, examples are used only to provide a tangible case study of typical development outcomes. The example site could be substituted for any number of other similar developments.

3. SOCIETAL COSTS

SGS identifies and quantifies a number of impacts on the broader community associated with the case study development.

The case study development results in a range of costs to the broader community and society in general. These costs include:

- Exacerbated urban heat island effect
- Social isolation
- Loss of private open space
- Loss of amenity from removal of trees
- Increased storm water runoff
- Reliance on active heating and cooling
- High embodied energy from poorly performing building materials

Some of these costs are external to the parties involved in a development, and so would not be accounted for in the private market and thus under-considered from a whole of society point of view. For example, removing an established tree which is visible from the street, impacts surrounding residents who can no longer view the tree, but this impact is not likely a significant consideration during the development process. Impacts of this kind are characterised by economists as a negative externality.[5] Other impacts are less tangible or not a priority in the development process and are therefore also largely ignored over the course of development.

Some costs have been identified as a lump sum (capitalised) and some are identified as an ongoing per-year impact (annual). To be able to compare costs we have assumed the capitalised (lump sum) costs are equal to 20 years of ongoing (annual) costs, that is, a capitalised cost is 20 times the annual cost.[6]

3.1 Urban heat island effect

The built form of the case study development has a high site coverage and large areas of impermeable surfaces such as roofs and impermeable paved driveways which have high heat capacities and thermal conductivity. These features can exacerbate urban heat island (UHI) effects as the more intense land use replaces pre-existing vegetation and green space, such as front and back yards.

At a city-wide scale, this effect alters the local energy balance and produces changes in the local climate, such as higher temperatures, and changes in precipitation and wind patterns.[7] The negative impacts of the UHI include increased energy use for cooling, higher emissions of air pollutants, human health risks and discomfort, and lower water quality.

The UHI effect can also exacerbate heatwaves, which, among other impacts, have been shown to cause economic losses because of reduced labour productivity as well as loss of life. Heatwaves are particularly harmful for older people, with mortality rates tripling in some

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[5] Gruber, Jonathan. (2011). *Public finance and public policy*. See Chapter 5.

[6] This time period is consistent with a typical cost benefit analysis assessment period. To simplify the analysis we have not applied a discount rate. SGS notes this is not a cost benefit analysis, and we recommend further work to apply a full cost benefit analysis framework to a suite of reforms once these have been settled.

[7] Estrada, Francisco & Tol, Richard. (2017). *A global economic assessment of city policies to reduce climate change impacts*. Nature Climate Change. 7. 403-406.

older age groups during severe heatwaves.[8] Heatwaves are of concern in the WA context. It is expected that Perth will experience a substantial increase in the number of hot days over 35 degrees, from 28 days a year to 67 days a year by 2070.[9]

SGS has used a benefit transfer method to estimate a per development cost stemming from UHI effects of the development. The annual costs of this (both economic and social) on a per sqm basis is around $90.[10] SGS has applied this to the areas of green space which have been lost following development (270 sqm) for an annual cost of $1,200 or a capitalised cost of around $24,000.

3.2 Social isolation

The case study development provides little opportunity for neighbourly interactions between occupiers of the triplex dwellings, or other residents of the street. This could exacerbate social isolation and create costs to society in terms of health and wellbeing, as well as economic productivity.

Strong social connections with neighbours, and to the broader community, is vital to an individual's wellbeing. People with strong social connections, including with their neighbours, tend to live longer, and report having more meaningful lives.[11] At a societal level, social connection improves the health of a population (both mental and physical) and enhances the economic prospects and productivity of workers.[12]

WA wide, the health and economic costs of social isolation are estimated to be around $795 billion annually.[13] The layout of our suburbs and the housing forms within them, contributes significantly to this cost as it can make it hard to make social connections.[14] Furthermore, not having social connections to one's neighbours and immediate community is key contributor to social isolation.[15]

The importance of being connected to your neighbours is especially important during difficult personal and societal events. This is illustrated with the current COVID-19 pandemic: although physical isolation is necessary, existing social bonds with neighbours and a community are especially important in getting through a stressful period.[16]

While physical design does not in itself determine the quantum and quality of social connections one can make, good design can gently encourage greater community connection, while bad design can prevent it.[17] For instance, the case study development provides little opportunity for serendipitous encounters with neighbours that a shared garden, open car port, or a communal workshop would enable. These encounters are vital for building connections with neighbours. Instead, the case study design allows for a resident to enter via

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[8] AECOM (2012), *Economic Assessment of the Urban Heat Island Effect* https://www.melbourne.vic.gov.au/SiteCollectionDocuments/eco-assessment-of-urban-heat-island-effect.pdf

[9] City of Perth (2016), *Urban Forest Plan*

[10] Based on the benefits green roofs would have on urban heat island effects as cited in Estrada, Francisco & Tol, Richard. (2017). *A global economic assessment of city policies to reduce climate change impacts*. Nature Climate Change. 7. 403-406.

[11] Grattan Institute (2012) *Social Cities*. https://grattan.edu.au/wp-content/uploads/2014/04/137_report_social_cities_web.pdf

[12] Deloitte (2019) *The Economic Benefits of Improving Social Inclusion.* https://www2.deloitte.com/content/dam/Deloitte/my/Documents/risk/my-risk-sdg10-economic-benefits-of-improving-social-inclusion.pdf

[13] Apportioned to WA from the national costs/benefits of social isolation calculated in Deloitte (2019) *The Economic Benefits of Improving Social Inclusion.* https://www2.deloitte.com/content/dam/Deloitte/my/Documents/risk/my-risk-sdg10-economic-benefits-of-improving-social-inclusion.pdf

[14] Grattan Institute (2012) *Social Cities*. https://grattan.edu.au/wp-content/uploads/2014/04/137_report_social_cities_web.pdf

[15] Australian Institute of Family Studies (2019), *Neighbour Day: It's time to reconnect with those around us* https://aifs.gov.au/cfca/2019/07/02/neighbour-day-its-time-reconnect-those-around-us

[16] The Conversation (2020), Social distancing can make you lonely. Here's how to stay connected when you're in lockdown https://theconversation.com/social-distancing-can-make-you-lonely-heres-how-to-stay-connected-when-youre-in-lockdown-133693

[17] It is also important to note that opportunities for neighbourly interaction also need to be balanced with enough privacy for residents.

their garage, shut the roller door and go inside, without any need to interact with their neighbours.

The triplex form also means that the two dwellings at the rear of the block do not have views of the street. This reduces opportunities for passive surveillance, personalisation, and a visual connection to street life. All of this could add to social isolation, compared to the pre-development dwelling form.

To quantify the consequential costs of social isolation from this development, SGS has used the per person cost to society of social isolation, as calculated by Deloitte, equivalent to around $1,100 a year per socially isolated person. This covers economic costs from poorer labour market outcomes, as well as the higher public health costs associated with social isolation.[18]

We apply this cost to the number of adult residents (six, or two per dwelling[19]) and scale it by the proportion of the population which identify as severely lacking social connection (around 10%).[20] This is further discounted to reflect that connection to neighbours enabled by the dwelling built form is only one contributory factor to loneliness and isolation.[21]

This results in a per development cost of social isolation annually of around $220 or a capitalised cost of around $4,500.

3.3 Loss of private open space

The case study development sees an intensification of housing densities, largely at the expense of the generous private open space provided in the original lot configuration. Following development, the new dwellings provide only a small area of open space, primarily in the form of small courtyards and usually covered.

Open space, including a back or front yard with lush vegetation, generates benefits in terms of being pleasurable to view (visual amenity), a space for recreation, and provides a connection to nature. Visual amenity benefits accrue not just to those who live in the property but also to those who live nearby or visit the area and can view a front garden from the street.

Private open space provides opportunities for recreation such as BBQs, backyard sport, or a quiet place to read. This is especially important in the WA context as outdoor living and entertaining are popular for much of the year due to a warm climate.

Private open space also provides a connection to nature which is associated with a range of psychological health benefits including boosted concentration, reduction in stress, and physiological regeneration.[22] Physical health benefits from experiencing nature have also been identified, including reduced blood pressure and improved immune system function.[23]

The benefits of visual amenity and recreation opportunities are reflected in a general preference for vegetation and greenery in an urban environment. One way this manifests is the impact of open space on house prices. One estimate found that high quality landscaping

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[18] This cost is from an approximately 15% change in social isolation, or the difference between communities with average inclusiveness and those with best practice, from Deloitte (2019) *The Economic Benefits of Improving Social Inclusion.*

[19] Approximate average household in middle ring Perth suburbs, 2016 Census..

[20] Australian Institute of Health and Welfare (2019) *Social isolation and loneliness* https://www.aihw.gov.au/reports/australias-welfare/social-isolation-and-loneliness

[21]People who are less connected to their immediate community are much more susceptible to loneliness and isolation, from American Psychological Association (2019) *The risks of social isolation* https://www.apa.org/monitor/2019/05/ce-corner-isolation

[22] [22] City of Melbourne (2019) *Quantifying the Benefits of Green Infrastructure in Melbourne.* https://www.melbourne.vic.gov.au/SiteCollectionDocuments/quantifying-benefits-green.pdf

[23] Haluza, D (2014) *Green Perspectives for Public Health: A Narrative Review on the Physiological Effects of Experiencing Outdoor Nature*

can add 5%-30% to house prices.[24] Other studies have valued visual amenity of suburban greenery and vegetation at 2% to 8% of property values. [25]

The health benefits of access to nature in an urban environment are also well established. One Australian study found that experiencing nature is associated with lower blood pressure and depression.[26]

The current COVID-19 pandemic also highlights the need for opportunities to connect with nature in our urban environments. With non-essential travel discouraged during lockdown, residential areas which have a good amount of greenery and open space allow for this connection to be made at home.

The case study development results in a net reduction of private open space. This means that the benefits of open space no longer accrue to the occupiers of the dwelling. SGS has used the indicative house price impact of high quality open space of 5% as a (likely conservative) proxy for the cost of the loss of open space. Applied to the case study house price (pre development) this means there is an average annual cost of around $900 or $18,000 capitalised.

3.4 Removal of trees

In addition to open space and vegetation being valued on a residential property, the presence of trees has been found to be of particular importance in terms of amenity. In the case study development, there is a loss of established trees and little opportunity to replace them, resulting in a net loss of trees.

Trees provide a wealth of benefits for our environment, our health, and our economy. They provide critical ecosystem services such as air and water filtration, shade, habitat, oxygen, carbon sequestration and nutrient cycling. Trees also benefit our health and wellbeing, providing a connection to nature which can be hard to find in urban areas.

A valuation technique of a single tree's amenity value is well established, and takes into account a tree's aesthetics, size, and location.[27] Using this method the loss of a single well established tree is valued at around $11,000 (capitalised). This assumes an average tree of 30cm diameter at breast height, in good condition, of medium life span, with high aesthetics, and located in inner-middle suburbs.

The case study sees the removal of two large trees while one large tree is maintained. This implies an annual cost of $1,100 or a capitalised cost of $22,000.

3.5 Increased storm water runoff

The typical development case study is characterised by the conversion of a large area of surface from permeable to impermeable. Permeable areas such as grass, vegetation, and trees (through their canopies and root systems) help capture and filter rainwater. This slows flow rates after rain events, reduces stormwater runoff and improves water quality.[28]

The change to impermeable areas, such as concrete driveways and roofs, results in increased stormwater runoff following rain events which creates costs to the community and Government. These costs include increased pollutants discharged into waterways and increased need for rehabilitation and maintenance of downstream waterway environments.[29]

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[24]Stephanie Thorne, *"How landscaping could add $15,000 or more to the value of your home",* March 6 2019. https://www.openagent.com.au/blog/landscaping-adds-value-to-property#
[25] City of Melbourne (2019) *Quantifying the Benefits of Green Infrastructure in Melbourne.* https://www.melbourne.vic.gov.au/SiteCollectionDocuments/quantifying-benefits-green.pdf
[26] City of Melbourne (2019) *Quantifying the Benefits of Green Infrastructure in Melbourne.* https://www.melbourne.vic.gov.au/SiteCollectionDocuments/quantifying-benefits-green.pdf
[27] City of Melbourne (2013) *Urban Forrest Tree Valuation*.
[28] City of Perth (2016), *Urban Forest Plan*
[29] Department of Industry, Innovation and Science (2016) *Enhancing The Economic Evaluation of WSUD.* https://watersensitivecities.org.au/wp-content/uploads/2016/12/IdeasforSA_EnhancingtheEconomic_WEB.pdf

Outside of rain events, the change in surfaces also results in lower infiltration, reducing baseflows in rivers.[30]

There is a known direct link between urban development, and the increase of impermeable areas, and declining waterway health. As noted by the South East Queensland Healthy Waterways Partnership: [31]

> *"Urban development changes the natural hydrological cycle. The impervious areas of developments, such as roads, roofs, driveways and footpaths, prevent water from infiltrating and evapotranspiring. Stormwater is conveyed more frequently and in greater volumes than occurs naturally via a system of pits and pipes to receiving waterways.*
>
> *This causes waterway erosion and significant disturbance of in-stream ecology. If untreated, stormwater carries large volumes of pollutants such as nutrients, sediment and litter that can seriously impact the health of aquatic ecosystems. This is known as urban diffuse pollution."*

These impacts are quantified for the case study below.

Waterway rehabilitation

An increase in the volume and velocity of runoff during rainfall events, increases instream erosion, the disturbance of in-stream ecosystems and the increases the risks to ecosystem function within waterways. With increased runoff these impacts need to be mitigated which creates stream rehabilitation costs. These costs have been assessed at around $2,100 a year per hectare of (total) land developed for a medium density development similar to the case study.[32]

Wastewater treatment

The other key cost of increased runoff is increased urban stormwater pollutant loads which damage the environmental quality of waterways. This means additional treatment is required to maintain water quality.

Wastewater treatment plants work to reduce phosphorous or nitrogen loads with treatment costs of up to $850 per kg of total nitrogen (TN) removed. This cost has been modelled to as up to $6,200 a year per hectare of developed land. [33]

Total costs increased stormwater runoff

Together these costs total around $8,300 a year per hectare of developed land. This cost, applied to the case study land area of 800 sqm, means an additional annual cost of $666, or a capitalised cost of $13,300.

3.6 Reliance on active heating and cooling

The case study is characterised by poor solar orientation, narrow eaves and materials with poor insulation properties. Furthermore the removal of trees providing shade can increase building temperature by up to 8 degrees.[34] This means the residents must rely on active

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[30] Melbourne Water (2017), *Impacts of stormwater on waterways*. https://www.melbournewater.com.au/planning-and-building/stormwater-management/introduction-wsud

[31] Water by Design (2010). *A Business Case for Best Practice Urban Stormwater Management (Version 1.1).* South East Queensland Healthy Waterways Partnership, Brisbane, Queensland. http://www.newwaterways.org.au/downloads/Resources%20-%20Policy%20and%20Guidelines/SW%20and%20GW%20Mgmt/2010_wsud_buscase_v11-4mb.pdf

[32] Inflated to 2020 dollars, based on Water by Design (2010). *A Business Case for Best Practice Urban Stormwater Management (Version 1.1).* South East Queensland Healthy Waterways Partnership, Brisbane, Queensland. http://www.newwaterways.org.au/downloads/Resources%20-%20Policy%20and%20Guidelines/SW%20and%20GW%20Mgmt/2010_wsud_buscase_v11-4mb.pdf

[33] ibid

[34] City of Perth (2016), *Urban Forest Plan*

heating and cooling to keep temperatures comfortable inside throughout the year. While this has direct financial costs to the residents in higher energy bills, it also creates costs to society in greenhouse gas emissions (GHG) resulting from higher energy use.

SGS notes the importance of energy efficient homes has been highlighted by the COVID-19 pandemic. Homes are being used more intensely and as places of work during lockdown, demonstrating the increasing importance of considering running costs at the design stage of development.

SGS has used the Nationwide House Energy Rating Scheme (NatHERS) as an indication of the degree of energy use required for a typical house. NatHERS rating tools predict the amount of heating and cooling a dwelling needs and converts this to a star rating between 0 and 10. A 10 star rated home may not need any active heating or cooling to keep the resident comfortable.

In WA, a 6-star NatHERS energy rating is the minimum standard. It indicates good, but not outstanding, thermal performance. If the dwellings were delivered with an 8 star rating, two above the minimum, this could reduce energy use on heating and cooling by around 25% or around 3,200 k/w a year for a typical household of this size.[35] Therefore by only meeting the minimum energy performance requirements, the dwelling is creating additional costs to society.

The additional energy use is equivalent to an additional cost of around $180 per year on energy bills.[36] In terms of costs to society the additional energy use results in around 0.9 tonnes of GHG emissions for each dwelling a year[37]. Valued at a standard price of $35 a tonne[38] and across the entire development, this is equivalent to an additional cost of around $90 annually, or capitalised at $1,900.

3.7 High embodied energy

The case study development is assumed to use building materials and techniques which have high embodied energy such as brick and concrete. This creates a cost to society in terms of higher GHG emissions in production, compared to materials with lower embodied energy.

Embodied energy is a measure of the energy consumed by the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery.[39] Choices of materials and construction methods can significantly change the amount of energy embodied in the structure of a building, as embodied energy content varies enormously between products and materials. Reuse of materials, when demolition proceeds building (as is the case with most infill developments), is also a way to substantially reduce the embodied energy of a new building.[40]

In 2016 the Sustainable Engineering Group at Curtin University assessed the embodied energy consumption associated with different materials in the construction of a typical Perth house and how this translates to GHG emissions.[41] SGS has used this analysis as indication of the costs created from using high embodied energy materials.

The study noted that some building materials, such as cast in situ concrete sandwich with PET foam cores, have significantly lower embodied energy consumptions with savings of up to 0.6Tj compared to conventional double clay brick homes. This is shown in the table below.

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[35] Sustainable Energy Association of Australia (2011) *Your 6-Star Guide to building an energy efficient home*'

[36] Synergy (2020) *Compare your bill* https://www.synergy.net.au/Our-energy/Energy-tool/Compare-your-bill/

[37] Carbon Footprint Ltd (2020) *Carbon footprint calculator* https://www.carbonfootprint.com/calculator.aspx

[38] Consistent with the method cited in Melbourne Sustainable Society Institute (2019) *Australia's Clean Economy Future: Costs and Benefits.* https://sustainable.unimelb.edu.au/__data/assets/pdf_file/0012/3087786/Australias_Clean_Economy_MSSI_Issues_Paper12.pdf

[39] Milne, G. (2013) *Embodied Energy*. https://www.yourhome.gov.au/materials/embodied-energy

[40] Australian Government (2013) *Embodied energy* https://www.yourhome.gov.au/materials/embodied-energy

[41] Lawania and Biswas (2016) *Achieving environmentally friendly building envelope for Western Australia's housing sector: A life cycle assessment approach.*

TABLE 4: EMBODIED ENERGY CONSUMPTION (TJ) FOR A TYPICAL HOUSE IN PERTH

	Double Clay Brick	Brick Veneer	Case In-Situ sandwich with PET foam core
Concrete Roof Tiles	6.3 (conventional)	6.2	5.8
Terracotta roof tiles	6.1	6.0	5.7 (best performing)

Source: Lawania and Biswas (2016) Achieving environmentally friendly building envelope for Western Australia's housing sector: A life cycle assessment approach

These differences were converted into tonnes of GHG emission, as shown in the table below.

TABLE 5: GREENHOUSE GAS EMISSIONS (TONNES) FOR A TYPICAL HOUSE IN PERTH

	Double Clay Brick	Brick Veneer	Case In-Situ sandwich with PET foam core
Concrete Roof Tiles	444 (conventional)	444	414
Terracotta roof tiles	432	428	404 (best performing)

Source: Lawania and Biswas (2016) Achieving environmentally friendly building envelope for Western Australia's housing sector: A life cycle assessment approach

This work illustrates that there can be an approximately 10% reduction in embodied energy between a typical and best performing build, based on the selection of building materials. This indicates that typical building material choices result in GHG emissions 10% higher (around 44 tonnes per dwelling) than their lower embodied energy counterparts. This in turn creates an additional cost to society. The study notes that the differential between the best and worst performing builds (as opposed to typical) is even higher, at around 20%.

Valuing GHG emissions at $35 a tonne and across the entire development, this results in an annual $233 a year, or $4,600 capitalised.

4. TOTAL COSTS

This section outlines the total societal costs at a per dwelling, per development, and WA wide level.

SGS has quantified the broader costs to society of the case study both on an ongoing (annual) basis, and on a lump sum (capitalised) basis. For the purposes of this study the capitalised cost is simply the sum of twenty years of the annual cost, or vice versa.[42] These costs have also been extrapolated to a WA-wide capitalised cost. This provides an indication of the wider costs to the WA community of these types of development.

Again, SGS notes that this work is not intended to be a detailed financial feasibility analysis, nor a cost benefit analysis. SGS recommends DPLH undertakes a detailed cost benefit analysis of a particular package of reforms once its details are settled.

4.1 Per dwelling and per development costs

The table below displays the results at the per dwelling level. These can be interpreted as the costs to society of sub-optimal outcomes resulting from a single newly developed medium density dwelling. That is, for every new dwelling there is an additional $29,200 of costs created (capitalised) or $1,460 of additional costs, annually. The most substantial costs are the urban heat island effect as well as the reduction in amenity from the loss of trees and private open space.

TABLE 6: COSTS: PER DWELLING

Impact	Cost (annual)	Cost (capitalised)
Storm water runoff	$220	$4,400
Loss of private open space	$290	$5,800
Loss of trees	$370	$7,300
Active heating and cooling	$30	$600
Urban heat island effect	$400	$8,000
Embodied energy	$80	$1,600
Social isolation	$70	$1,500
Total	***$1,460***	***$29,200***

Source: SGS Economics and Planning

[42] To simplify the analysis we have not applied a discount rate. SGS suggests further work to apply a full cost benefit analysis framework to further explore the quantum of costs and benefits once a policy direction is settled.

The following table shows the results at the per development scale, this is simply three times the per dwelling costs.

TABLE 7: COSTS: PER TRIPLEX DEVELOPMENT

Impact	Cost (capitalised)
Storm water runoff	$13,000
Loss of private open space	$18,000
Loss of trees	$22,000
Active heating and cooling	$2,000
Urban heat island effect	$24,000
Embodied energy	$5,000
Social isolation	$4,000
Total	*$88,000*

Source: SGS Economics and Planning

4.2 WA wide costs

The following table extrapolates the results to a WA wide level. This is based on an average supply of new medium density dwellings of around 4,000 a year.[43] This means that every year there are around $117 million of additional costs to society stemming from medium density development.

TABLE 8: COSTS: WA WIDE

Impact	Cost (capitalised)
Storm water runoff	$17,800,000
Loss of private open space	$23,300,000
Loss of trees	$29,300,000
Active heating and cooling	$2,500,000
Urban heat island effect	$31,900,000
Embodied energy	$6,200,000
Social isolation	$6,000,000
Total	*$117,000,000*

Source: SGS Economics and Planning

These costs are cumulative over time, meaning that over a decade there could be a cost of around $1.17 billion stemming from medium density developments. These are substantial costs to the community which require further investigation and possibly government action.

Conversely, an alternative way of looking at these costs is that any policy which addresses these issues could have a benefit of around $117 million a year. [44]

[43] Based on dwelling growth from WA Tomorrow projections and Perth and Peel 3.5 million infill targets. Applies historical proportions of medium density housing from Urbis (2019) *Medium Density Definition and Market Conditions*

[44] We note that benefits depend on the specific policies chosen and *net* benefits would also need to also account for the costs of the policy change.

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