# Challenging sites

**A challenging site sets stringent constraints, from physical and social factors, on the design of your home. A number of strategies and techniques are available to address the design challenges of constrained sites and achieve sustainable outcomes.**

It may be preferable not to build on a challenging site because of environmental impacts and additional costs. On the other hand, it is often possible to achieve good passive design and innovative solutions on challenging sites and they can be exciting places for creating a sustainable home.

Not everyone wants to face the challenges of difficult sites but those who do can often, with an imaginative and flexible approach, find opportunities that others might overlook.

*An imaginative and flexible approach can find solutions that others might overlook.*

The design and construction of a home for a challenging site raises three questions:

- What are the characteristics of this type of site?
- What difficulties does this type of site create for the homeowner, builder or designer?
- What principles, tools and techniques can help solve these difficulties while reducing both the environmental impacts and the costs of achieving high performance?

The approach to dealing with difficult constraints while minimising environmental impacts, maximising positive design outcomes and ensuring value for money starts with consideration of:

- structure — topography, natural and artificial structures
- environment — climate, health, bushfire, flood, cyclone, visual and acoustic parameters
- space — size, shape and volume
- location — remoteness, proximity, servicing (i.e. access to infrastructure and services the occupants want)
- ecology — ecological value, landscaping.

## Structure

Structural constraints apply to the physical factors of the site that include topography, and natural and artificial structures.

Topographical conditions relate to geological conditions that have been created over time. Three key topographical factors are:

- site slope (fall)
- ground conditions
- stormwater runoff.

### Site slope

A steep site generally has a gradient exceeding 30°. The slope has an impact on the type of home that can be built: flat land house types (slab-on-ground) are good for flat sites; hillside houses (such as pole framed houses) match steep sloping sites. This typology aims to minimise the amount of cut and fill needed to accommodate the slope. The slope may also be irregular with some parts steeper than others, and the fall may lie diagonally across the site. Steep sites require careful consideration of the contours for an appropriate design response.

Three environmental strategies often used on steep sites are to:

- balance cut and fill
- avoid retaining walls higher than 1m
- build along contours.

Another strategy is to build into the slope to create an earth-sheltered home.

The slope also affects the types of materials that can be used economically, and solar access, wind exposure and physical access to the building for disabled. In most

A challenging site can bring out the best in design.

climates, creative use of building energy rating tools can solve site issues while achieving energy efficient performance and comfort. Strategies such as adjustable shading, substitution of high mass building materials by high insulation, and PV powered heating and cooling equipment may need to be combined.

This house has an earth bermed wall on its south side.

## Ground conditions

Ground conditions influence the type of foundations and disturbances to the site. Different soil conditions, such as rock, sand, clay or wetlands, place different constraints on design requirements.

The most challenging and difficult ground conditions are clay and wetlands due to their inherent instability. Rock on the other hand presents the most stable ground condition but environmental penalties are large for building basement or earth-sheltered structures in these conditions.

## Stormwater runoff

Steeply sloping sites increase stormwater runoff above and below the surface, from surrounding land and the site itself. Both site slope and hydrological ground conditions can constrain the building process and form.

Strategies for environmentally responsive design include:

- directing stormwater runoff to appropriate destinations — and using it effectively where possible
- collecting and using runoff for landscaping
- minimising interference with subsurface hydrology.

Early identification of existing artificial and environmental features is crucial. Artificial structures on or below ground level are best identified early in the site selection and analysis phase. The consequences of artificial structures can be as important as for pre-existing natural structures, particularly where they affect waste, pollution, solar access, wind exposure, bushfire risk and services, whether subsurface or overhead. The costs of mitigating existing conditions can create an unintended design challenge, so early identification is critical for effective site planning and later construction work.

Photo: Kathie Stove

Some hillside 'solutions' may cause further problems.

# Environment

Environmental constraints arise from the variability of a site's biophysical conditions and include climatic, health, visual and acoustic parameters. Such constraints may be part of the natural environment but are increasingly a result of the way our built environment has been developed. We now live in a time of climate change so design must allow for this change over the building's life. Stronger winds, more severe rain and hail storms, more frequent and severe bushfires, hotter weather and increased risk of inundation may all affect your home.

Photo: Kathie Stove

A well-designed house can sit comfortably on a steep slope.

Four main environmental strategies apply:

- Undertake and integrate climatic analysis in site selections and site planning.
- Look for positive effects in the local environment, e.g. nearby buildings, vegetation or hillsides to the west for shade from the late afternoon sun.
- Set priorities for key environmental factors such as solar access and airflow that can generate solutions.
- Address environmental problems (e.g. erosion and drainage) at source where possible rather than on the site.

A site suffers exposure to extreme climatic elements when it is directly affected by the full force of wind, water and sun (macroclimate conditions) without moderation from topographical or artificial structural constraints. Careful examination of the climate of the region and microclimate of the site, and the local history of extreme weather conditions and projections of local climate change, can reveal opportunities to address constraints.

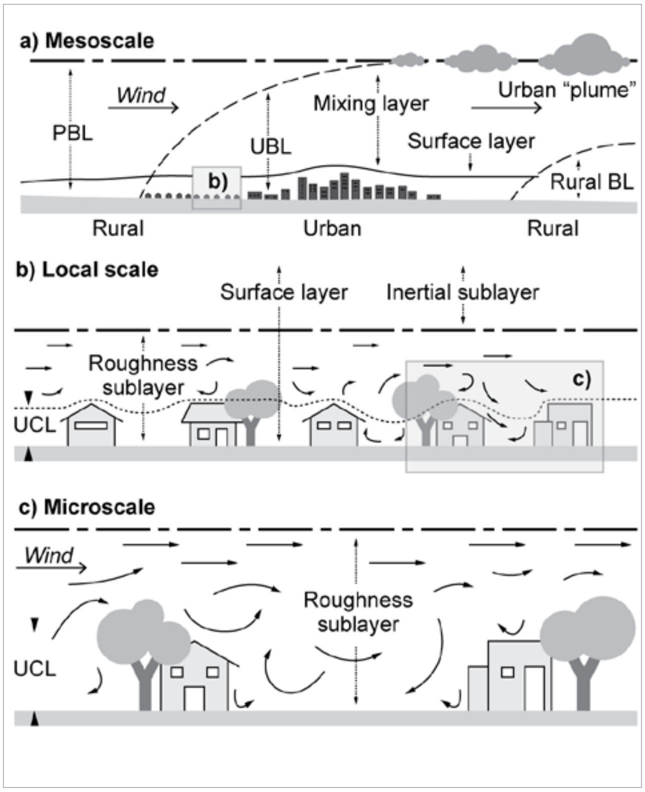
Vulnerability of the site to extreme conditions can create a significant impact on site planning and building location. Life threatening events such as flooding, storm damage and fire create measurable risks but careful site planning and ongoing maintenance can minimise those risks. Sites exposed to 100 year flood levels as well as storm and fire paths should be identified and planning measures adopted.

A mesoclimate is a regional climate modified by topography and other local conditions. The five main mesoclimates are:

- **Coastal** — sea breeze/land breeze effects, which moderate regional extremes; storm exposure
- **Flat open country** — subject to accelerated wind speeds; minor changes in topography can have significant effects
- **Woodlands and forests** — differential solar access and airflow; higher humidity
- **Valleys** — differential solar access and temperatures dependent on location and elevation
- **Cities** — elevated ambient temperatures; differential solar access and airflow; increased turbidity.

Topography and other factors negatively impacting on the climate, for example reducing the effects of natural heating or cooling, can make for challenging sites. Where two mesoclimates overlap, such as cities in coastal areas, the benefits of one can be negated by the other.

Microclimate conditions are the effects of local and adjacent structural conditions on mesoclimate temperature, humidity and airflow. Sites can be challenging where these microclimate conditions negate climatic effects used in passive design, e.g. when adjacent buildings overshadow the site and limit solar access in winter. Compounding factors in some locations can include security concerns or noise affecting the scope for overnight ventilation through conventional windows.




Source: modified after Oke 1997

Climate is affected at the mesoscale and the local scale.

## Climate change

The climate has changed measurably within a generation and it is reasonable to expect continuing change and more extreme and challenging conditions.

> *As the climate continues to change, your home needs to be able to cope with the changes.*

Coastal sites are expected to experience more frequent and stronger storms. Is your site likely to become susceptible to inundation from seawater during extreme storms? Design for:

- increased, heavier rainfall and flooding
- more hot days and longer heatwaves
- extreme conditions in low-lying coastal environments. (see *Adapting to climate change*)

### Other environmental parameters

Moderation of health, visual and acoustic parameters starts with identification of excessive noise, pollution and smells. The difficulty may lie in identifying intermittent phenomena, for example noise from an air conditioner only on hot nights, air pollution from only a particular wind direction. Noise from your home may affect neighbours, and vice versa: consider where to place air conditioners, pool pumps, heat pump hot water service units and other noisy items. And remember people's voices may create unwelcome noise.

## Space

Spatial challenges arise unless there is a proper fit between the size, shape or volume of the block, the building program and environmental factors. Strategies to address spatial challenges include:

- keeping the building footprint to 50% or less of the site area
- making every square metre of floor space count for greater planning flexibility
- considering the building as a 'volume' on a tight site
- consolidating blocks rather than subdividing.

The subdivision of land for building in Australia usually generates rectangular blocks of land. Non-rectangular geometries of small area, usually from subdividing an existing block into two blocks, are often constraining.

'Setbacks' are the clearances between the site boundary and building walls required by planning rules. Setbacks constrain the height and location of walls above the ground and have a profound influence on building volume and spatial configuration, and on size and orientation of windows where overlooking may be a problem. They may exacerbate the limitations of non-rectangular geometries on a block and prevent construction in those areas.

A 'tight site' has little flexibility in the fit. The shape of the block and the building program determines building responses and environmental factors. Specific design solutions may be needed to overcome issues of difficult orientation, circulation and access (see the case study *Howard Street* at the end of this article). It may also affect the practicality of different construction techniques.

Options for mitigating the effects of a tight site include:

- reducing the physical building footprint
- increasing the number of building levels
- consolidating blocks.

Innovative design solutions can gain optimum orientation and solar access in infill development.

Reduce the ratio of the building's ground floor area to site area (building footprint) and use effective planning that eliminates waste space and optimises the footprint. Increasing the number of storeys releases site area, and allows optimisation of orientation, circulation and access. When these measures fail, it may be necessary to consolidate blocks to make a larger site.

Small sites are generally more constraining than large sites but a smaller house can use fewer resources than a large one, and minimising size and resource use is part of any strategy for sustainability.

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The various strategies for dealing with poor orientation or solar aspect, particularly for existing homes, include adding solar reflectors to bounce light back into south-facing windows or effective adjustable shading, and using clerestory windows or advanced glazing systems. A building simulation or rating tool can help you investigate a range of options and their effectiveness.

Dense urban environments can provide the most constrained and challenging sites of all. It may be next to impossible to guarantee northerly solar access. In such locations, good design that works from first principles can still achieve effective passive solar performance. It is possible, for instance, to use solar gain from non-northerly aspects to bring light and warmth into a house provided shading and ventilation is designed to complement the configuration.

Overshadowing by trees, natural features or built structures can also impact on performance of on-site renewable energy systems. Remember to allow for changes in the path of the sun over the year.

## Location

Remoteness and lack of proximity to services can become design constraints. The design of a sustainable home may be significantly constrained by being close to a protected area such as a national park.

Remote sites are those located at such a distance from main population centres that they create challenges for the supply of materials and services. Their limited access to building services (gas, water, electricity and waste disposal) can be exacerbated by limited access to other networks such as road, rail, bus and pedestrian mobility. Increased energy is required to transport construction materials and skilled tradespeople are often not available. Modular factory construction, careful selection of materials and their sourcing, and appliances whose performance can be remotely monitored and diagnosed can reduce costs and improve reliability.

### Services accessibility

Lack of access to services dictates a greater need for building autonomy and provision on site of technologies for water and energy supplies and waste disposal. In general terms, the more autonomous or 'self-sufficient' your home, the more sustainable the solution. Lack of access can thus generate better environmental outcomes. However, design of stand-alone systems requires specialist knowledge.

### Pedestrian and vehicular access

Challenging sites may prevent easy access for vehicles and pedestrians. On sloping sites, steep roads or large volumes of cut and fill may be the only solutions. Wheelchair access for disabled pedestrians requires a ramp with a maximum incline of 1 in 14 (AS 1428.1-2009, Design for access and mobility — General requirements for access — New building work), which may need to be excessively long. A lift or similar device may be a cost-effective option in these situations.

## Ecology

Constraints to ecological value and landscaping arise from the challenges of dealing with the interrelationship of living organisms on a site where humans are one of the resident species. Flora and fauna studies are needed when sites may have high ecological value and endangered or unique species are present. How to restore ecological value and biodiversity can become the primary challenge.

On sites with high ecological values consider:

- establishing a habitat conservation area
- monitoring ongoing impacts of construction
- monitoring activities that may disturb the habitat. (see *Landscaping and garden design*)

### Habitat conservation and enhancement

Maintaining and enhancing existing habitats is a central issue on sites with high ecological value. Make an inventory of existing species and examine the impacts of site planning on species distribution and the viability of habitats. Establishing areas for habitat conservation becomes a central strategy; reduce noise and light pollution impacts of the home on these areas. (see *Landscaping and garden design*)

### Restoring and enhancing ecological value

The development of subdivisions often removes existing flora and fauna, and inner city sites rarely contain even remnant vegetation. Measures to restore or enhance ecological value are then needed. Reintroducing the local gene pool of the soil is an imperative. If the soil from the site's clearance has been stored it can be reintroduced across the site. Subsurface and surface hydrology must be considered to re-establish catchments and enhance water flow across the site. On some sites, wildlife pathways can be created to allow animal movement across blocks and plant food sources can be introduced for both humans and native animals.

Sites are challenging when little ecological value remains or the pre-existing ecology has been destroyed. Increasing the ecological value of the site as part of the landscaping plan is an obvious strategy, particularly on inner-urban sites. Strategies that increase biodiversity range from restoration of indigenous species to the establishment of permaculture gardens. (see *Landscaping and garden design*)

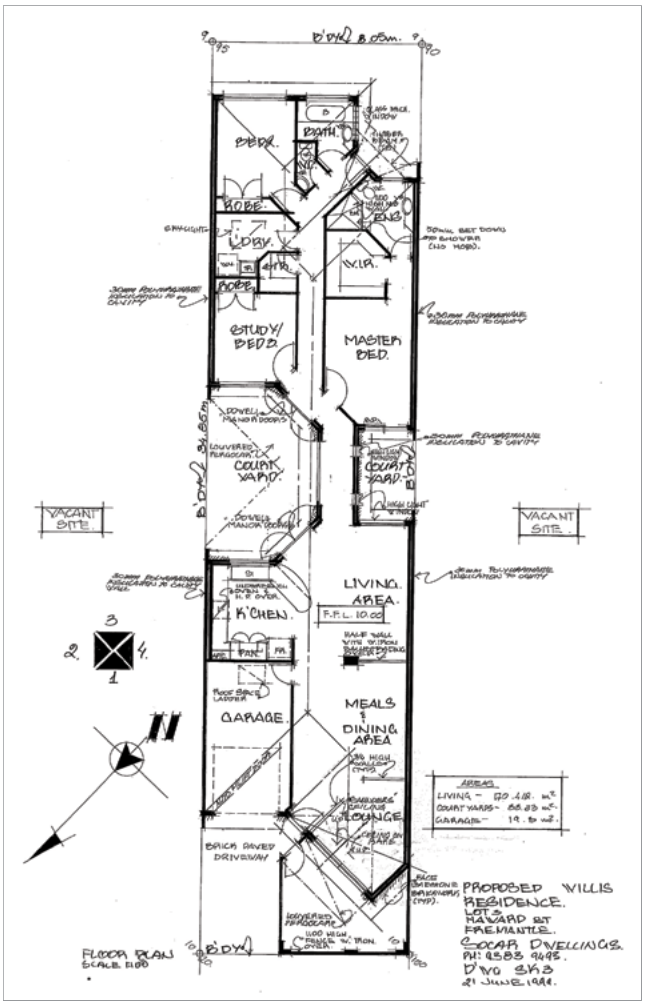
## Case study: Howard Street, Fremantle, WA

The brief was to design a passive solar, energy efficient home on a tight, urban infill block. The long narrow block with an 8m frontage was orientated 45° west of north on the street and garage access was possible only at the front. Solar access was compromised by an existing two-storey neighbouring building and the block was bordered by high parapet walls on both sides. The brief posed quite a challenge for the designer.

To overcome these obstacles the front living room wall of the home was angled to face directly north with the ceiling of the room raked and tapered up to a window set in the gable to increase solar access. Air volume was minimised and thermal mass introduced on the floor and vertical internal walls. This ceiling and window configuration effectively almost doubles solar heat gain, which can then be stored in the vertical thermal mass. (see *Design for climate*)

Two internal courtyards allow further solar gain and combined with carefully selected shading for summer protection also assist with airflow in summer to naturally cool the home.

Use of energy efficiency rating software, such as AccuRate, would have suggested a combination of advanced glazing and carefully designed shading to be used on the windows facing the street, increasing useful floor area and reducing overall building complexity and cost. Low-e (low thermal emissivity and double glazing are net collectors of winter solar energy (see *Glazing*), and north-east and north-west windows can be shaded by, for example, wing walls or adjustable awnings.




Source: Solar Dwellings – Energy Efficiency Homes


Frontage of Howard Street house.

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Updated by Paul Downton, 2013