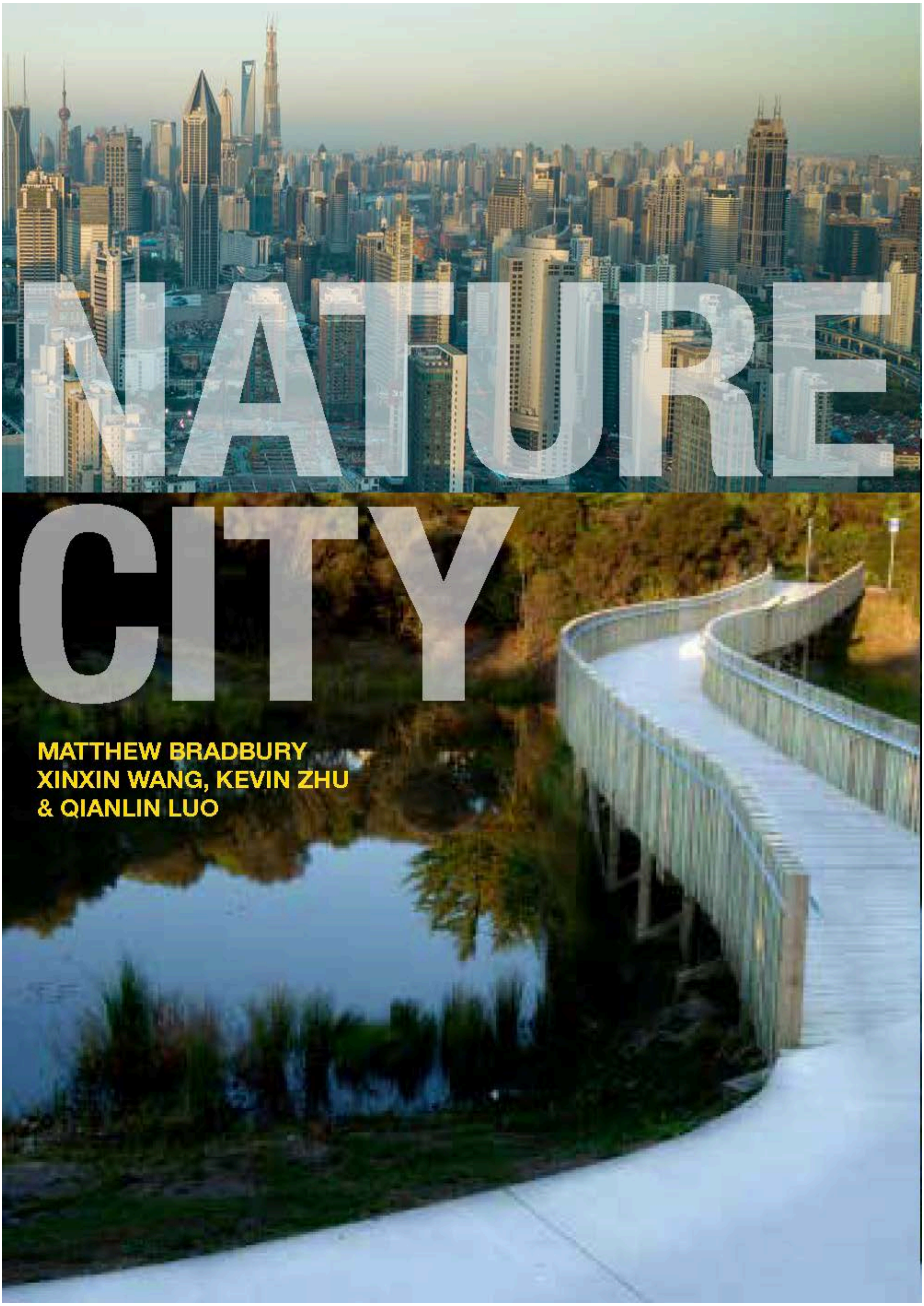

NATURE CITY

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NATURE.
CITY

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SECTION ONE

INTRODUCTION

This handbook will assist civic authorities to create a newer, greener urban form. This will see cities become more environmentally friendly, with cooler urban streets and public spaces, and increased green space for citizens. In addition, cities will be less vulnerable to flooding.

The building of cities, roads, public spaces, buildings and infrastructure has historically meant the destruction of native ecology, smoothing of existing topography, covering up of natural watercourses; the obliteration of the indigenous landscape.

This loss causes a profound modification to native hydrological systems. The construction of large areas of hard surfaces, buildings and roads make it difficult for rainwater to be absorbed into the ground. Instead, rainwater accumulates, leading to flooding. The rainwater also picks up contamination from dirty urban surfaces, roofs, roads and footpaths, leading to the pollution of existing water sources.

Destruction of native flora and fauna habitat also causes a loss of biodiversity, which has implications for cities. Biodiversity is important, helping to keep trees and plants healthy: even a small fragment of properly-looked-after woodland, with the right species, can survive in the city. Healthy vegetation in the urban environment can help in the reduction of CO2, diminishing the the heat island effect (higher temperatures above urban areas), and reducing smog.

THE EFFECTS OF URBANISATION ON THE ENVIRONMENT OF THE CONTEMPORARY CHINESE CITY / The breakneck speed of urbanisation in China over the last 30 years has led to a vast improvement in the standard of living for millions of Chinese citizens. However, as Chinese cities have grown, the existing hydrological landscapes – streams, overland flow paths and wetlands – have been heavily modified, concealed, or destroyed. The consequences have been an increasing number of devastating floods in urban China.

The construction of new cities, the building of new roads and infrastructure and the day-to-day running of a city, the use of petrol-driven cars, the emissions from heavy industries such as steel-making and petrol refineries, and coal burning for electrical generation have all caused an increase in pollution, smog and CO2 emissions. Vegetation, especially trees, is able to absorb these emissions and lower smog; however much has been lost in the new construction.

Public disquiet about increased flooding and air pollution is growing, and the Chinese government is establishing a series of measures to combat this crisis.

RESPONSE TO THE ENVIRONMENTAL PROBLEM / In 2015 the Chinese government articulated five new initiatives to guide the future development of China; one of these was to improve the environment. This has been followed by a number of initiatives to improve the environment of Chinese cities. The first major announcement was to help alleviate and prevent flooding in Chinese cities. This new strategy was branded 'Sponge City' and was aimed at preventing urban flooding by making both new and old cities more absorbent of urban rainfall runoff. The Chinese government backed up this initiative with a firm requirement that 20% of cities accomplish this task by 2020, while 80% of cities achieve this by 2030. A number of major cities have signed up to the 2020 target.

While the Sponge City project is very important, it is just one of a range of recent schemes from the government. In 2016, the Chinese state housing minister announced the importance of ecological restoration as part of any urban development. Following this announcement, the Ministry of Housing and Development is publishing a guide for ecological restoration and urban retrofitting.

NEW ZEALAND / New Zealand is best known for its clean and pristine environment and low-density cities. To preserve the particular character of the natural environment in New Zealand, urbanists and scientists have developed a range of techniques to ensure that increased urbanisation will lead to minimal damage to the environment, especially indigenous vegetation and original hydrology. Two important strategies that have been developed are the integrated catchment management plan (ICMP) and low impact urban design and development (LIUDD).

The ICMP is used to understand the environmental layout of a catchment/watershed – the hydrology, the topography and the ecology. One of its most important uses in New Zealand is in understanding the impact of new urban developments within a greenfield site.

LIUDD is an example of a non-structural stormwater methodology developed in New Zealand. One of the aims of LIUDD and similar regimes is to retain/enhance the biodiversity and health of the existing aquatic ecosystem in a catchment during and after the urban development process.

What these strategies do is to rethink the city as a landscape rather than a collection of buildings. One particular landscape type that is a helpful model in this discussion is the catchment, or watershed. This is a geographical term that defines a practical topography where two landscape conditions join – a valley, gully or depression – and the way in which rainwater falls and is collected in this particular topography. The catchment helps to define and quantify specific social and biological systems, such as the amount of rainwater that falls in a specific area or the way in which certain plant species might grow and spread. The catchment as a concept works not just as a system in a natural environment but also in the city. A good example is the way water moves through a city, the smallest element being the single street drain that is connected through a common element, stormwater, to a citywide stormwater system.

THIS BOOK / This book is a how-to manual: it offers practical techniques for city officials, planners and designers to solve the environmental problems caused by rapid urbanisation, in particular urban flooding and stormwater contamination.

The book starts with a discussion about the environmental problems caused by urban development, loss of vegetation, and the consequent increase in and contamination of stormwater, as well as increased heat and smog.

The second section discusses reconceptualising the city not as an urban /architectural system but as a landscape that is made up of interconnected ecologies. This section discuses the how the city can be thought of primarily as a water catchment system.

The next section looks at specific techniques to address environmental problems in the city. The emphasis in this chapter is on structural techniques to deal with water contamination and flooding, such as rain gardens, green roofs and so on. However, it also asks if these piecemeal techniques are effective, or could there be another model that treats the environmental issues as part of the problem in a holistic way, making a city development mimic the prelapsarian condition.

The following section lays out a new planning methodology that uses catchment management techniques to conceptualise the city as a hydrological system, GIS mapping tools to materialise these specific conditions, and a reconfigured urban plan as a way to both alleviate and remediate urban flooding and to build a strong and resilient green network.

The book then presents four case studies; two greenfield sites and two brownfield sites, one each in New Zealand and China, that use this new planning methodology to reduce flooding and increase biodiversity.

The first example is a greenfield site on the periphery of Auckland, New Zealand. A structure plan for the urban development of the site has been proposed. The case study demonstrates a way in which the structure plan could be modified by considering the extensive catchment system of the site. A new plan is proposed to show how existing hydrological corridors can be protected and enhanced by increasing the absorption of runoff, directing flooding, promoting biodiversity and increasing public space. The initial consequence of these actions is to reduce the number of dwelling units within these zones. However, by reconsidering the housing density of the site to include apartment dwelling, the expected real estate return is maintained.

The second example is a greenfield site near Shoaguang City, the People's Republic of China. The site is a large valley dominated by agriculture, with a largely pervious surface. A masterplan has been proposed for the building of a new city. The new city plan is mapped and analysed, and the likely hydrological consequences of an increase in impermeable surfaces is calculated. Mapping the indigenous hydrological system over the proposed city plan gives a clear idea of how the plan may impede existing flood paths, and the increase in pervious surfaces lead to increased runoff. Through modification of the city plan, a number of beneficial effects are suggested, increasing permeable surfaces to help absorb runoff and prevent flooding. The new green corridors can also help increase biodiversity in the city by promoting the planting of indigenous vegetation; these corridors will also increase the amount of public space.

The two brownfield case studies begin with a New Zealand example. The first is a proposed inner-city waterfront development in Auckland, on an existing reclaimed site. To ensure that the original hydrological balance of the site is restored, GIS mapping is used to identify the natural hydrological patterns of the site. The coastal edge and overland flow paths are identified, and protected from development. To achieve an increase in pervious surface for the site, the existing masterplan is reconfigured through an amalgamation of building uses and an increase in building height. The proposed development masterplan is radically redefined to allow for a massive increase in pervious surfaces through a manipulation of the required building Floor Area Ratio. The result is a new kind of urban development within a new urban park that connects citizens to the natural world while ameliorating environmental problems.

The last study is a brownfield site in Jinan, China. Here the study starts with acknowledging a real problem, the flooding of an existing Chinese city. GIS mapping identifies the existing topography and the urban catchments that have contributed to the flooding. A hydrological analysis reveals the overland flow paths that confirm the location of the flooding at their nexus. The study identifies existing green areas in the catchments that can be used as retention basins. Planners can also use the study as a document to guide the future urban development of the catchment, increasing the amount of green space and public space for the citizens of the district, and reducing the likelihood of flooding in the future.

For cities to address serious environments problems – the production of smog, the spread of the heat island effect, and increased flooding – city managers and designers must increase

green infrastructures.

This book encourages civic authorities to rethink the traditional city plan, a street grid that is filled with building blocks, whose function – retail, commercial, residential – is readily interchangeable. Instead civic authorities and planners must think about the city as a landscape, and in particular a catchment with its own unique hydrological patterns. The structure of the city must alter to accommodate flood plains and overland flow paths. The city's infrastructure, building and public places must fit around these landscape conditions if urban flooding is to be prevented. More green spaces must be created to help in the absorption of rainfall runoff, to help promote biodiversity and create new public space for the citizens of the city.

This proposition is difficult to achieve in an existing city – a patchwork of different owners, stakeholders and interest groups, who are all competing and not always agreeing. The greenfield site is more amenable to this new urban planning technique. It is on this site, with no obstruction to the existing hydrological systems, that a new urban planning methodology could be developed. However, the presence of an existing conventional masterplan is not a hindrance; on the contrary, it provides a financial yardstick with which the economic feasibility of the project can be measured, regardless of the expected shape of that masterplan.

ONE. THE PROBLEM

WATER / In the construction of a city, the residential, commercial, and industrial building and infrastructure necessitate the removal of vegetation and the amendment of the natural topography, which leads to disruption of the natural hydrological system of the building zone.

Rainfall is no longer absorbed into vegetation or the open ground, instead it is repelled by the new impervious surfaces of the city; roads, pavements and buildings all contribute to increasing water runoff into adjacent streams and harbours – the receiving environment. The presence of pollutants on impervious surfaces, and pollutants in the general urban environment also often contaminate the runoff.

The increase in impervious surfaces has two effects on the hydrological system. The first is an increase in the volume of rain not absorbed by the ground, and the second is an increase in the speed of the water flow. This is caused by the transformation of streams and rivers into an artificially enclosed drainage system of pipes and channels, that are designed to smooth the progress of water through the network. These two conditions, the volume and the speed of runoff, have the effect of increasing the discharge of water within a shorter amount of time. The quickness or 'flashy' nature of peak flow runoff has a deleterious effect on the receiving environment, with flooding and damage to the littoral zone at the discharge point of the runoff.

The other effect of an increase in impervious surfaces is the increase in contaminated stormwater. There are a number of urban activities that contribute to the pollution of urban stormwater. These include contamination from paved and road surfaces; construction processes in the building industry, such as the removal of topsoil as preparation for building; and the debris and particles from the different kinds of building materials used. This leads to the contamination of stormwater with suspended solids. Effects of this contamination on the receiving environment are a smothering of the flora and fauna in the littoral zone with the suspended particles, and a reduction in water transparency.

Different industrial processes contribute to a myriad of pollutants from direct sources and from processes; methods of storing finished and unfinished industrial products can cause contaminated runoff to enter the stormwater system, as well as the more obvious sources from waste generated from industrial processes and emissions.

Roof and gutter corrosion leads to runoff becoming contaminated by corroded materials. This causes both toxicants and suspended solids to enter the water system. Incorrect waste disposal practices, leaks from existing sewer systems, and chemicals spilt on impervious surfaces all contribute to runoff contamination. Vegetative waste can also cause stormwater contamination; leaf litter and bark can contribute to a heightened organic carbon load. The effect of this condition is to decrease the presence of oxygen in water. This can lead to smells in the receiving water, plus organic carbon can also combine with other particulates and toxicants.

The sources of contamination affect not only the quality of the runoff but also the way in which contamination occurs. This phenomenon is referred to as build-up and brush-off pollution. The build-up of pollutants on urban surfaces is related to specific urban conditions; the amount and form of the impervious surface and the weather, especially the duration of dry periods. The brush-off phase refers to movement of pollutants from the surface to the receiving environment via the stormwater process.

All these pollutants contribute to the contamination of the receiving environment, leading to a loss of native flora and fauna in the adjacent water bodies – the sea, lakes and rivers – resulting in a loss of marine biodiversity.

VEGETATION / The other consequence of urbanisation on the natural environment is the loss of native vegetation. The native vegetation of a region is often degraded, fragmented or lost entirely as a result of urbanisation. The rich interconnections of native flora and fauna, the complex interactions between different systems at different scales, the biodiversity of native ecotones, are lost.

The replacement vegetation, if any, differs in composition and pattern from native vegetation. The structure of the typical urban vegetative stand has a more open edge condition and a more open internal structure. The greatest difference is the presence of exotic species; these are present at a number of levels and forms in urban vegetation, the closer to the urban centre the more exotic species are present. In many cases, the larger the city and the greater the population density, the greater the exotic species variety that are found, and consequently the greater the loss in native biodiversity.

Not just native vegetation, but also native soils are often highly compromised in the urban environment. Subject to the building of urban infrastructure, their make-up is often highly modified. The composition of many urban soils is often the result of extensive filling operations, where soils from different regions are mixed and compacted to form new city territory. Urban soils are often subject to pollution by highly toxic contaminants released from industrial zones over many years.

The modification of vegetation and soils through urbanisation has a number of effects on the city. The effect of the loss of trees on the urban climate is well known; one of the consequences is the phenomenon of the urban heat island. The temperature in the core of a city is often one to two degrees warmer than that of the surrounding districts.

With the loss of trees able to absorb the high levels of carbon dioxide (CO2) and other emissions produced by a number of industrial and agricultural processes, these gases form an impervious layer in the atmosphere, helping to trap heat from the Earth. This process is known as the greenhouse effect.

REMEDIATION OF CONTAMINATED STORMWATER / A number of techniques have been developed over the last 20 years to clean contaminated runoff in an urban environment. One of the first ideas was to detain this runoff before it could enter a natural waterway. The idea of detention expanded to include cleaning the water by recreating a wetland environment. Contaminants in the runoff could be absorbed by wetland vegetation, and the polluted sediment could sink into a silt layer at the bottom, to be mechanically removed at a later date. A number of issues have arisen after the installation of constructed wetlands. The amount of space required for a remediation wetland relative to the size of the contributing catchment can be large. While the installation of wetlands within a greenfield site is relatively easy, the installation of a wetland within a brownfield site or within an existing city plan is often problematic, due to the expense and availability of the land required for the wetland construction. Another issue with the efficiency of the constructed wetland is the difficulty of processing contaminated runoff during storm events; in effect, the wetland is overwhelmed by flood conditions.

In response to these issues, research into the treatment of stormwater has emphasised small-scale, local techniques that are applicable to both greenfield developments and existing cities. The measures are conceptualised as interventions in the typical journey of stormwater from its genesis as it first falls on an urban surface – roof, pavement or road – to its eventual discharge into an adjacent water body – river, harbour or lake. The concept of these interventions is to retard, retain and clean runoff through a series of small-scale measures, which form a 'treatment train'. A number of devices and structural interventions have been developed to accomplish this goal. These devices are hybrid systems, a combination of conventional architecture or urban construction such as roofs, pavements, curbs, parks, and landscapes; meadows, wetlands, and stream margins.

The roof is an important start point in the stormwater runoff train. Green roofs, with a vegetated surface, are used to minimise the runoff that occurs from conventional roof surfaces. A green roof can help to delay and reduce the runoff from a storm event. This helps to divert the volume of water that would have been treated by a conventional stormwater system. The next intervention in the treatment train is vegetative drainage measures. The quality of stormwater runoff can be improved by runoff passing through vegetation and growing media, filtering out pollutants. There are two types of vegetative drainage area; the first are swales. Swales work like conventional curb and channel systems but with open vegetated channels. The vegetation acts in two ways, one to attenuate the flow of stormwater, the other to remove a variety of pollutants and trap sediments. The second vegetative device is the rain garden, or bio-retention system. These actively treat stormwater in situ by filtering the runoff through vegetation and fine media layers. The effect is to slow down runoff flow and to improve stormwater quality. The vegetation layer acts to remove larger sediment, while the below-ground layers trap certain pollutants. These can be sized at different scales: from the domestic, situated within a suburban garden, taking runoff directly from a roof; to a civic scale, treating water from a large impervious structure such as a bus station.

To treat contaminated runoff from larger civic-scale projects, detention ponds and wetlands still have a place in the arsenal of stormwater attenuation and cleaning measures, if space is available. Constructed ponds are dammed water bodies with a low range of water-level movement and marginal vegetation. Ponds help trap sediments and pollutants from stormwater runoff in silt layers. Ponds are also able to take up some pollutants, through the activities of phytoplankton. Constructed wetlands are still useful devices to treat stormwater, as part of a larger treatment-train model. The wetland is formed as a contained shallow-water system with aquatic vegetation, which regularly fills and empties. Wetlands also trap sediments and pollutants, and the vegetation helps to take up dissolved pollutants.

DISCUSSION / These stormwater cleaning devices have been installed all around the world over the last 10 years. This has allowed a more considered analysis of the effect of these devices on the reduction and treatment of stormwater runoff. This revaluation has led to a rethinking of assumptions about the duration and strength of urban stormwater runoff in both small-scale events and in flooding.

Findings from recent research have led to a more sophisticated thinking around controlling runoff from peak events to controlling runoff from frequently occurring events; in effect to controlling the volume of water that is being discharged to the surrounding environment. In New Zealand, previously accepted models of stormwater mitigation have focused on a catchment stream/river model under a one-to-two-year storm event. The design of conventional stormwater control devices such as rain gardens, pervious paving, green roofs and swales have been based on these hydrological conditions. Recent research, especially in urban areas, suggests that increased stormwater volumes from areas with a large percentage of impervious surfaces will cause an impact to the receiving environment not just in a storm event but every time it rains. Conventional runoff mitigation devices are not specifically designed to control the volume of water flow for everyday runoff events. Research suggests that controlling and mitigating small, localised and frequently-occurring rainfall events is critical, as these events produce the most urban runoff and contribute more pollutants (with the exception of eroded sediment) than large-scale storm events. The response to this challenge is to develop a range of measures that focuses not so much on localised devices around individual suburban houses and gardens and the immediate street, but on large-scale mitigation measures such as water harvesting, evapotranspiration, topsoil infiltration amendment and canopy interception.

Research in Europe is also considering the efficacy of small-scale stormwater treatment devices. With the increase in urban flooding in Europe, the EU has mandated strategic risk assessments of flooding in urban areas. The improvement of stormwater quality is also an important part in thinking about overall water management in Europe. This has lead to the development of a planning methodology for the design of stormwater treatment devices that are based on the definition of a catchment area and site characteristics such as gradient, soil types, infiltration and storm event properties. The other critique of conventional stormwater treatment devices is the structural problem of combining stormwater pollution remediation and mitigation of flooding.

An example of this problem is illustrated in a study in Birmingham. A 170ha site of industrial and commercial buildings that borders the Severn River is used as a site to test the efficacy of structural stormwater-control devices. A 12ha study area on the Eastside was identified and a 2007 storm event was used to test both 1D and 2D flood-modelling software to see what the effect of the flooding would have on the site and how effective a number of structural stormwater interventions would be on mediating these effects. The results are telling: while the three proposed interventions – a green roof, an infiltration trench and porous paving – will reduce the overflow discharge volume, the percentage reduction is only 30%. The authors of the study note: 'this is a relatively modest percentage reduction and the subdued mitigation effects are partially due to the dense urban environment, which limits the type of SUDS that could be implemented and the number of potential installation locations within the site.' The authors go on to specifically discuss the efficacy of green roofs and note that while a green roof will retain up to 20% of rainfall for up to 30 minutes in the first storm peak flow, thereafter the efficacy of green roofs in retarding storm flow is questionable. Not only is the efficacy of a green roof in storm conditions questionable, but the ability of existing buildings to be retrofitted with green roofs has also been queried in recent research. A recent study of the applicability of retrofitting buildings in the Melbourne CBD with green roofs has found that by taking into account 'the position of the building; location; orientation of the roof; height above ground; pitch; weight limitations of the building; preferred planting; sustainability of components; and levels of maintenance', FOOTNOTE only 15% of all building stock had the potential to be retrofitted with green roofs. The finding is rather dispiriting for advocates of green roofs in existing dense urban CBDs.

SUMMARY / This research reveals two problems with the use of structural stormwater devices. Firstly, much of the writing and thinking about the efficacy of these devices is predicated on a suburban location, houses situated in gardens, and the larger suburban structure of wide streets and parks. This suburban structure is loose enough to be retrofitted with stormwater devices or, as in new subdivisions, to allow for the design of stormwater devices before construction. The research shows the difficulty of using these devices in ameliorating the effects of stormwater in a highly urbanised catchment. In this kind of city location, with a dense living pattern, tight urban streets, an existing, historically dense network of pipes, and a high degree of impervious surfaces, the possibility of successfully retrofitting with piecemeal structural devices at source is problematic. The second problem revealed by this research is the inability of these devices to function with runoff from the extreme ends of the spectrum, that is everyday rainfall and extreme storm events that lead to flooding.

TWO. THE ALTERNATIVE

THE HYDROLOGICAL CATCHMENT / A watershed (catchment) is a geographical unit in which the hydrological cycle and its components can be analyzed. (Gheorghe CRETU & Timisoara)FOOTNOTE

The serious environmental and social problems that accompany urbanisation can be addressed by rethinking the city not simply as an urban morphology but as a landscape, an interconnected network made up of ecological systems. To help think about the city as a landscape, the catchment is a particularly useful landscape type. Catchment analysis can be used in two ways, firstly to understand the hydrological behaviour of a given area and secondly to understands the heath of a particular ecosystem in terms of biodiversity. To understand how water will behave in the city or the countryside, the catchment (known as a watershed in the United States) is defined as a specific geographical unit. The catchment is a hydrological system within a geographically specific terrain. Traditionally a catchment is a valley with a central water course defined by the surrounding ridges. A more precise definition would be to take a cross section at 90 degrees to the watercourse as it rises to the hinterland until a ridge is reached and the ground drops away into the neighbouring catchment. This point is known as a divide, and defines the edge of the catchment.

A catchment/watershed works in three ways. Once the rain has fallen into the catchment/watershed, the water percolates into the ground. The infiltration process is influenced by a number of factors – the topography, the climate, the type of vegetative cover present and the soil type. Secondly, the catchment stores rainwater within the ground as an aquifer, or spring. The type of surface cover of the catchment will often determine how deep the percolation goes. And thirdly, once the soils are saturated, the rainfall begins to run off and form creeks, streams and rivers. They will lead to a point where the runoff, (the rainfall after it has passed through the catchment) discharges into a receiving environment – a larger river, a lake, or the sea.

The catchment/watershed contains and is defined by a hydrological network. The network is made up of all the watercourses that discharge into a receiving environment. The operation of the network is influenced by four factors; the geology of the catchment, the slope, the climate and the environment. The watercourses themselves are classified, from upstream to downstream, into a hierarchy of orders, from their origin to confluence to termination.

The entire network can be described as a river continuum. The model is based on an understanding of how a hydrological system within a catchment acts as an ecosystem.

The watercourse is dynamic; it interacts with the adjacent riparian zone, soil, vegetation and topography. Change to the surrounding, or buffer, conditions affects the condition of the watercourse.

The river continuum can be divided into three sections: the headwaters, the middle reaches, and the lower reaches. Each section can be described by the order of streams it contains and their typical gradient. Thus the headwaters contain first- to third-order streams, usually with a steep gradient. The middle reaches contain fourth- to seventh-order streams, which are usually wider and with a lower gradient. This zone is usually industrialised/urbanised, so this water is usually the receiving environment for pollution. The last section, the lower reaches, is of larger-order rivers.

CATCHMENT PLANNING / Throughout the 20th century, and especially in the Untied States, the study of hydrological behaviour within the boundaries of the catchment/watershed has led to the development of the science of catchment planning. Once a catchment has been defined spatially, then it becomes possible to define the behaviour of the dynamic hydrological network that is contained within the catchment.

Geographers and scientists developed catchment planning as a science, as a way of exploiting the natural world. The science of catchment/watershed planning became a tool for foresters to map the development of new forests, and especially for the proponents and planners of hydroelectric power development. In the second half of the 20th century, the focus of catchment planning in the US shifted from being an agent for the exploitation of nature to a tool to help in the preservation of natural resources. With a growing environmental awareness in the US in the 1960s and 1970s, a range of legislative measures was introduced to congress to ensure clean water standards. The metrics behind these new standards were based on an understanding of catchment/watershed systems.

From the 1980s, the idea of looking at a catchment as simply a hydrological system expanded under the influence of environmentalism to a more holistic understanding of the catchment as a biophysical entity that encompasses ecological systems, and the behaviour of those systems within the catchment. One way to conceptualise the way in which larger environmental systems might behave in a catchment system is through the term biodiversity. Catchment planning has also broadened to encompass the social, in particular the idea of participatory democracy. The catchment was conceptualised as a political entity, a community of concern that recognised the tangible environmental problems and issues around a definable physical entity.

CONTEMPORARY CATCHMENT PLANNING IN NEW ZEALAND / In early 21st century New Zealand, the concept of catchment planning has been developed into a more sophisticated tool, the integrated catchment management plan (ICMP). The ICMP is used to understand the environmental layout of a catchment/watershed; the hydrology, the topography, and the ecology of a catchment. With this data a more accurate plan of the future land use of a particular zone can be organised. In New Zealand, the ICMP will often include such data as how the catchment is defined, the current land use, the hydrological pattern of the catchment including the different kinds of receiving zones, streams, rivers, the harbour, lakes, plus any data about the condition of the immediate junction between the discharge point and the receiving environment, such as the settling environment. The ICMP will also include information about any contaminated sites, maps of existing stormwater and wastewater infrastructure, and the presence of any monitoring regimes (Young, 2010).

ICMPs are used for a number of reasons in New Zealand. One of the most important uses of an ICMP is in understanding the impact of new urban developments within a greenfield site. Environmental impact findings from the ICMP can be fed into a structure plan to inform land-use planning decisions. For example, the structure plan can explicitly protect streams and native habitats, and allow for the provision of recreation zones. ICMPs can also be used to assess a specific problem in a catchment, for example, the presence of polluted streams. The gathering of environmental data can help address immediate environmental issues while the larger process of the ICMP, such as community consultations, can help organise larger community decisions. Another use of the ICMP can be to measure the effects on the environment of increasing the discharge from wastewater or stormwater networks. In New Zealand, specific legislation – the Resource Management Act – obliges governmental agencies to obtain an ICMP to help in the assessment of the effect of these operations. As part of a resource consent process, the ICMP can also be used to describe the catchment, the effect of the proposed work in the catchment and possible wider effects (Hunter).

In the preparation of an ICMP for possible urban growth in a catchment, the findings of the ICMP can alert agencies to possible environmental problems at a catchment scale. These findings can help determine appropriate land-use planning regimes at a large scale and make the detailed consideration of urban runoff remediation linked to large-scale issues. When ICMPs are used for a more focused goal, such as stormwater management, then the outcomes are narrower and more concentrated on the immediate effects of contamination. The study will often focus on the immediate solutions to fix the immediate problems with appropriate remediation and/or mitigation measures. Larger issues such as land use and the effect of existing infrastructures that have an impact on the generation of stormwater management can be left out of this equation (Hunter).

Catchment planning can help conceptualise the behaviour of runoff within a geographically-defined area. Catchment planning can also encompass larger environmental questions such as the health of water systems. This discussion is intricately connected to the margins of waterways and their ecological health. Lastly, catchment planning involves the community affected by the hydrological behaviour of the catchment and the beneficial or harmful effects of any proposed development within the catchment.

CATCHMENT MODELLING / There are a number of ways to understand the metrics of the effects of runoff within an existing catchment and the effects of any development within that catchment. Mapping a catchment can show the three-dimensional hydrological pattern, while there are a number of software models as well as simple formulae that can quantify the volume of the runoff.

Geographic Information System (GIS) is software that helps in the analysis and design of data, especially environmental data. GIS can be used to map a catchment and to analyse the hydrological pattern. GIS landscape analysis starts with the construction of a digital three-dimensional model of a given landscape. Digital elevation models can take two different forms according to the base data; the first is a digital surface model – that is, a model that represents the surface of the earth plus all objects on the surface such as trees and buildings. The base data for this model might come from drone mapping. The second model is a digital terrain model that represents just the earth's surface. Base data for this model often comes from a surveying method such as Lidar.

A digital elevation model is represented in GIS in both raster and vector files. The raster forms a grid with elevation points, and is known as a digital terrain model. In the vector form the model is known as a triangular irregular network (TIN). This is a series of points with three-dimensional coordinates that are joined in a triangular network. Using one of these base models, a number of environmental conditions of a site can be modelled, such as the aspect of the site, its relationship to the cardinal points of the compass, the slope of the site and the gradients of the topography.

Using a digital model of the site, the hydrological behaviour and pattern of a landscape catchment can also be modelled. Using ArcGIS (ESRI) software, the original Digital Elevation Model DEM data can be integrated with hydrological information to determine the boundaries of a catchment network on any given terrain. ArcGIS is also able to map the area of rainfall within the catchment from point data. Using, ArcHydro, a range of tools and data models part of the Arc GIS toolkit, the hydrological pattern of the catchment area can be displayed. The software can help define the catchment boundaries of the site and the stream order pattern of the site catchment from the edges to the discharge point. The modelling can also show the effects of an increase in rainfall and the effects of a lessening or increase in perviousness of the different surfaces in the catchment.

While ARCHydro software is typically used to determine the hydrological behaviour of unmodified catchments it can also be used to determine the hydrological behaviour of urban catchments. However when carrying out GIS analysis of an urban catchment there are a number of specific urban/landscape conditions that need to be taken into account to ensure an accurate measurement of catchment runoff. These conditions are artificial changes to the terrain through contour modification, an increase in impervious surfaces through building and infrastructure construction, and the installation of reticulated stormwater systems. These are all conditions that are not found in natural catchments but will affect the accurate measurement of the effect of runoff within the urban catchment.

The percentage of pervious and impervious surfaces within a catchment is a critical measure in understanding the hydrological behaviour within a catchment. The simplest way to understand this ratio is through an aerial photo survey to measure the percentage of building and roads versus unbuilt surfaces such as parks and reserves. This method doesn't allow for any complex analysis to include factors such as the soil condition and the types of absorbent vegetation. To give more certainty, ground truthing (a site inspection) of the selected landscape can yield a more accurate analysis of the specificity of the ground conditions. Finally, a specialist investigation of soil and subsoil conditions will yield hard data on the ability of soils to absorb runoff.

The construction of underground drainage systems has the greatest effect on the hydrological behaviour of the catchment. A drainage system can drain areas outside the existing catchment boundaries, thereby removing the immediate sub-catchment runoff from around that drainage point. Conversely, runoff outside a specific catchment can be drained into a catchment, thus increasing the catchment size.

STORMWATER MODELLING / The runoff from the catchment and the size of the remediation or detention devices that are required to remediate or alleviate the effect of excessive runoff due to impervious surfaces can be modelled using a number of software programmes. Some programmes are more suitable as conceptual design tools for the study of how an urban stormwater management regime could be integrated into the urban landscape, rather than for more specific hydrological analysis.

Certain software can be used to model water and pollutant runoff, transport and routing. This data is important in assessing future land use policies. Large-scale catchment modelling can be used for assessing regional water quality and pollutant loads, and for assessing broad-scale management actions. More specific programmes can be used to model the performance of conventional and innovative water supply, stormwater and wastewater provisions. These programmes are useful for measuring the impact that innovative water-services regimes can have on various urban development options. Programmes can be specifically designed to determine water quality and to demonstrate how a range of stormwater treatment measures will operate. Remediatory regimes for stormwater cleaning and flood prevention can then be modelled. Other programmes can be used to size stormwater infiltration systems, and to help in the design of rainwater tanks, grass swales and bio-retention systems.

There are also a number of simple mathematical formulae that can determine the amount of runoff. The Rational Method is a commonly-used mathematical equation to calculate the maximum value of flood runoff from a small watershed. This is a formula that relates the intensity of rainfall, the area of the catchment and the consequent runoff (Thompson, 2007).

Q = CuCiA, (1)
where:
Q = design discharge (L3/T),
Cu = units conversion coefficient,
C = runoff coefficient (dimensionless),
i = design rainfall intensity (L/T), and
A = watershed drainage area (L2).

The units conversion coefficient, 3 Cu, is necessary because the iA product, while it has units of L3/T, is not a standard unit in the traditional units system.

C = Runoff coefficient / The runoff coefficient is the fraction of the rainfall that is converted to runoff, that is, the rainfall that is not absorbed into the ground. The runoff coefficients of different ground conditions can be found in a number of commonly-available tables. This figure can be manipulated by increasing the permeable surface through the provision of new public spaces like parks, and by decreasing building footprints.

i = Design rainfall intensity (L/T) / Rainfall intensity is the relationship between four conditions; the geographic location of the catchment, storm duration, storm intensity, and storm return interval. This figure has already been calculated for a number of geographical locations and has been developed into readily classifiable formulae on the internet. For example in New Zealand, the National Institute of Water and Atmospheric Research (NIWA) has developed an online calculator for any New Zealand location. There are also a number of online tools to help with this calculation (LMNO Engineering, 2015).

THE ECOLOGICAL CATCHMENT / Biodiversity is the diversity of life and processes in community's ecosystems and landscapes (West, 1993)

Urban development has a particularly deleterious effect on native ecosystems. Through a removal of native ecological biotones, biodiversity is compromised or lost. The main agents in this process are a growing proportion of non-native species becoming established, reduced resources for native flora and fauna, an increase in natural enemies and a change in the physical environment.

However, cities can become ecologically sustainable by connecting to a landscape structure that generates biodiversity through supporting ecological processes. "Biodiversity is made up of three elements: compositional, structural, and functioning parts of an ecosystem" (Noss, 1992) FOOTNOTE An example would be a species (compositional) is linked to habitat diversity (structural), that is dependent on containing renewal through natural processes (functional).

To understand how biodiversity might be maintained or enhanced in the contemporary city, the concept of island biogeography can be used to understand the location and enhancement of indigenous landscape systems within a catchment. Island biogeography springs from the concept that within many cities there are isolated patches of remnant indigenous vegetation, parks (though often exotic vegetation), abandoned sites, railway tracks and motorway margins. While these sites may seem isolated, they have the potential to be linked through 'corridors'. These can be terrestrial, alongside transport corridors and also, especially in New Zealand, aerial, with the importance of birds spreading seed. Two factors determine the viability of organisms within the 'island'; the composition and health of the habitat patch, and the dispersal distance between patches.

A number of metrics can be developed, to measure the effectiveness of these new conditions. Patch richness is based on a number of factors, the number of patch types in the landscape, a measure of ecological diversity of the different patch types, the proportion of total area of the catchment occupied by a particular patch type and a measure of dominance of patch types.

The largest patch can be found by developing a patch index, that is the proportion of total area occupied by the largest patch of a type. Patch density can be measured by the number of patches per 100 hectares. The mean patch size can be determined number of patches divided by the selected area.

In New Zealand, Muerk and Hall (2006) have developed specific techniques to enhance biodiversity within a wide range of ecosystems, exotic as well as indigenous, urban as well as rural, using a patch/corridor methodology. The authors advance a number of practical metrics to help designers and stakeholders plan for the restoration of indigenous patches and corridors to link with other patches, to encourage native biodiversity back to the city. The authors point to the special New Zealand conditions of flora and fauna; birds usually assist in plant propagation, so connections between patches don't always have to be land-based green corridors.

Maintaining or upgrading a city's biodiversity can be understood through an analysis of the patches or islands. These can be improved through a deliberate policy of enriching the vegetation and soils within the patch. The location of patches can be enhanced through a number of deliberate design strategies such as the provision of parks or green areas, and the protection of existing natural areas in the city.

LOW IMPACT URBAN DESIGN AND DEVELOPMENT / The catchment is a useful way to both conceptualise the city as a landscape and to develop a series of metrics around the hydrological and ecological behaviour within a catchment. The catchment can also be used to develop a model which can be tested to improve hydrological and ecological health through an iterative process.

Low Impact Urban Design and Development, (LIUDD) (van Roon & van Roon, 2005) is a planning methodology that uses a catchment model to define the environmental consequences of any urban development of a greenfield site. This work is presented as a hierarchy of three scales of practice. The first scale is at the level of the catchment, with the aim to maintain an existing ecosystem. The second scale helps to locate the site within the larger catchment through a series of ecologically-derived metrics. Examples include making the best use of the existing infrastructure, minimising the effects of the development through site selection, and matching the development to the carrying capacity of the [1]ecosystem. These goals are developed through the use of specific techniques contained in the third level of the hierarchy. Reducing contaminants through the restoration and protection of the natural landscape, and minimising waste through reduction and reuse of water are some examples of specific ways of working that help the attainment of these goals.

One of the aims of LIUDD and similar regimes is to retain and enhance the biodiversity and health of the existing aquatic ecosystem in a catchment during and after the urban development process. The objective of LIUDD is to ensure that even after development there is no change to the health of native water ecosystems; the term for this condition is hydrological neutrality.

The idea of carrying out urban development with no effect on the hydrologic and ecosystem health was originated by researchers in Washington State. They christened the concept Zero Impact Design (ZID), in which any urban development must 'retain or recreate' the indigenous hydrological conditions. As much of Washington State is covered in forest, the ZID regime is specifically oriented toward the protection of indigenous forest within a catchment. Under urban development, the duplication of forest-like functions such as evapotranspiration and ground infiltration of runoff is promoted.

In urban developments in New Zealand, hydrological neutrality is ensured through a range of techniques. These include protection of riparian margins, increasing evapotranspiration, using clustering as an urban design model, and limiting the effective impervious area of the development to 15% of the catchment.

Protection of riparian margins is critical, and achieved with the planting of indigenous high biomass species. This helps to increase aquatic and terrestrial biodiversity within the riparian corridors, and also to increase evapotranspiration. Increased evapotranspiration rates are important in ensuring the preservation of hydrological neutrality. In addition to riparian corridors, wetland and flood detention areas should also be protected.

However, riparian protection by itself is not enough to ensure a healthy terrestrial and riparian ecosystem. Building a conventional urban masterplan that uses a traditional grid/block pattern should be avoided. Designers should search for an urban form that values and preserves open space and rationalises infrastructure.

To accomplish this, the built component of the masterplan should be 'clustered'. This can be accomplished at different scales; from the suburban, where individual houses can be grouped into village-like compositions, to more intensive developments with different building types such as terrace housing or apartments . Clustering can also be accomplished by combining different urban uses – commercial, industrial and residential – within one building. In this way the impervious building footprint of development can be reduced and open space can be increased. The provision of this open space can then be used for promoting biodiversity through the preservation and replanting of indigenous vegetation.

The urban operation of clustering buildings into a village-like form and/or folding building functions together into a single footprint is shadowed by another technique or measure: limiting the effective impervious surface of any urban development to less than 15% of the area of the catchment. 'Effective impervious' is a term that that defines an impervious area that drains directly into a waterway. This can mean an impervious surface directly adjacent to a waterway, or an impervious surface that is linked to a waterway via a piped system: if the runoff from the impervious area can be intercepted with a pervious surface like a swale, then the impervious surface is no longer considered part of the effective impervious area.

The concept of hydrological neutrality seems to offer a strategy to address the environmental problems of contaminated stormwater, flooding and loss of biodiversity caused by urbanisation.

THREE. THE ANSWER / DECREASING IMPERVIOUS SURFACES

INTRODUCTION / The environmental problems caused by urban development can be reframed in a more holistic way to make their remediation more responsive and resilient. By rethinking the city as a catchment, civic authorities and stakeholders can conceptualise the environmental issues of urbanisation within a landscape/topography. This geographical definition helps to develop metrics of where and when urban flooding can occur and the deleterious effects of the loss of biodiversity. The metrics can also be used to develop a model, which can be used in an iterative manner to help stakeholders understand the way in which remediation measures for these problems might be advanced.

The key measure to lessening urban flooding and increasing biodiversity in the city is to decrease the amount of effective impervious surface. Remodelling a highly urban impervious surface as a pervious surface is an important step towards preventing stormwater contamination and urban flooding.

ANALYSIS / An analysis of an urban catchment reveals the size and shape, and the hydrological behaviour of the catchment, the location of overland flow paths and the amount of runoff generated in a storm event.

1. Define the catchment using GIS software mapping.
2. Define the hydrological pattern of the catchment, in particular the overland flow paths, using the appropriate modelling software.
3. Determine the ratio of pervious to impervious surfaces within the catchment.
4. Define the amount of runoff from the catchment, using a mathematical formula such as the Rational Method, or a computer model.

This data will reveal any potential flood zones and the extent of vegetative loss.

DESIGN / With this data, designers have the ability to ameliorate the effects of flooding and the loss of biodiversity in the design of the new city on a greenfield site, and in an existing city on a brownfield site. The common goal for both situations is to redesign the shape of the city to allow for more pervious surfaces. The mapping of the overland flow path network will show where flooding might occur, and the subsequent travel path. By protecting the existing hydrological systems by 'buffering' and expanding the margins of the existing streams and overland flow paths, the amount of impervious surface can be decreased. Simultaneously, new public space can be created and an increase in biodiversity can be effected through the planting of indigenous species within the new buffer zones.

GREENFIELD URBAN DESIGN /

In order to protect the receiving environment of streams, rivers and ocean from the effects of contaminated stormwater runoff from new city construction, the building of effective impervious surfaces has to be reduced.

Current stormwater mitigation practice concentrates on controlling flooding and pollution rather than on protecting the ecological heath of the receiving environment, in particular the urban stream. By thinking in a holistic way about the hydrological system in the catchment and trying to replicate the edenic hydrological processes – in particular, the runoff pattern, native infiltration and evaporation of water – the water quality in the receiving environment will be assured.

By protecting the areas around urban streams through the replanting of indigenous species, erosion and sedimentation can be reduced. Phosphorus, nitrogen, and other contaminants present in urban runoff can be trapped and removed. The creation of riparian zones can also protect and enhance wildlife habitat both aquatic and terrestrial. Buffer zones should be between 15 and 30m wide to ensure these ecological functions are achieved. While grass will help absorb pollution in overland flows, the planting of indigenous vegetation, preferably from the appropriate ecotones, is a more effective way of treating contamination while at the same time helping to increase biodiversity. The buffered hydrological network can also act as a flood corridor during extreme rainfall events. Green corridors can also be used a connectors of urban patches, helping to increase the biological viability of the city. Additional social functions within the stream corridors like parks, reserves, and sports facilities can also help to increase the amount of pervious surface.

A specific GIS function, buffering, can be used to map riparian corridors around existing stream and overland flow paths. However, protecting existing stream networks by themselves is not enough to replicate the predevelopment hydrology of a catchment. Even the smallest streams and overland flow paths contribute to the hydrological health of the catchment so their protection, that is that they are not built on, is also critical.

Two conditions that contribute to the preservation of the predevelopment runoff regime are evapotranspiration and infiltration.

Evapotranspiration is a term that describes the way in which water is moved from the ground to the atmosphere through plant transpiration and evaporation from a surface. Infiltration is a process whereby water percolates through the soil. These two conditions contribute to water loss in a catchment – that is, the water doesn't make it to the stream network.

How do planners and designers 'mimic' the predevelopment condition of the catchment based on these two operations? Water loss by deep seepage is minimal, but water loss by evapotranspiration in an undeveloped catchment can vary from 30 to 60% while from impervious surfaces the rate rapidly decreases to 10 to 25%. The change in vegetation cover also affects the evapotranspiration rate, with grass having a much lower transpiration rate than trees, while native forest cover has the best rate.

A combination of topography and vegetation cover – hill slopes and native forest – proved the most effective zone for both soil absorption of runoff and evapotranspiration. These areas can be located using the GIS function of hill slope analysis.

To enhance the biodiversity of the new city, provision for the location of urban paths and associated connective corridors should be made. The mapping of riparian corridors and steeper topography can be combined with a number of patch-design metrics developed by New Zealand researchers. The minimum size for a viable indigenous forest patch in a city is 6ha. This can be sized as a 250m x 250m square, which has a core area of 2ha (15m x 150m) surrounded by a buffer area of 4ha. This reserve is a 'core sanctuary'. Patch sizes can be smaller if treated as 'stepping stones', so smaller patches of native vegetation can be 1.6ha and .01ha, provided they are spaced at specific distances. The 6ha patches are spaced 5kms apart, the 1.6ha patches 1-2kms apart and the 0.1ha patches 200 metres apart. Propagating the city with these patches at different sizes, in addition to the more conventional lineal land corridors around roads and riparian corridors will help to increase biodiversity in the city.

BROWNFIELD URBAN DESIGN / An existing city and the conventional masterplan of a new city present a number of obstacles to the remediation of urban flooding and increasing biodiversity through the expansion of effective pervious surfaces. Existing cities are usually dense networks of existing infrastructure and networks in archaeological-like layers. Complex ownership patterns likewise encrust the city surface. The logistics of flood prevention and increasing biodiversity in the city through an increase in pervious surfaces come up against the seemingly intractable face of property ownership and existing infrastructure. In a similar way, the conventional city masterplan, the urban road grid with block building, often displaces the landscape logic of the site. By occupying the site with highly impervious surfaces the city plan relies upon an engineering solution, typically a piped drainage network, more recently with the addition of stormwater remediation measures such as rain gardens and swales, to solve the subsequent problems of urban flooding and the loss of vegetation.

The greenfield site-design methodology is of limited value in this situation. However the data gained in the analysis phase of the catchment planning can instead be used as a future-planning tool. Firstly the catchments/hydrological patterns derived from the GIS analysis can be mapped over both the existing urban plan and a proposed urban masterplan. In this way stakeholders can see how buildings and infrastructure will obstruct an overland flow-path network or occupy a flood plain. The second way in which the analysis can be used is the way the runoff data can inform an agency of the expected discharge of stormwater from the catchment under different weather conditions. Using this data, stakeholders can see the way in which the impervious footprint of existing or proposed buildings and infrastructure contributes to the accumulation of runoff, and can lead to potential flooding.

For an existing city, planning policies can be developed to earmark buildings that occupy flood corridors and flood plains for future purchase and removal. The staged removal of buildings along the flood corridors will lead to an increase in pervious surfaces in the city and the opportunity for increasing the planting of trees and making more public space.

In the case of a proposed city masterplan, by overlaying the hydrological mapping on the proposed plan, buildings can be identified that will obstruct water flow or occupy flood plains. This analysis can lead to a recasting of the masterplan to allow for the free flow of stormwater along identified flood corridors. At the same time, beneficial environmental and social outcomes can be added to the masterplan, such as planting along the new flow-path corridors and increasing the social spaces for new citizens.

Other uses of the new zone of pervious land could be as a site for large-scale stormwater retention ponds to treat contaminated stormwater from the remaining catchment. Techniques, such as wetlands and the daylighting of stormwater infrastructure, that are extremely difficult to use in conventional urban developments, because of the limitations on land availability, are viable in this new urban configuration. Similarly, goals for urban sustainability through the development of specific urban eco systems can be developed. Restoration of native habitats, both terrestrial and aquatic, and positioning of urban habitat patches, are some of the rich possibilities opened up by this radical new urban configuration.

URBAN DESIGN / The increase in pervious surfaces in an existing city plan and a master-planned city will decrease the accumulation of stormwater, and help in the lessening of the urban heat-island effect and the build-up of urban air pollution through the planting of trees. However, the loss of buildings in exchange for an increase in pervious surfaces

represents a potential loss of return for the building owners.

In modifying a proposed urban masterplan to allow for the existing hydrological pattern and planning new buffer areas around the overland flow-path networks, there will be a reduction in the expected real estate build. The Gross Floor Area (GFA) that the developer or government agency is allowed on the site will be reduced; consequently the ‘missing’ GFA has to go somewhere.

One solution is to increase and relocate the expected building density of the site. If the urban project has allowed for single suburban dwellings, then a change in building specification to townhouses or apartment buildings will allow for the same number of dwelling units on the site. By ‘lumping’ the GFA into a more dense development with a lower footprint, an increase in permeable surface while retaining the expected financial return is possible.

The real estate requirements of contemporary urban development can be remodelled to allow for a more hydrologically equitable realm. By redistributing the expected GFA into a new urban configuration, the occupants of the new city will have a new connection to the urban landscape, and the building owners or developers are assured that they will still attain the expected financial return. However, the cost of the design and construction of the new pervious surfaces has to be financed somehow.

One solution that has been used by Western civic authorities is a manipulation of the control of the allowable FAR (Floor Area Ratio) of an individual building (the allowable FAR of a building is usually set by civic agencies). In the normal building process, a developer usually pays a contribution to the city authorities as part of the development of civic infrastructure, in the form of parks and public art works. Some cities have made a decision to deliberately trade an increase in the allowable FAR for a building site, thus increasing the profit for the developer, in exchange for an increase in development contribution. Vancouver is an example of a city that has used the manipulation of a site’s FAR to ensure a greater developer contribution. The particular urban form that Vancouver has adopted over the last twenty years for the CBD is a tall, skinny apartment tower with large podium that fills a city block and offers a range of street-edge-activating experiences.

The payment for community benefits is derived from the allowance for extra building height (and the associated extra profit for the developer). The extra height for the building is governed through the mechanism of the Community Amenity Contribution. Vancouver has married a typical and widespread planning mechanism, the developer contribution, to a special urban form, the tall skinny high-rise building, making an urban virtue out of a development necessity and at the same time deriving considerable social amenities.

The development industry, both private and public, is acutely aware of the financial implication of environment changes such as flooding and air pollution on valuable property investments. Public space assumes a much more critical role; the building of remediation measures for flooding, and urban tree planting are critical. All these measures rely upon a new green infrastructure with a dual purpose: firstly, to protect valuable real estate under severe weather conditions of flooding and storm events and, secondly, to act as green public spaces.

SUMMARY / In privileging water systems so that a site is restored towards a hydrologically neutral field, our traditional understanding of the relationship of the landscape to the city – the park or garden within the urban realm – has to be reconceptualised as the city within the landscape. This insight could provide a provocation to accepted ideological models of urban development, based on the grid and the block, and opens up a huge range of urban possibilities that an understanding of hydrological systems can lead to.

SECTION TWO THE CASE STUDIES

INTRODUCTION

Four design case-studies have been developed to demonstrate how the ideas discussed in the previous chapter can be manifest as a planning methodology. To fully test these ideas, case studies have been developed for both greenfield and brownfield sites in New Zealand and China. In this way both the advantages and shortcomings of the methodology can be fully explored. Each case study starts with a description of the larger region, or catchment, where the site is located. The case study site is then described, especially its particular landscape qualities. Each of the case studies has a particular urban or environmental problem that has been addressed by a new masterplan. An alternative strategy to the new masterplan is then outlined; one that is generated from a landscape understanding of the larger catchment, and an environmental inventory. A speculative urban plan is then advanced to address the original concern.

STUDY ONE. GREENFIELD / NEW ZEALAND

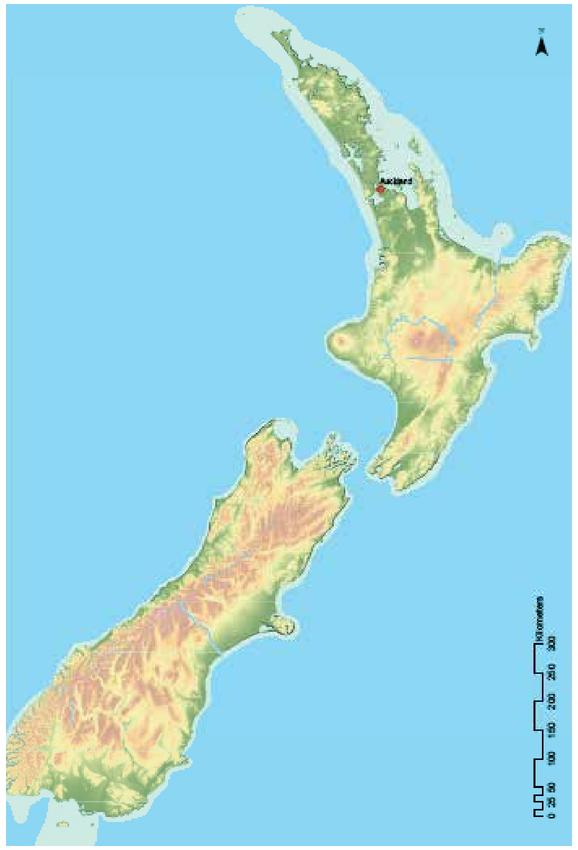
WHENUAPAI

BACKGROUND TO THE STUDY SITE

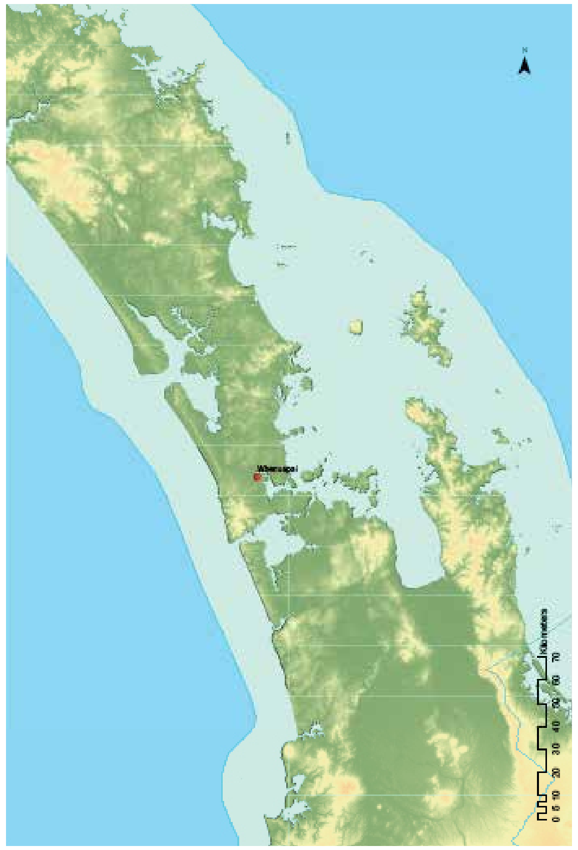
Whenuapai is a new city being planned to the west of Auckland City, New Zealand. (ill.1) Auckland (also known by it's Māori name, Tāmaki Makaurau) is the largest city in New Zealand, with a population of 1.57 million. (ill.2) Auckland City is located on an isthmus – a land bridge between two harbours, the Manukau, to the south, and the Waitematā, to the north. The Manukau Harbour connects to the Tasman Sea to the west, and the Waitematā Harbour connects to the Pacific Ocean to the east. Two ranges further define the city; the Waitakere ranges to the west, running beside the Tasman Sea, and the Hunua ranges to the east. Tāmaki Makaurau has been occupied by the indigenous Māori people since the12th century, and European (English) people since the19th century. Whenuapai (ill. 3) is located on the southern side of the upper Waitematā Harbour, with Brigham's Creek forming a boundary to the west and State Highways 16 and 18 forming the southern and eastern edges of the site. The greater part of the site is a moderately flat plateau approximately 25m above sea level. An airfield, the Whenuapai Aerodrome, dominates this plateau (ill. 4).

Whenuapai can be divided into four major catchments (ill.5). These catchments are bisected by a number of streams: Brigham, Rarawara and Waiarohei Creeks. Ten watercourses discharge into the harbour (ill 6). The average annual rainfall in Whenuapai is 1333.5mm, and the average monthly rainfall is 111.1mm. The average rainfall in January, the driest month, is 79.3mm. The wettest month is June, with an average rainfall of 147.8mm. The aspect of Whenuapai is mostly northerly with an east-west division along the sides of the stream corridors (Ill. 7). The slope of the majority of the site is flat (0-5 degrees) however, alongside some of the stream corridors the slope increases from 5 to16 degrees (ill.8). The site was originally clad in New Zealand native coastal forest. The typical vegetation of the coastal edge of the Whenuapai catchment is characterised as belonging to the Kowhai-Kotare Harbour Coastline Ecosystem. The dominant tree species are pohutukawa, kōwhai, kohekohe, pūriri, kauri, karaka and tītoki. Shrub species include karo, astelia, whārangi and ngaio.

Māori used the area mainly as a portage, with Brigham Creek (Pitoitoi) used as a portage to the Manukau Harbour, while nearby Riverhead (Rangitopuni) was used as a portage to the Kaipara Harbour to the north. The first European occupation of Whenuapai was devoted to the extractive industries, tree felling and milling, and kauri gum collection. Small-scale industries followed; flour milling and brickworks, before the land was cleared in the late19th century and livestock farming began. In the 20th century the land use changed to small-scale orchards typical of West Auckland This has produced a distinctive landscape pattern of horticulture blocks



ill.1 / LOCATION IN NEW ZEALAND



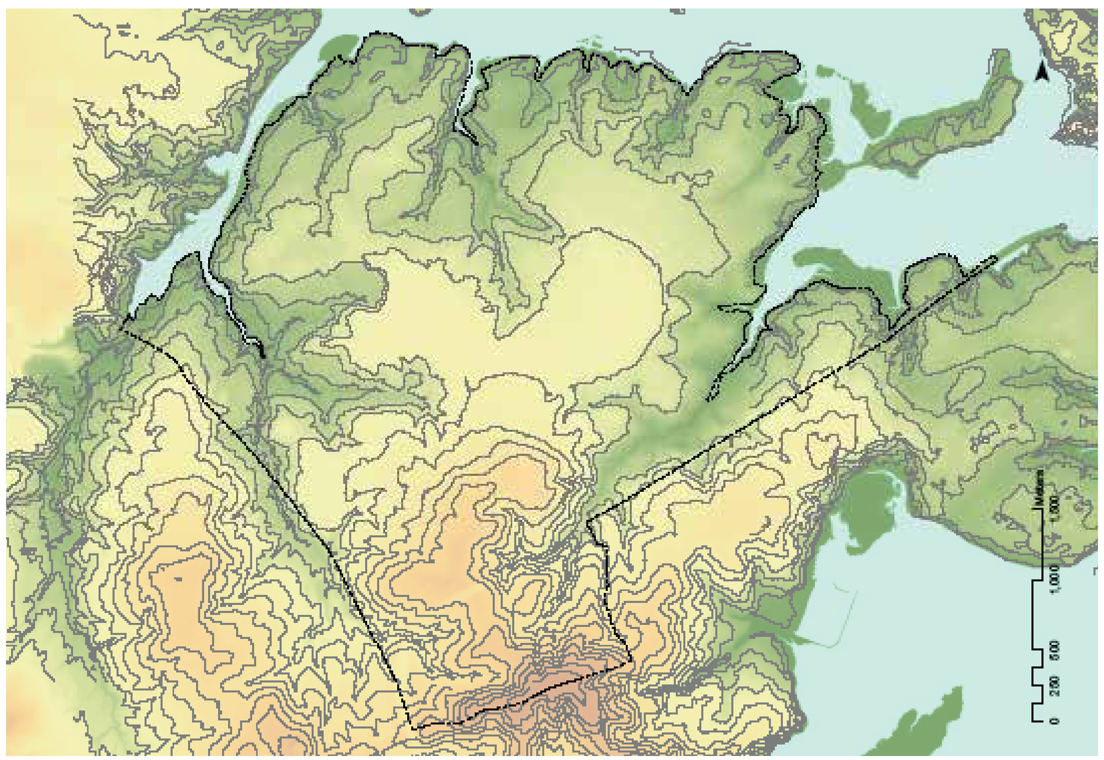
ill. 2 / LOCATION IN AUCKLAND REGION

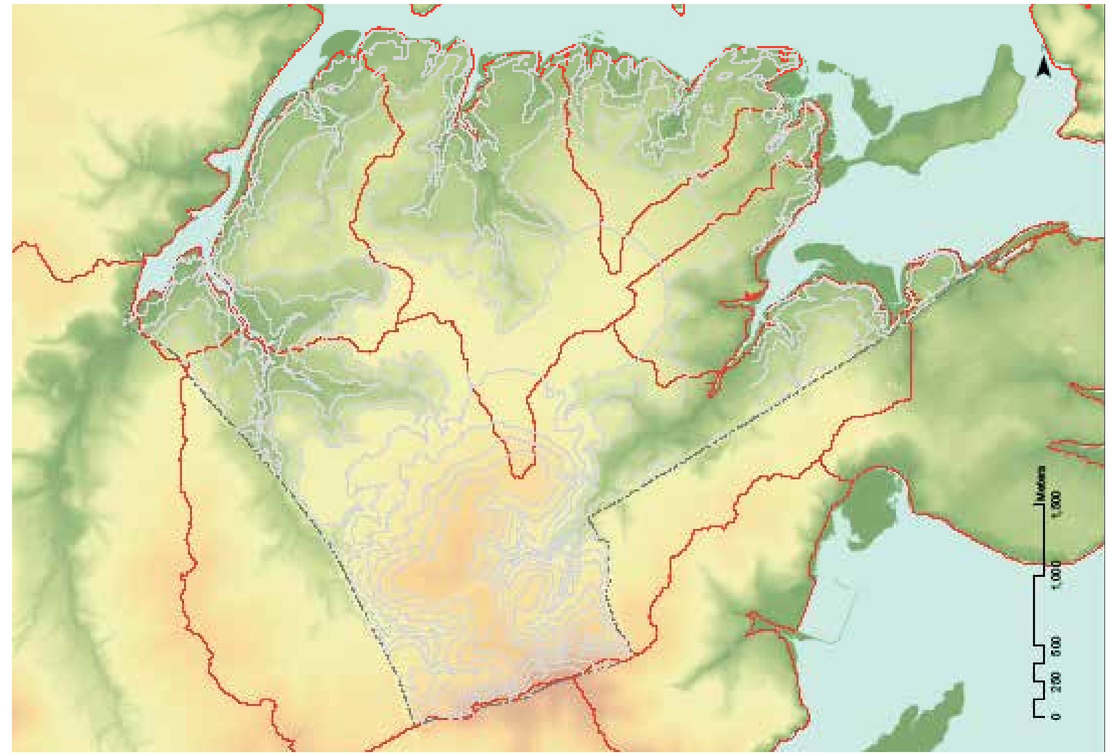
defined by shelterbelts. Over the last 20 years, the land use has changed, with the establishment of lifestyle blocks, especially along the coastal edge, and the construction of large single-family houses. The most important use of the site was as an airfield, constructed by the US air force during the Second World War. The site consisted of a concrete runway and typical base infrastructure, housing and workshops built around the airfield. After the war, the base was handed over to civic authorities and Whenuapai became Auckland's first airport. After the decision was made to build a new airport at Māngere, the Whenuapai airfield was returned to military use.

Auckland is undergoing rapid urban growth. Over one million new citizens are expected to arrive in Auckland over the next 20 years. As consequence of this growth there is an acute housing shortage. Whenuapai is located adjacent to SH16, an important motorway in the western growth corridor and near the new NorthWest Shopping Centre. Whenuapai is also neighbours with the successful Hobsonville housing development, making Whenuapai a natural successor for future urban development. To address the urban pressure Auckland is facing, the Auckland Council (in 2016) developed an urban structure plan for Whenuapai to help to conceptualise the shape of future urban development. The structure plan efficiently zones the available land according to proximity to infrastructure; industrial land and an apartment zone are located adjacent to the main transport routes, SH16 and18. Housing zones are located nearer to the edge of the Waitematā Harbour. Single-storey housing with large sites is zoned for the coastal margin, while more intensive housing (terrace) is zoned between the coastal edge and the industrial zone (ill. 9). »

ill. 3 / AERIAL PHOTO

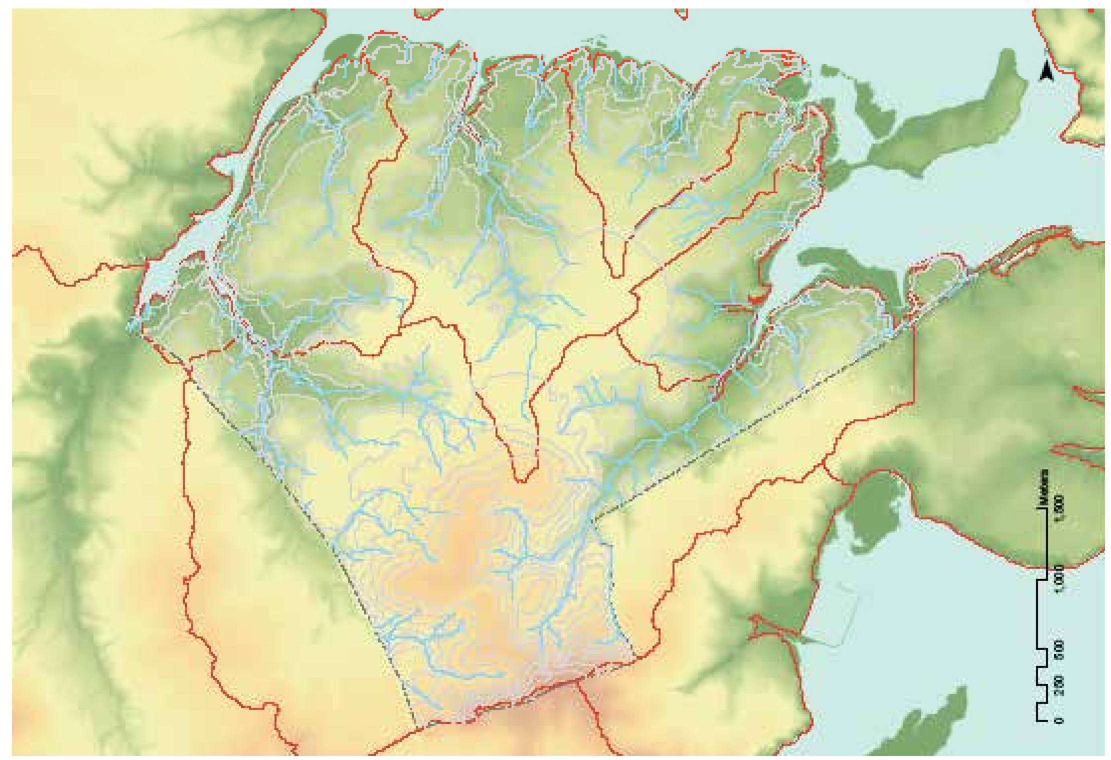
ill.4 / CONTOURS

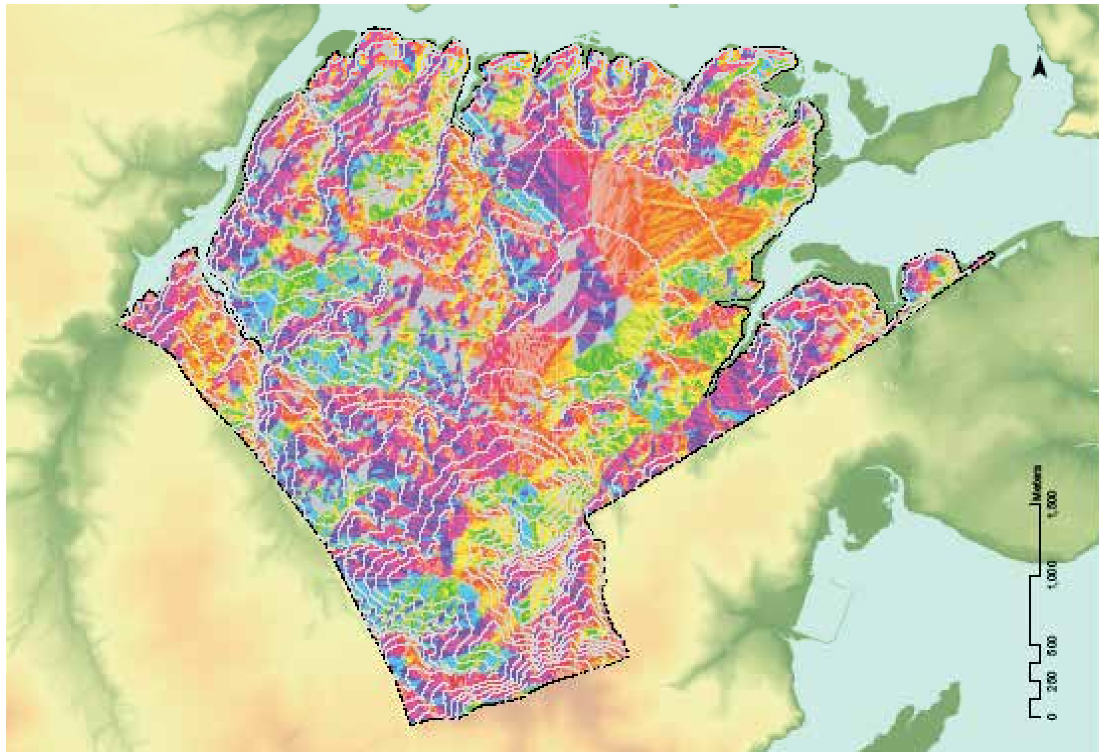




ill.5 / CATCHMENT

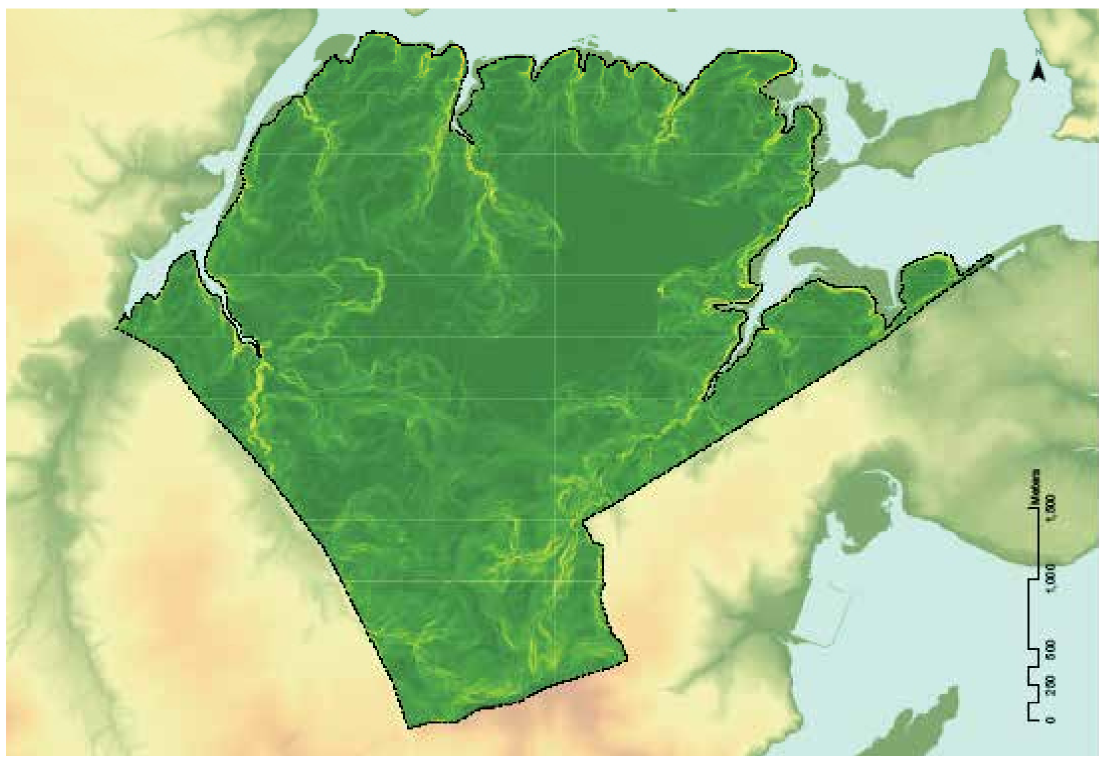
ill.6 / OVERLAND FLOW PATHS

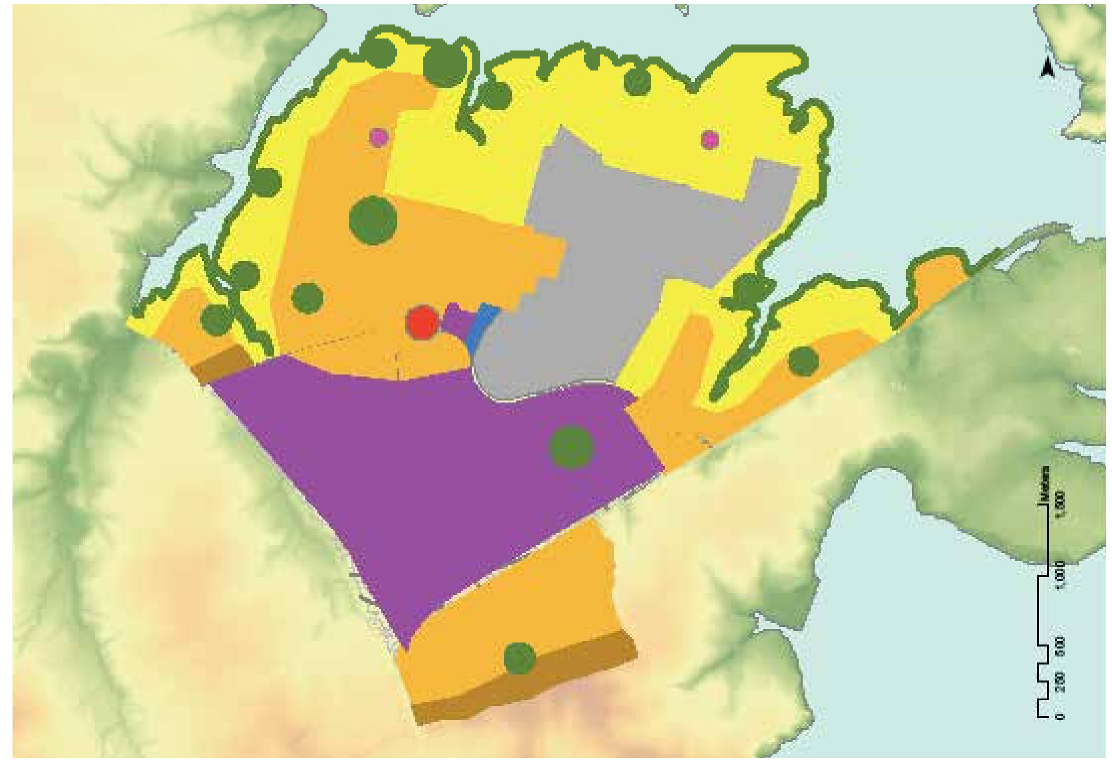




ill. 7 / ASPECTS

ill. 8 / SLOPE





ill. 9 / STRUCTURE PLAN

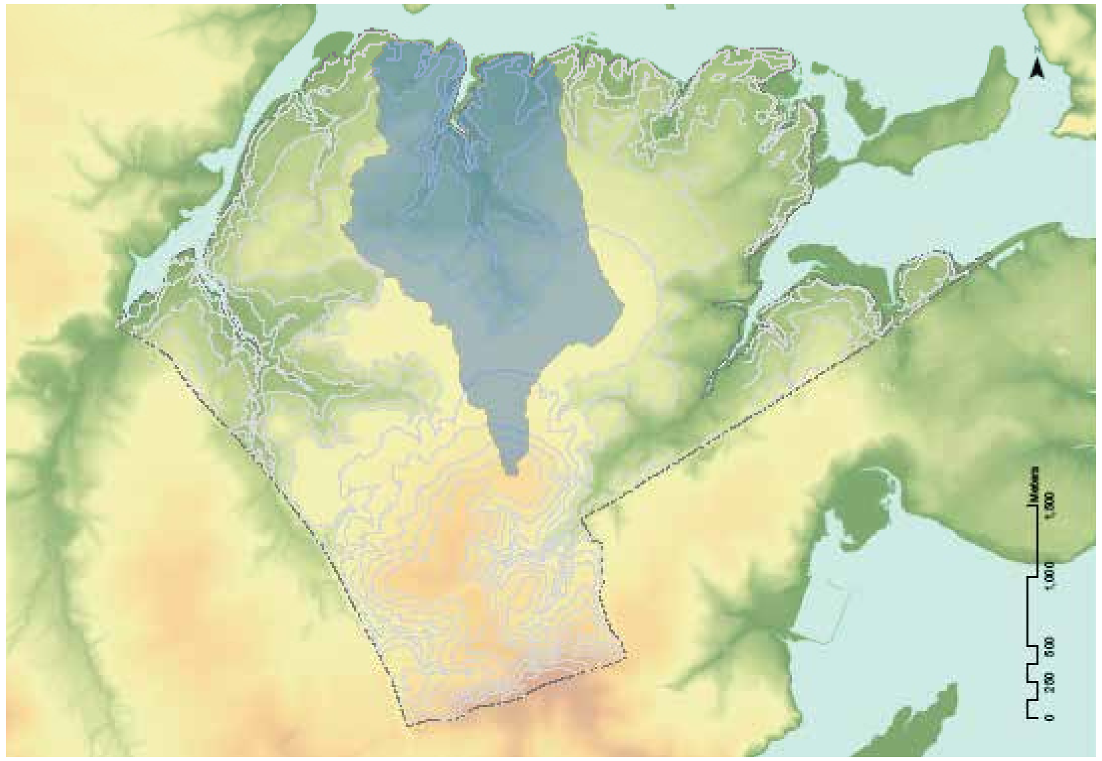
CASE STUDY
THE RARAWARA CATCHMENT

Location Whenuapai, New Zealand
Size of catchment (s) 324ha.

TOPOGRAPHY / The Rarawara Catchment is a moderately flat site bounded to the north by the Waitematā Harbour (ill.10). To the west the site is defined by the Brigham Creek/Pitoitoi Stream catchment, to the east by Whenuapai village and airfield, and to the south by the intersection of SHW16 and 18 (ill.11 12).
VEGETATION / The predominant vegetation in the catchment is grass, a product of the mostly rural economy of the catchment, and the area around the airfield. The other vegetation is decorative gardens around the housing areas, and shelterbelt species from the small horticulture and orchard blocks.

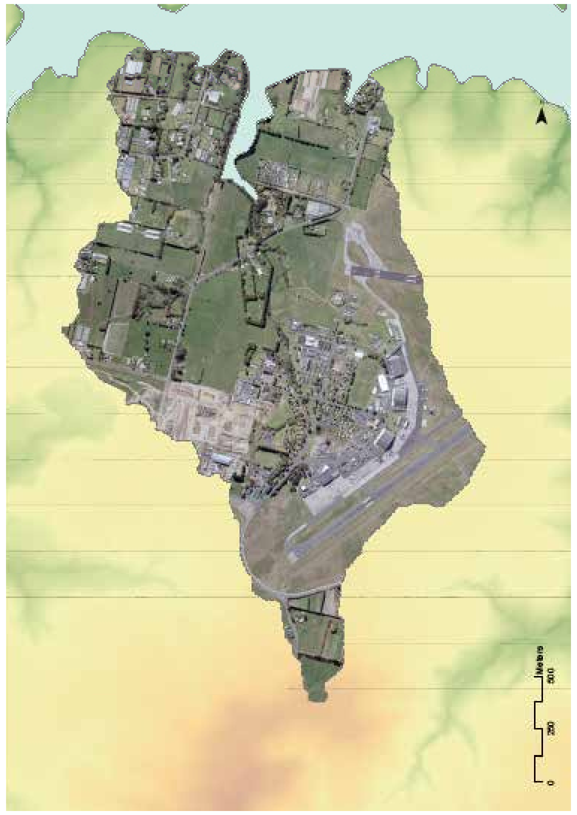
HYDROLOGY / The catchment drains into the dominant stream, the Rarawara Creek (ill. 13). This runs roughly north-south and bisects the catchment. There are three sub-catchments (ill 14). The stream exits into the estuarine mouth before connecting to the Waitematā Harbour. There is a subsidiary stream to the west and two smaller streams from the hinterland to the coast on either side of the Rarawara.

ASPECT AND SLOPE / The aspect of the Rarawara Catchment is mostly northerly with an east-west division along the sides of the stream corridors (ill15). The slope of the majority of the site is flat, 0-5 degrees, especially the aerodrome site. However, alongside the steam corridors the slope increases from 5 to 16 degrees(ill.16).»

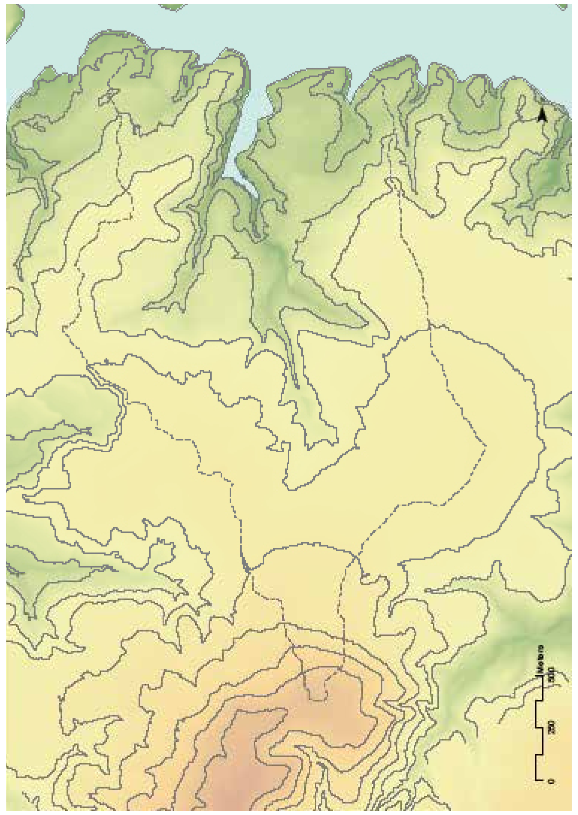


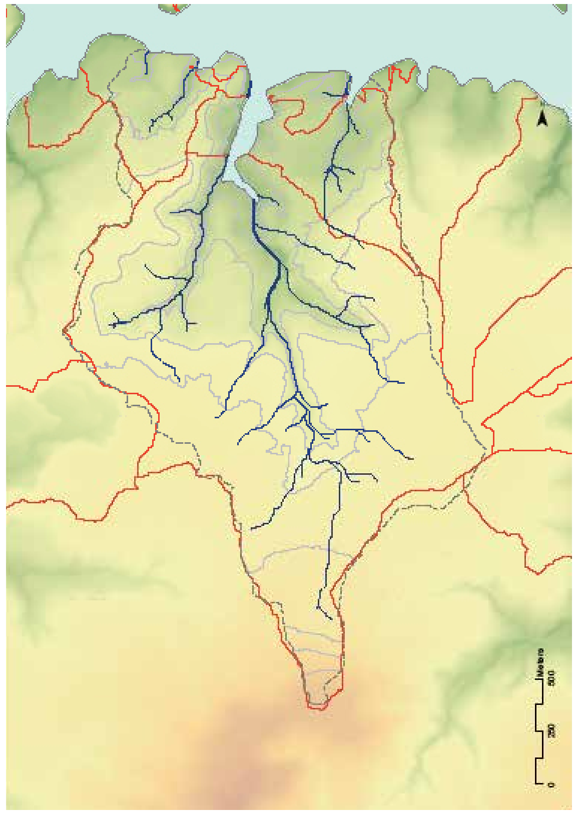
ill. 10 / LOCATION AND BOUNDARY OF SITE

ill. 11 / AERIAL PHOTO

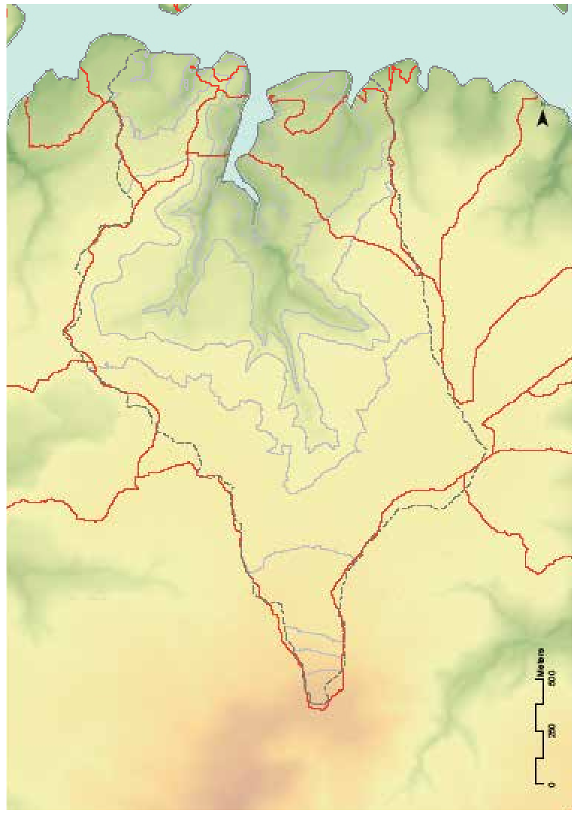


ill. 12 / CONTOURS



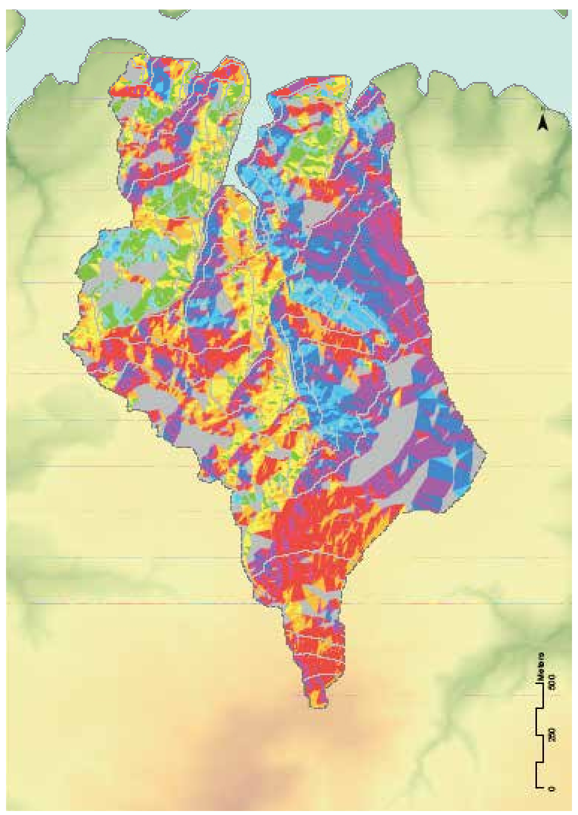


ill. 13 / OVERLAND FLOW PATHS

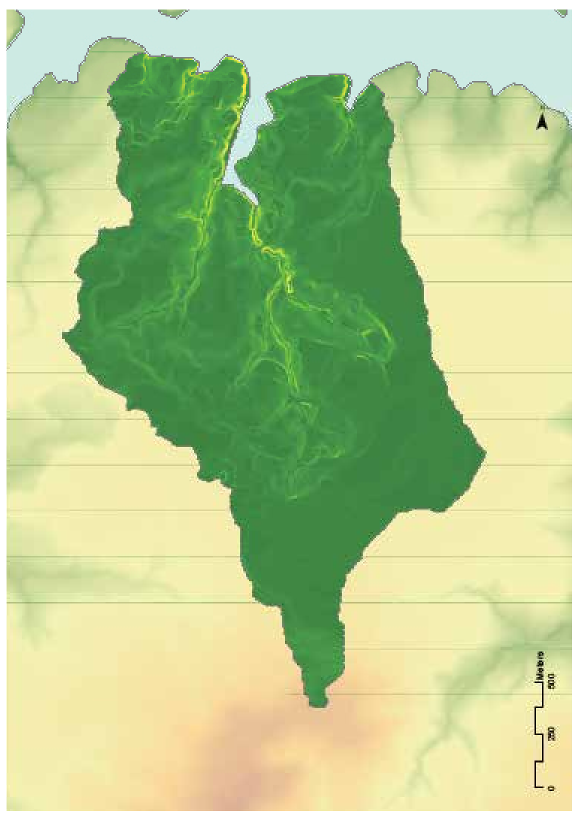


ill. 14 / CATCHMENT

ill. 15 / ASPECT

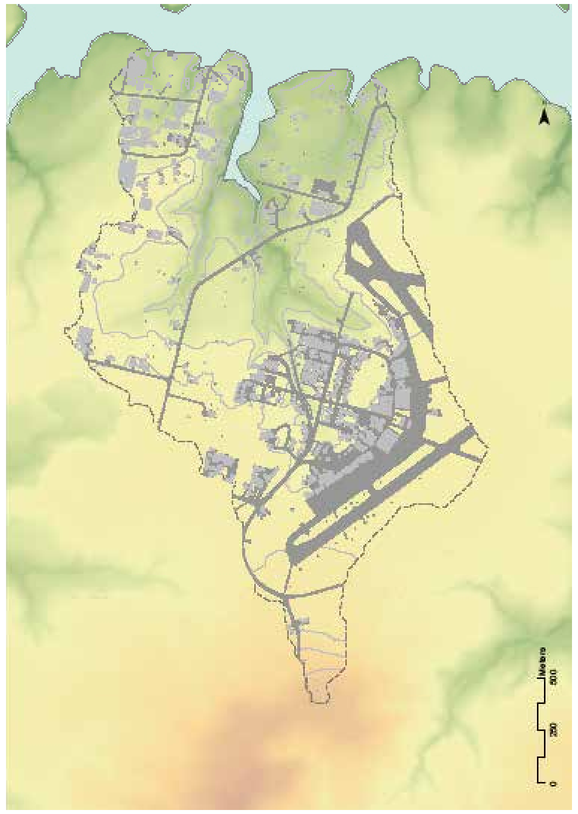


ill. 16 / SLOPE

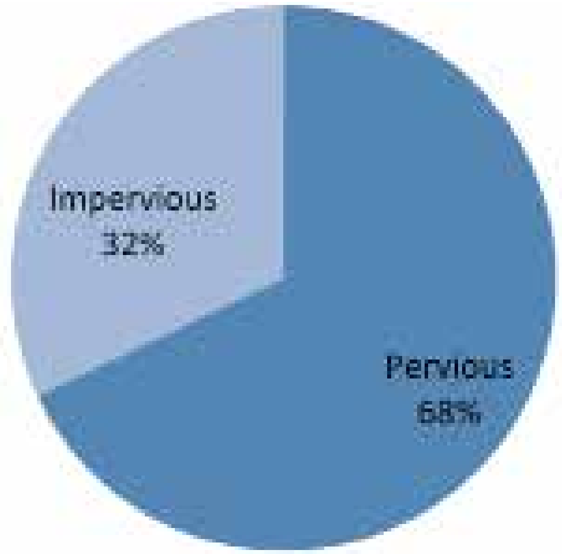


LAND USE / The land of the catchment is separated into two broad uses. The first is suburban housing, large lifestyle houses and sections on the northern coastal edge, and a smaller subdivision to the west of the airfield. The rest of the catchment is made up of rural lifestyle blocks, and small horticulture and orchard blocks.

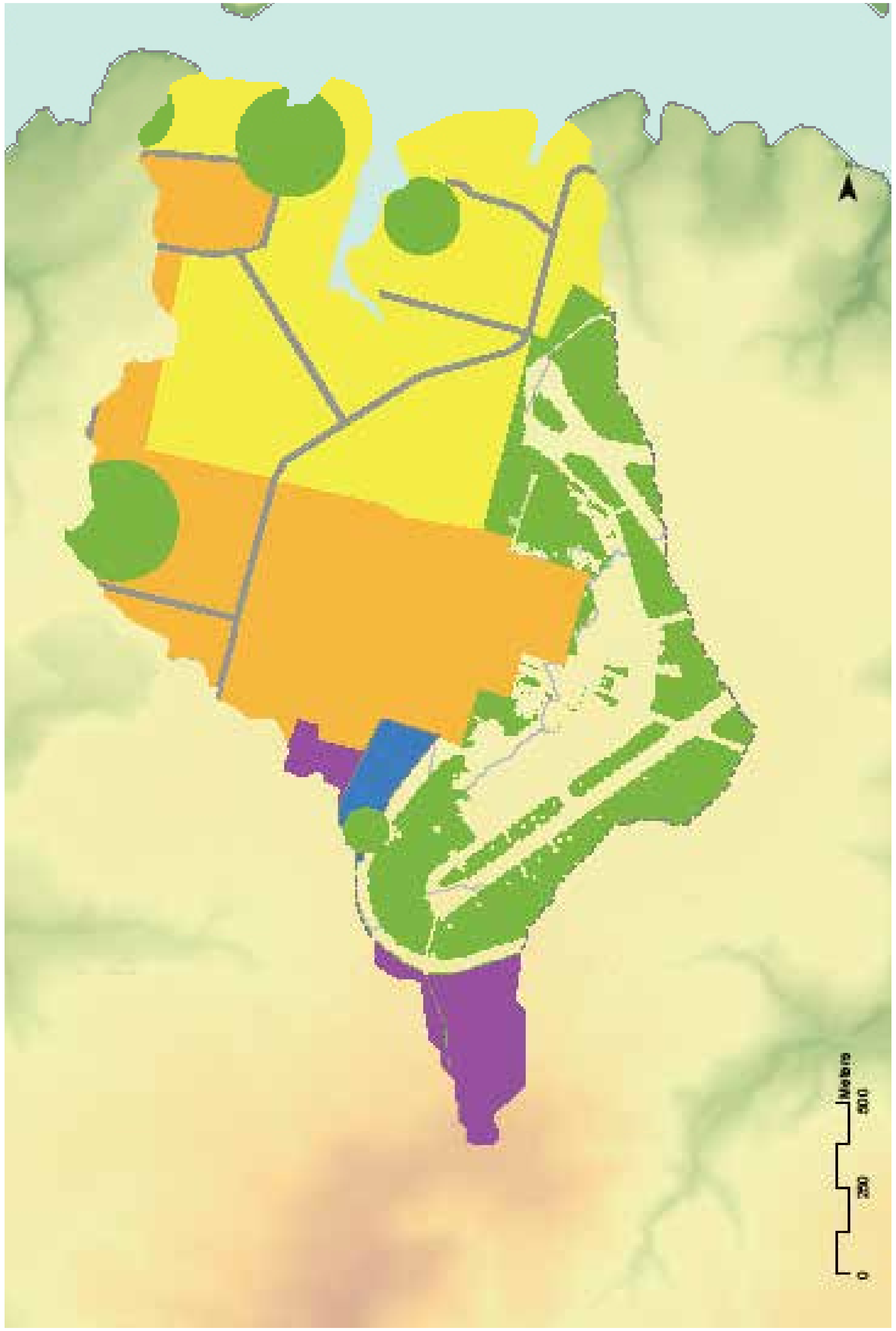
PERVIOUS/IMPERVIOUS RATIO / Due to its mostly rural nature, the catchment is largely made of pervious surfaces (ill. 17).The impervious areas are the roading infrastructure and the airfield (ill.18). The existing Rarawara Catchment area is 324.1753ha. The impervious surface area is made up of roads (81.8428ha) and buildings,(20.1004ha). The total impervious surface area is 104.1488ha. The total pervious surface area is 220.0265ha, giving a ratio of pervious to impervious of 2:11 (ill.19).
AUCKLAND CITY STRUCTURE PLAN / The effect of the Auckland Council's Whenuapai structure plan on the Rarawara Catchment is to configure the catchment into four housing zones and an industrial zone (council plan ill.20). The area closest to the coast is zoned for low-density single-storey housing, along an approximately100ha coastal margin. Allowing for one dwelling unit (DU) per 500m2 gives 2008 DUs, and 50ha of impervious surfaces. A medium-density housing zone of 82ha is planned behind the coastal zone. Allowing for one DU per 300m2 equals 2743 DU, giving 61ha of impervious surface. The remaining area is zoned industrial/commercial with two apartment zones to the east of the airfield zone. Three parks are proposed of approximately 35ha in total. Roads, proposed and existing housing make up 212ha of impervious surface. »


ill. 17 / IMPERVIOUS SURFACES


ill. 18 / PERVIOUS SURFACES



ill. 19 / PIE CHART - ORIGINAL SITE


ill. 20 / PROPOSED PLAN

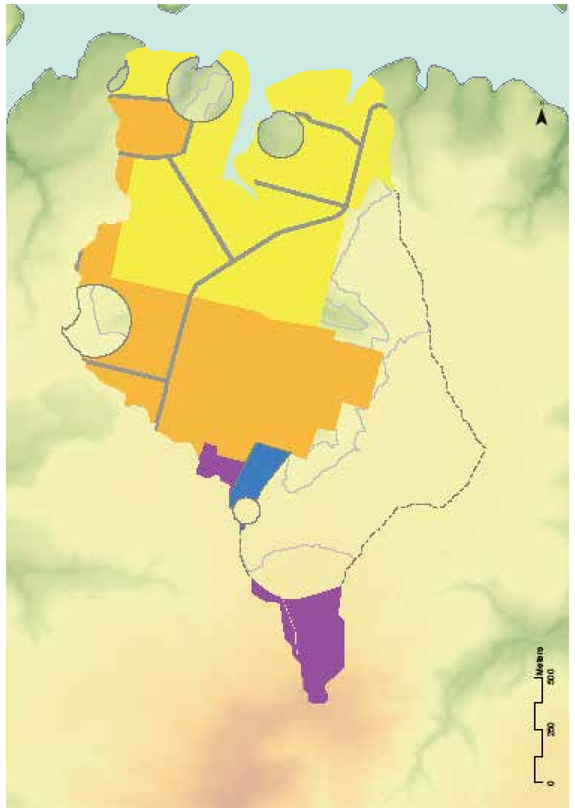
THE PROBLEM

ENVIRONMENTAL PROBLEM / With the construction of the new housing and the associated infrastructure, the hydrological pattern of the existing territory will be irrevocably changed; increased runoff with increased sedimentation will add to already high levels of sedimentation in the upper Waitematā harbour. Runoff will also be polluted from roading contaminants and roof debris.

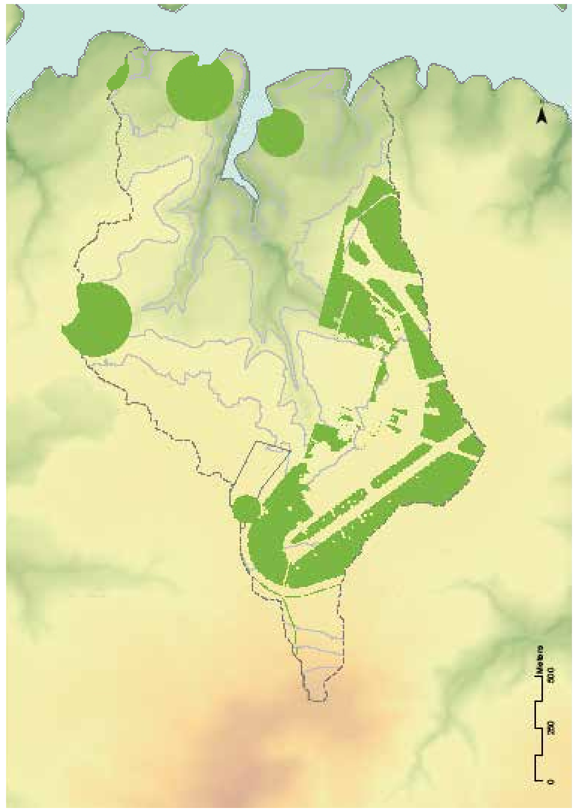
PERVIOUS/IMPERVIOUS RATIO / In the Auckland Council structure plan the impervious surface in the Rarawara Catchment will increase markedly. The new structure plan for the Rarawa Catchment area (324.1753 ha) is made up of road area 81.8428ha, and building area 206.9095ha, making an overall total of impervious surface of 288.7523ha (ill 21). Pervious surfaces are 35.423ha (ill 22), giving a ratio of pervious to impervious of 8:1 (ill. 23). If this plan was built then the result of this high degree of imperviousness would be a large amount of contaminated storm water runoff discharging into the harbour.

To calculate the volume of stormwater that will be discharged from the catchment under the new structure plan, the Rational Method can be used. The runoff discharge flow rate over two years (m3/sec) will be 5.95 m3/sec; the required storage and treatment wetland for this runoff is sized at 32140.04m3. For a 10-year runoff discharge flow rate of 8.71 m3/sec, the required storage volume is 47019.68m3. For a 100-year runoff discharge flow rate of 13.95 m3/sec the required storage volume is 75350.53m3.

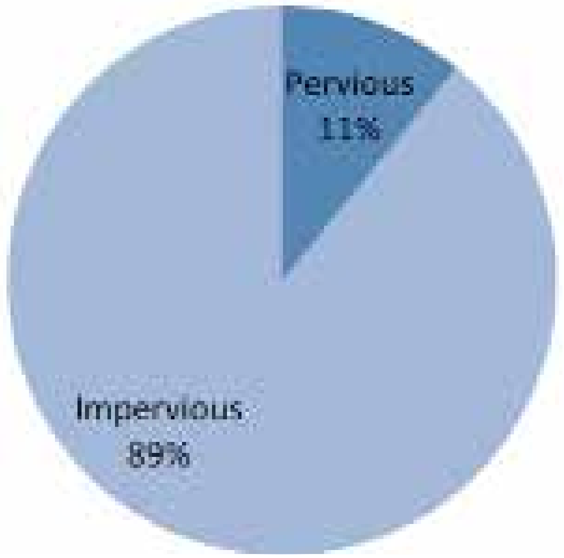
SOCIAL ISSUES / The social gradient of the structure plan, from single stand-alone housing on the coastal edge to apartments around an industrial zone at the edge of the highway, gives rise to a number of questions. Why should the coastal edge be the sole preserve of wealthy, single, stand-alone housing? Why should the more intensive apartment housing be located away from the desirable coastal edge? Will the proposed housing mix of mostly single-storey and terrace housing go far enough towards providing affordable housing in Auckland? These questions give rise to a series of speculations. Would it be possible to give the new citizens of Whenuapai a better connection to the natural environmental? Do the apartments have to be located by busy roads and industrial zones, or can the new citizens of Whenuapai connect to the existing natural systems of the site? »



ill. 21 / PROPOSED PLAN - IMPERVIOUS SURFACES



ill. 22 / PROPOSED PLAN - PERVIOUS SURFACES



ill. 23 / PIE CHART- PROPOSED PLAN

THE SOLUTION / NATURE CITY PLAN

DESIGN METHODOLOGY / To ameliorate the effects of urbanisation on the coastal receiving environment, an understanding of the hydrological behaviour of the catchment is necessary. The first step is to determine the structure and shape and size of the catchment on the site, through mapping with ARCHydro. This data can be manifested as a series of maps showing catchment boundaries and a network of overland flow paths. From this mapping we can determine both the size of the catchment and the ratio of impervious to pervious surface. Using the Rational Method we can gain an understanding of what the rainfall runoff will be with the expanded site. By measuring the increase in impervious surface due to the number and type of housing zones, the increase in stormwater runoff can be calculated. Once the connection of housing density to the impervious/pervious surface ratio is established, the different zoning densities and associated impervious/pervious ratios can be manipulated to allow for grater permeability while at the same time ensuring that the planned number of dwelling units remains the same.

DESIGN WORK / THE RARAWARA CATCHMENT

HYDROLOGY / How to ameliorate the environmental damage from increase in stormwater discharge into the upper Waitematā catchment? Decreasing the amount of impervious surface through the removal of infrastructure such as roads and housing will lead to an increase in the amount of pervious surface, leading to an increase in the absorption of stormwater runoff.

One way is to increase the pervious surface of the catchment is by protecting and enhancing the existing stream network by establishing a protective buffer zone of at least 25m around the stream and overland flow paths (ill.24). Protection of the coastal edge is another important environmental measure; a buffer of 30m would give a zone of 43ha. These two measures increase the area of pervious surfaces within the catchment by 128ha. This intervention also has the effect of developing a new park system along the stream corridors and the waterfront coastal edge (ill. 25).

Accommodating these two measures necessitates a change in the housing footprint. This is accomplished by decreasing the low-density zone from 100ha to 23ha, and decreasing the medium-density zone slightly, from 82ha to 74ha.

The loss of housing land is ameliorated by a new housing zone of a more intensive housing type – apartments, 8.8ha – located in the coastal zone around the existing stream mouth (ill.26).

URBAN DESIGN / To accomplish the increase in pervious surfaces and the consequent decrease in stormwater discharge means a loss of housing units. Under the Auckland Council structure plan the number of low-density DUs in the catchment is 2008 and medium-density 2743, equalling 4752 DUs (with no provision for high-density units). By enlarging the pervious surface area, the number of DU in the low-density zone will drop to 473 DUs and in the medium density zone to 2471 DUs. The shortfall in DUs will be 1827.

One solution to this real estate shortfall is the provision of two high-density apartment zones within the low-density area. This solution will increase the number of DUs to 1468, making a total of 4420. By increasing the apartment zone by making it denser or higher, the shortfall of 1827 DUs could be matched or even surpassed to give a better real estate return (Ill. 31).

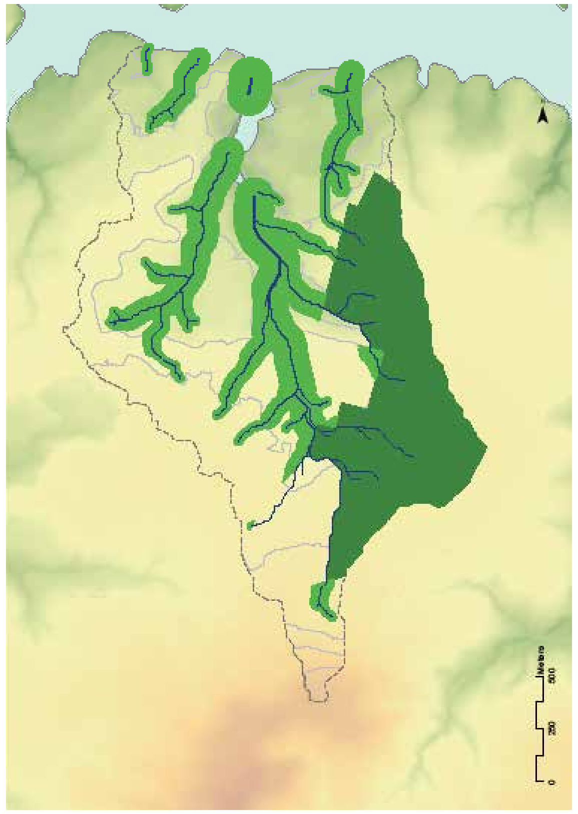
PERVIOUS/IMPERVIOUS RATIO / The Nature City Plan solution for the Rarawara Catchment area (324.1753ha) has an overall total impervious surface of 196.1642ha, made up of roads, 65.9289ha and buildings, 130.2353ha. Pervious surfaces are 128.001ha, giving a ratio of pervious to impervious of 2:3. (ill 27 and 28).

Using the Rational Method, the effect of the new pervious surfaces will lead to a two-year runoff discharge flow rate of 29304.15042m3, compared to the discharge of 26468.26489m3 from original site and 32140.03594m3 discharge with the proposed Auckland Council structure plan (ill.29 and 30).

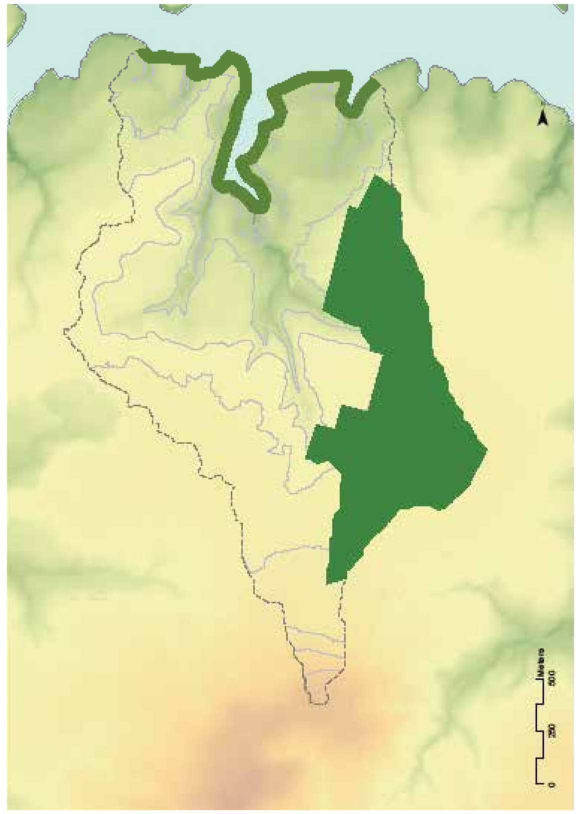
In the 10-year runoff discharge, the flow rate of the new plan is 42870.88672m3, compared to the discharge of 38722.09123m3 from the original site and 47019.68221m3 from the proposed Auckland Council plan).

In the 100-year runoff discharge, the flow rate of the new plan is 68701.95265m3 compared to 62053.37659m3 in the original site and 75350.52871m3 in the Auckland Council proposed plan.

PLAN	PRESENT CATCHMENT	AUCKLAND CITY STRUCTURE PLAN
2 YEAR RUN OFF	26468.26489m3	32140.03594m3
10 YEAR RUN OFF	47019.68221m3	38722.09123m3
100 YEAR RUN OFF	62053.37659m3	75350.52871m3

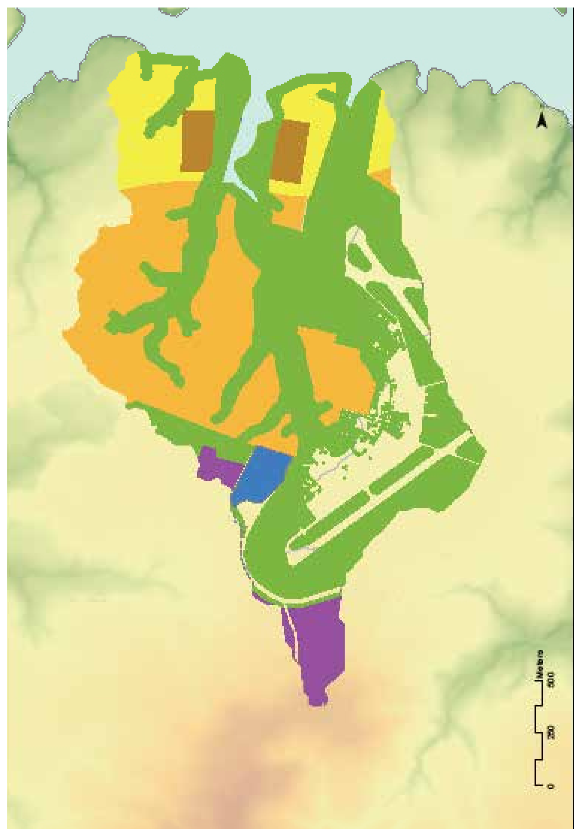


ill. 24 / STREAM BUFFER

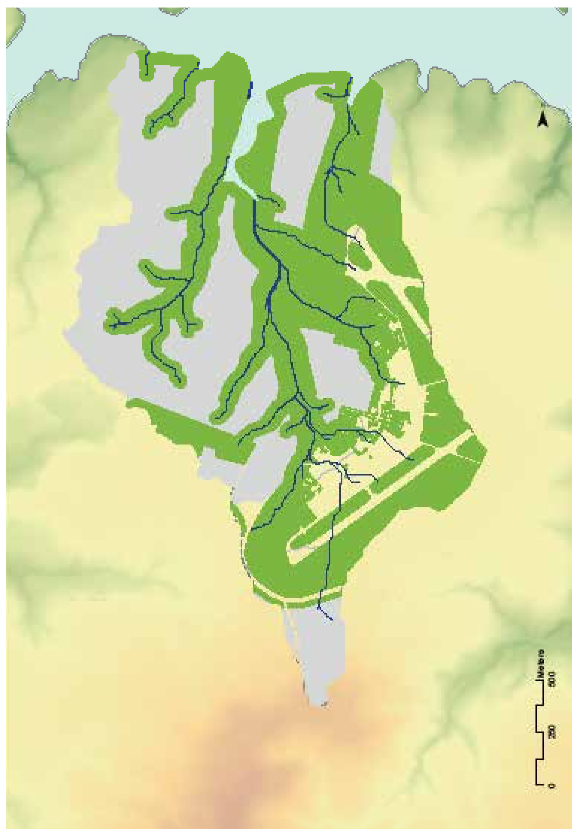


ill. 25 / COASTAL BUFFER

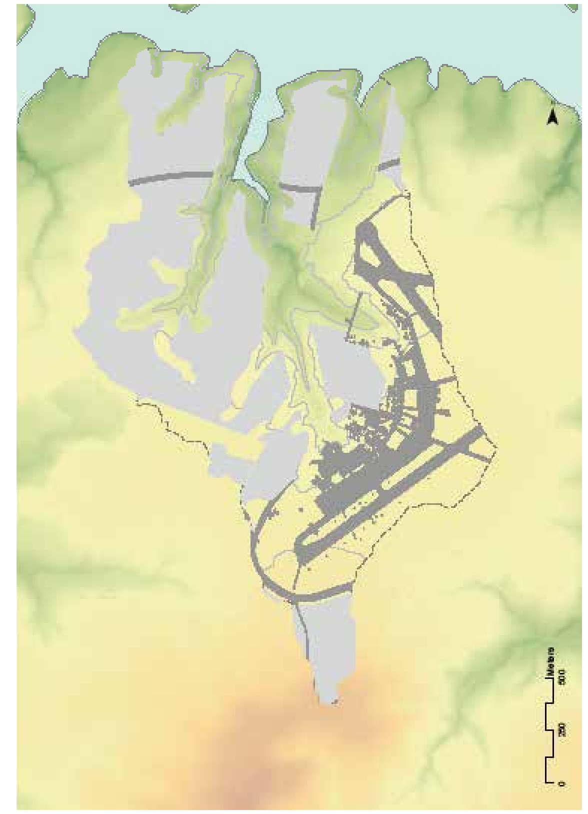
ill. 26 / STREAMS OVERLAP WITH LAND USE



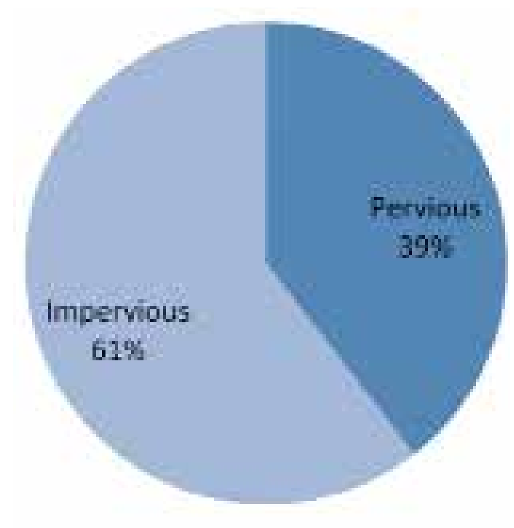
ill. 31 / NEW PLAN



ill. 27 / PERVIOUS SURFACES

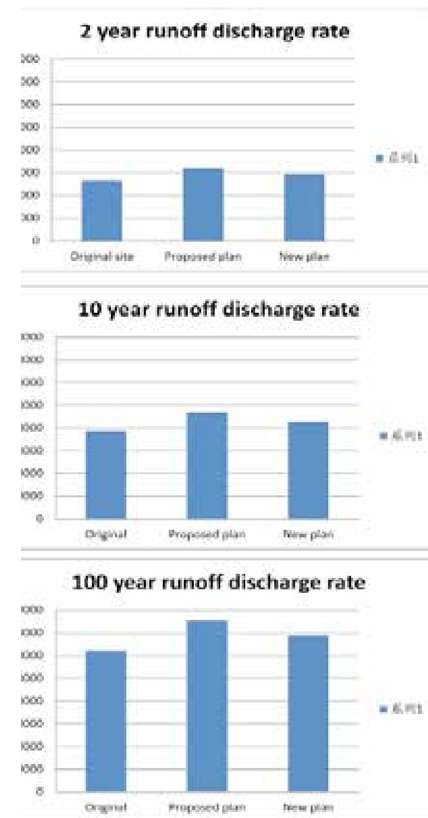


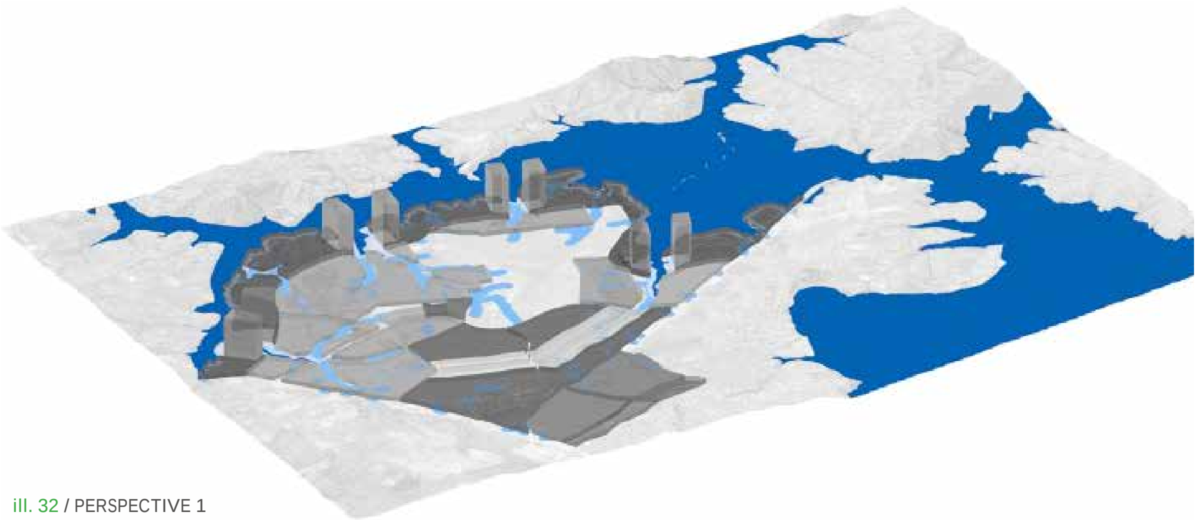
ill. 28 / IMPERVIOUS SURFACES



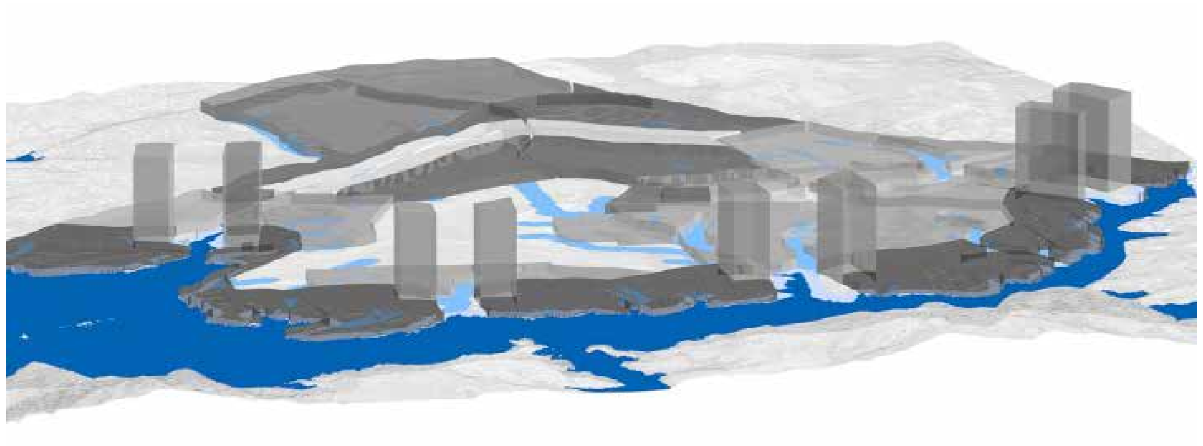
ill. 29 / NEW PLAN

ILL. 30 / STORMWATER DISCHARGE CHART / 30

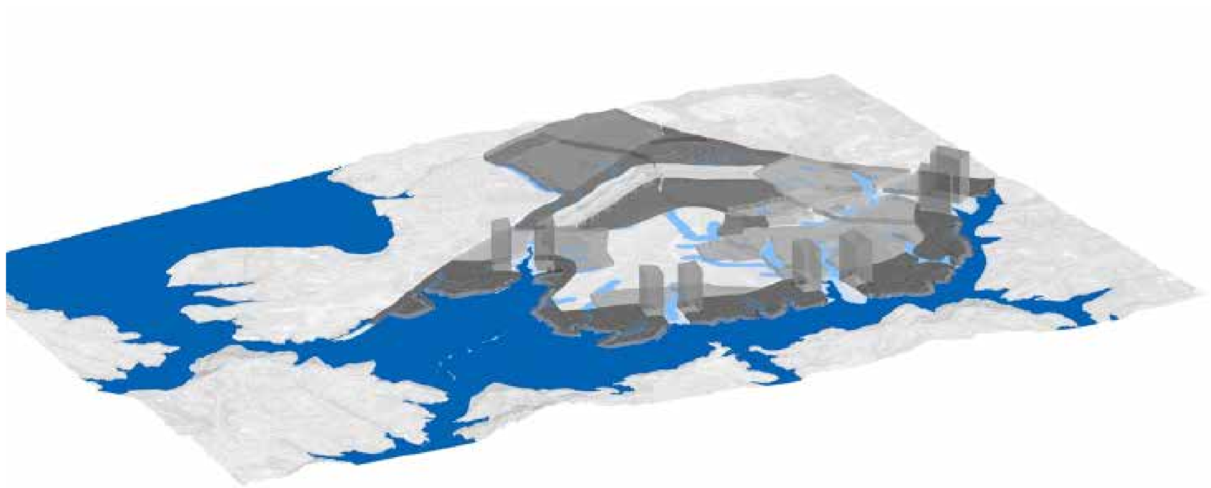




ill. 32 / PERSPECTIVE 1



ill. 33 / PERSPECTIVE 2



ill. 34 / PERSPECTIVE 3

ENVIRONMENTAL AND SOCIAL IMPLICATIONS OF THE NATURE CITY PLAN

STREAM NETWORK / A buffer zone around the revealed hydrological network will enable the stream corridors to be revegetated with native species. The zone also gives the opportunity to allow for the location of structural stormwater cleaning instruments; in particular, wetlands and a rain garden – these can all be installed within the new zone. This stream zone can form a deep connection from the coastal edge to the hinterland, creating an ecological corridor (ill.32).

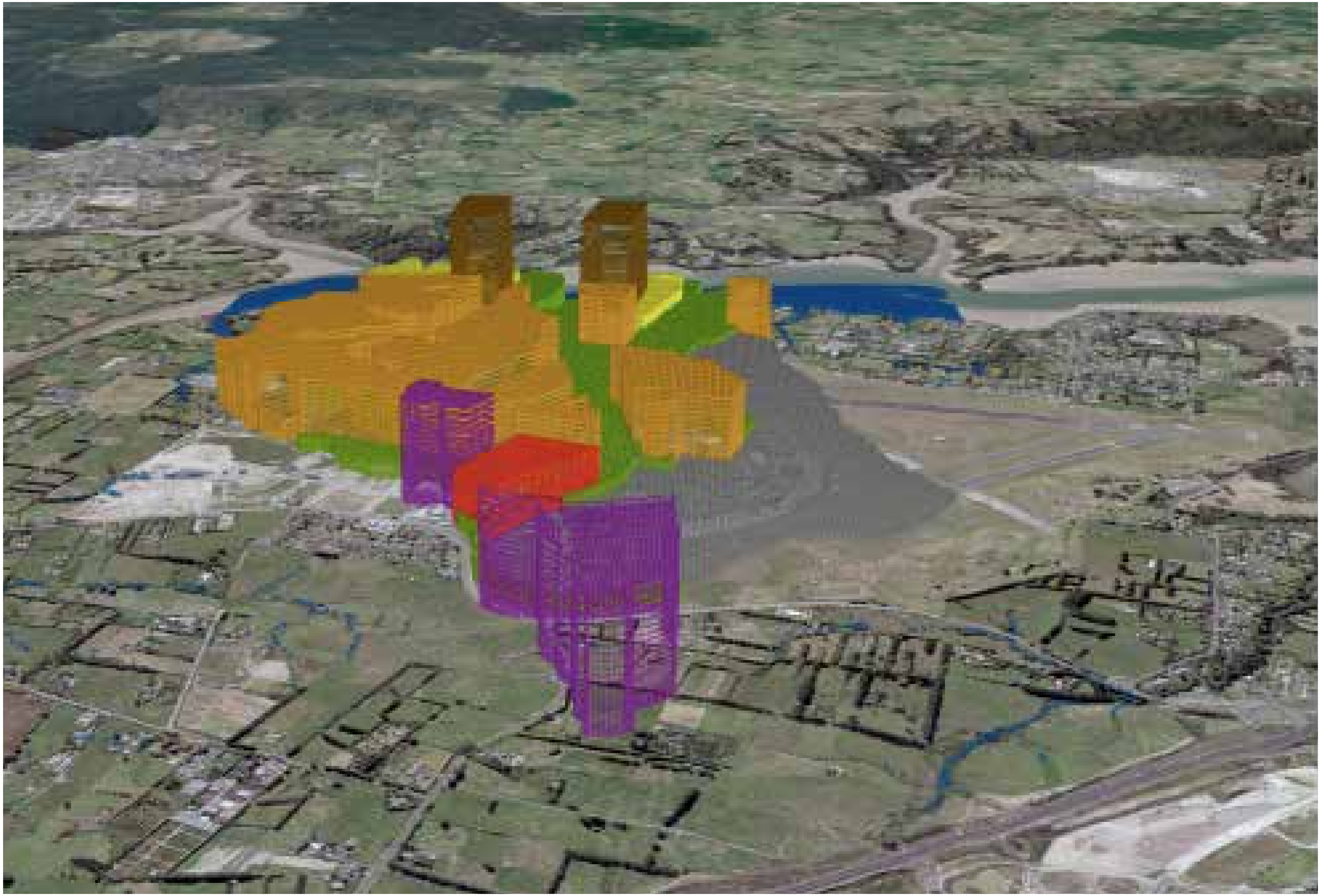
The adjacency of housing to the new river zone will also help to increase real estate values. By locating medium-density housing along the edges of the new stream parks, the new owners can enjoy views of the water and native vegetation. The nature of the new river zones, the link from the coast to the hinterland, give the opportunity for the owners in the centre of the development to have access to the coast.

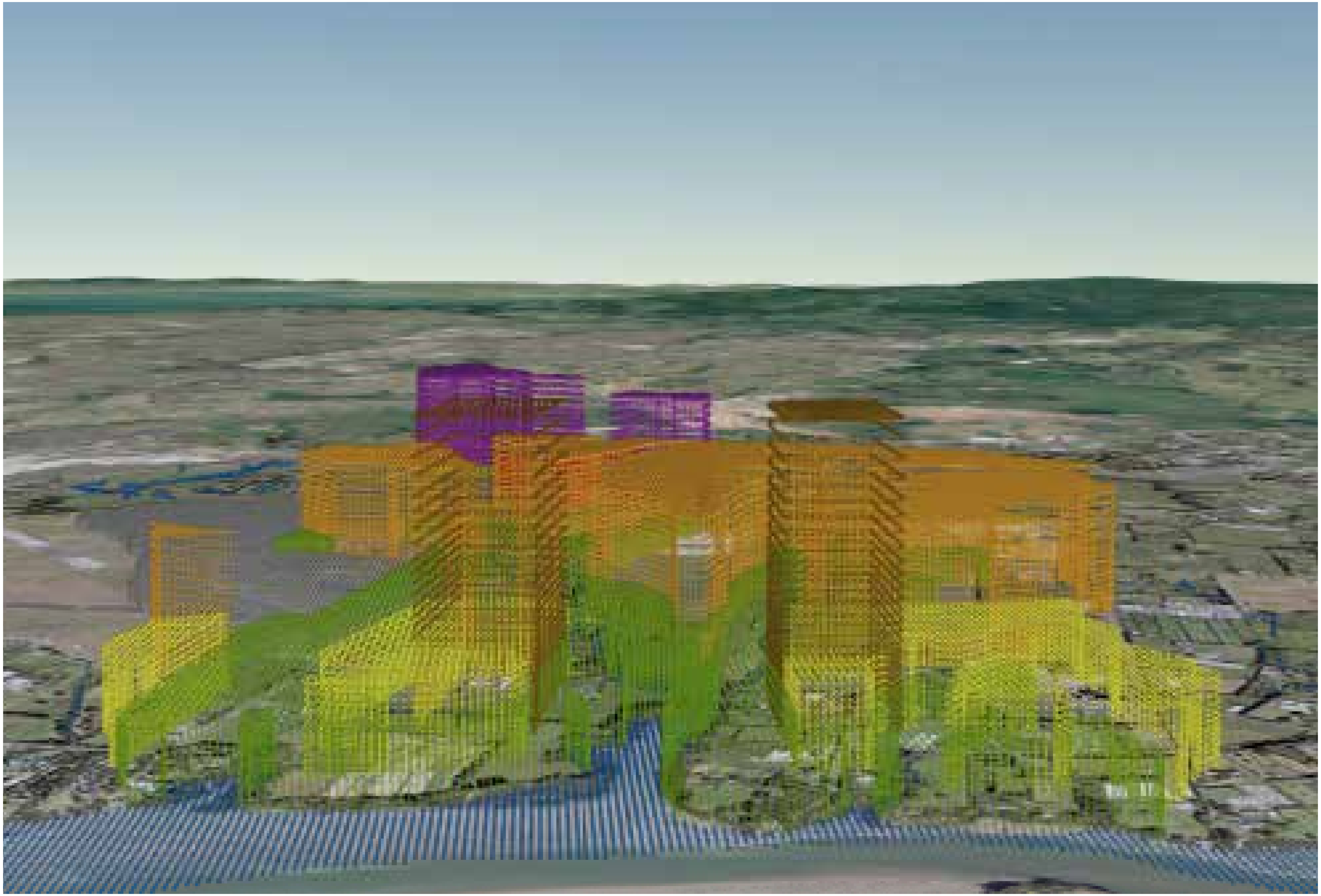
COASTAL ZONE / Establishing a coastal buffer zone means that the critical environmental conditions in this zone will be protected. Critical riparian ecologies can be restored and protected, damage from building in this zone can be ameliorated (ill.33).

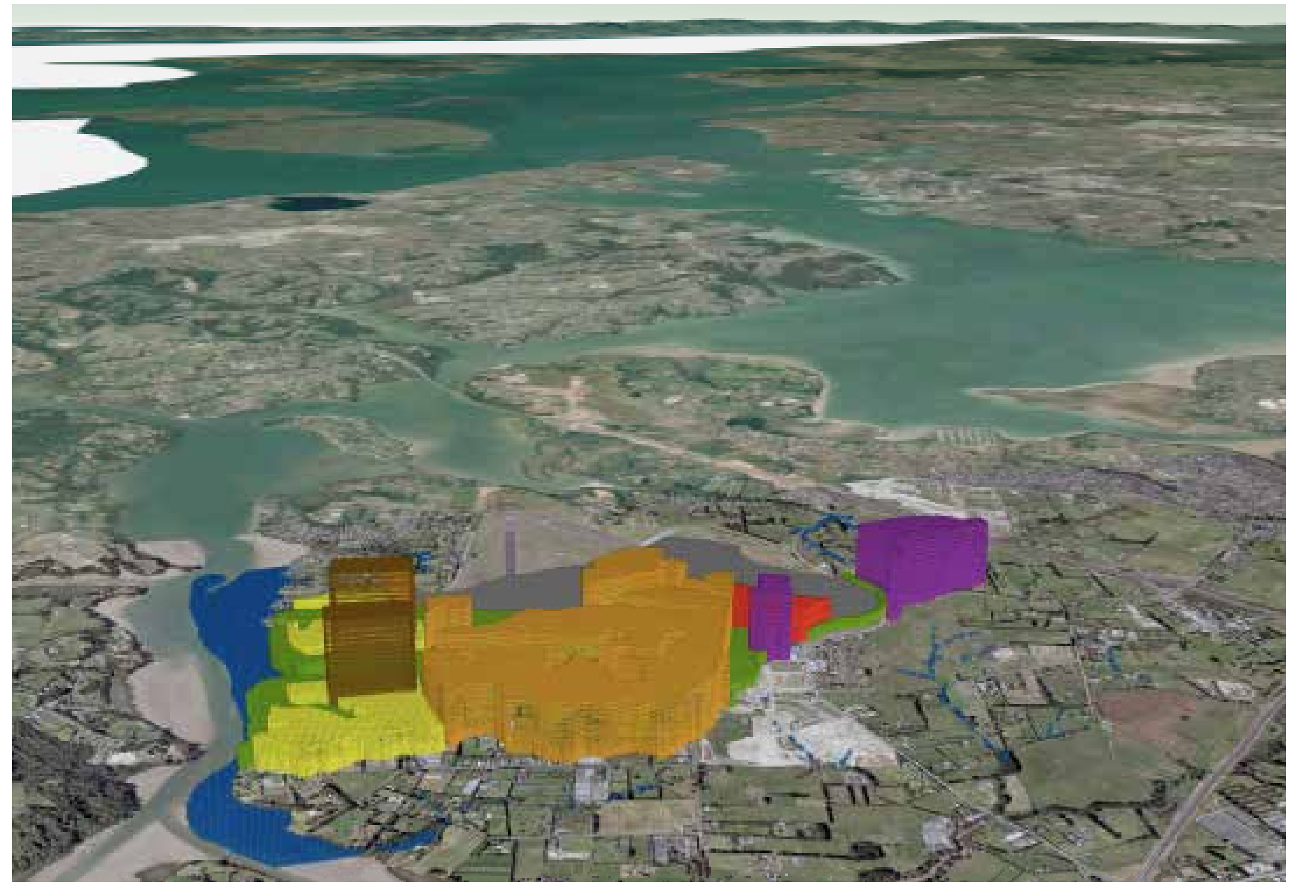
SUMMARY

Establishing a protective buffer zone around the coastal and stream hydrological networks will increase the ability of the Rarawara Catchment to absorb rainfall, rather than to add to runoff into the upper Waitematā Harbour (Ill 34). To ensure the same economic return is met – that the same number of DUs are constructed as specified in the Auckland Council Structure Plan – the loss of low- and medium-density housing is met by a greater number of apartments, with a smaller, denser footprint.

Building apartments in the coastal zone is not a foreign urban typology to Auckland; there are many examples in Kohimarama, Herne Bay and Takapuna. These sites also demonstrate the possibility of coexistence between low-density two-storey single housing on the coastal edge with apartment dwelling. The result is a low-rise domestic landscape of garden and houses broken by tall prismatic apartment towers that emphasise the entry to the unique stream zones. ■







STUDY TWO. GREENFIELD / PEOPLE'S REPUBLIC OF CHINA

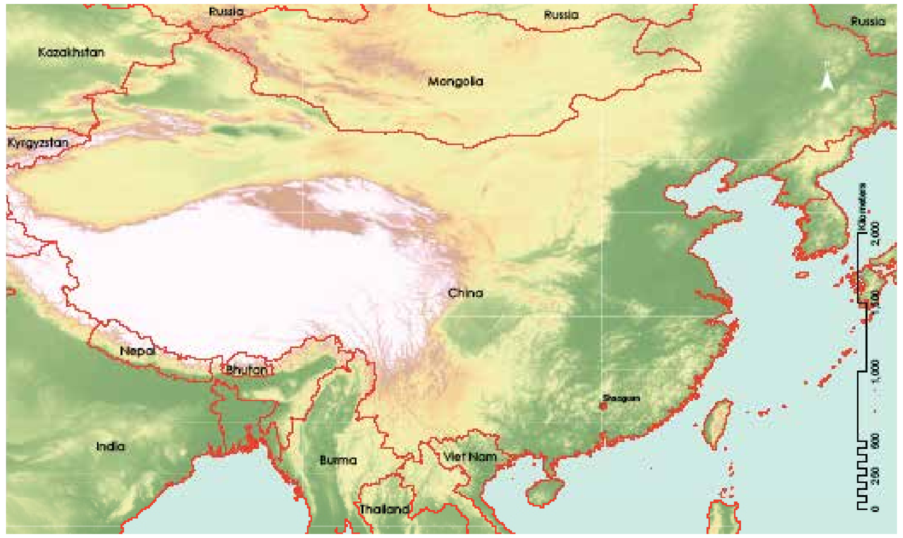
FURONG NEW TOWN SHAOGUAN

BACKGROUND TO THE STUDY SITE

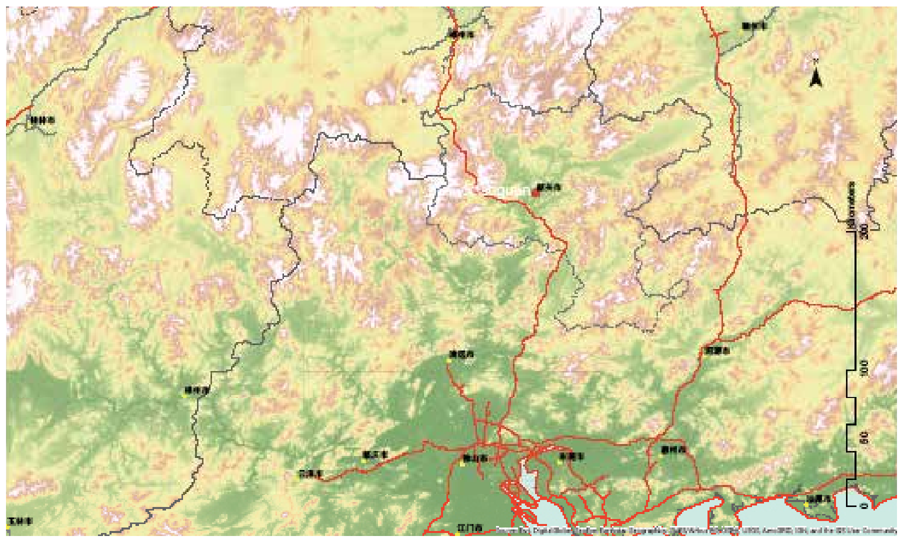
Furong New Town is a new city to be constructed adjacent to Shaoguan in northern Guangdong Province, the People's Republic of China (ill. 1). Shaoguan is a Prefecture-level city, located in the north of Guangdong province (ill 2.) in the upper reaches of Beijiang River Basin (ill 3). The city lies to the south of the Nanling Mountains, which form a boundary between southern and central China. The city of Shaoguan is located in an important pass linking Hunan in the north with Guangzhou in the south (ill.4).

The major rivers in the Shaoguan region are the Zhenjiang, the Wujiang, the Mojiang, the Jinjiang, the Nanhuaxi, the Nanshui, the Wengjiang, the Beijiang and Xinfeng Jiang (ill. 5). Shouguang City is located on the confluence of two rivers, the Zhen River from the northeast and the Wu River from the northwest. The two rivers connect, becoming the North River, or Bei Jiang, linking Shaoguan to Guangzhou. There are five major catchments in the region (ill.6). The average annual rainfall in Shaoguan is 160.4 days, and 1583.5mm. The average rainfall over 100mm is in the months of February to August: the month with maximum rainfall is May (253.2mm), the second heaviest rainfall is in April (230.3mm).

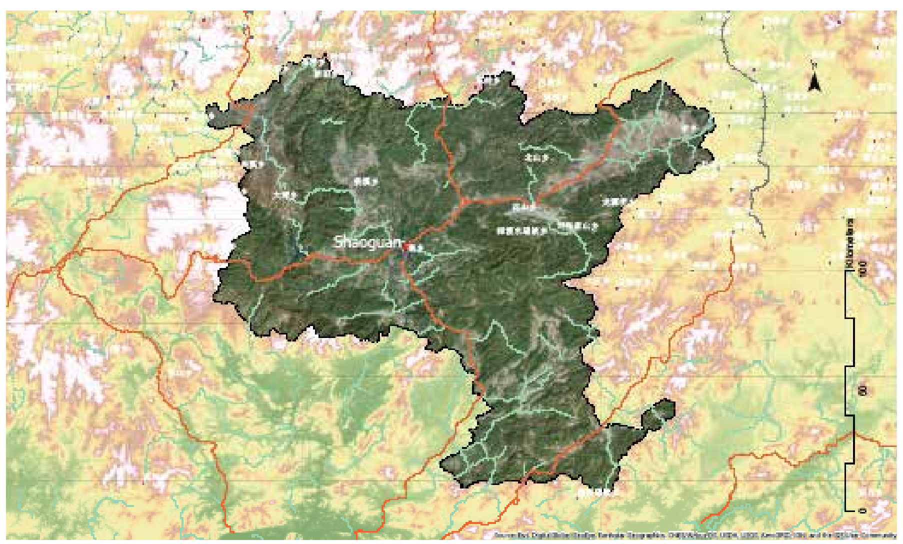
Shaoguan is located in the southern foothills of Nanling Mountains, which run in an east-west direction. Shikengkong is the highest point of Guangdong Province, at 1902m. The lowest point is Shaoguan City, at 35m. The aspect of the region can be seen in illustration 7, while the slope can be seen in illustration 8. »



ill. 1 / LOCATION IN CHINA



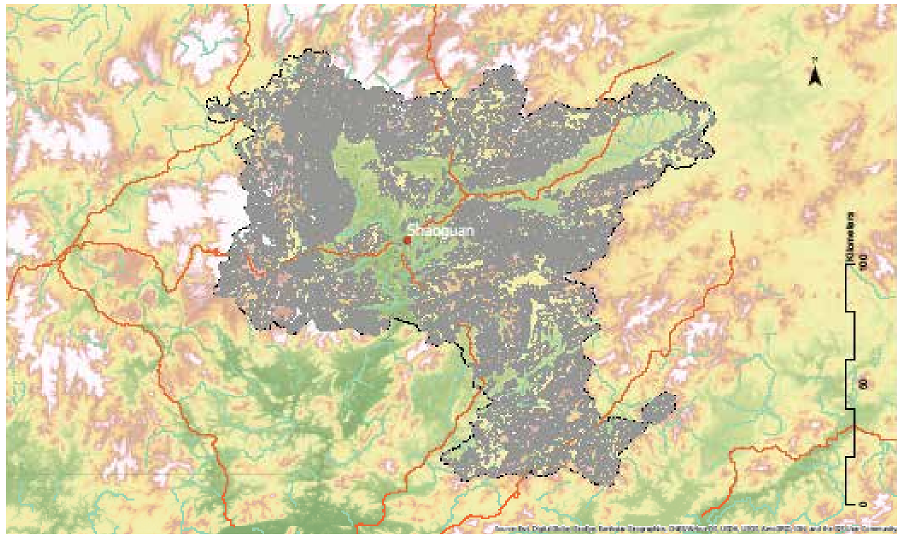
ill. 2 / LOCATION IN GUANGDONG PROVINCE



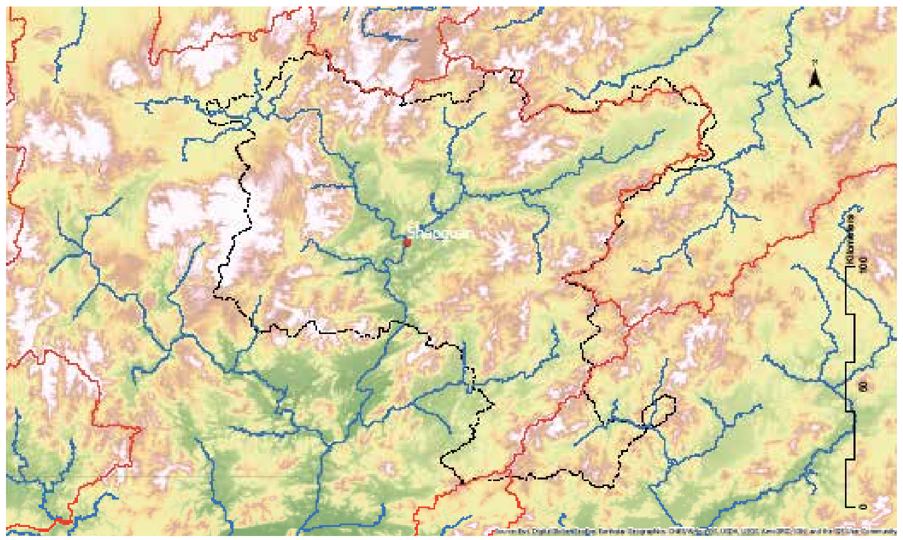
ill. 3 / LOCATION IN SHAOGUAN

Human habitation in the Shaoguan region can be dated to 129,000 years ago. In the Han dynasty (206 BC-AD 25) the earliest city was named Qujiang. During the war of resistance against Japan, the city was renamed Shaoguan, and became the temporary capital of Guangdong Province from 1943 to 1945. In 1975, Shaoguan was upgraded to a Prefecture-level city. The Shaoguan region now contains three districts and seven counties. The Shaoguan region has 22 nature reserves, with an area of 2168 km^2. The region has 28 forestry zones, with a total area of 929 km^2. These forests act both as a major source of timber as well as biological gene pool for South China. The forests contribute to the associated watershed. Land use of the Shaoguan region is dominated by forests, which cover about 76% of total land area. Primary agricultural land and orchards cover 16.3%, urban and rural settlements occupy 6.3%, mining and industrial land occupies 0.3%, while water bodies cover 1%.

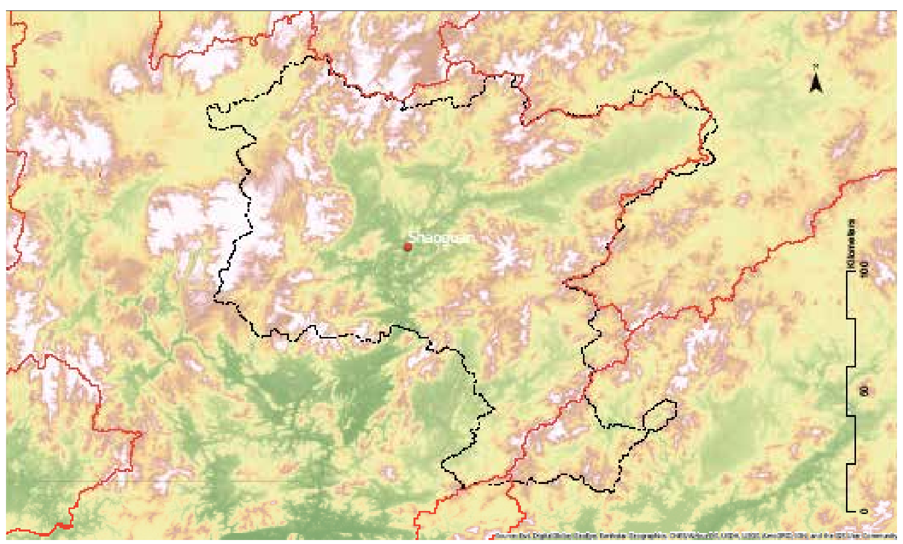
The rapid growth of Shaoguan City is constrained by its location on the confluence of the two rivers and the topography of the surrounding hills. The city also retains a critical role as a link between two parts of China. The new Jingguang high-speed train line from Beijing to Guangzhou is located near the old city. The new Jingzhu expressway from Beijing to Zhuhai is also located adjacent to the city. To address these issues a new city is being built in a 2500ha valley to the south of the existing city. The new high-speed rail station is located on the western side of the valley. This new city, Furong New Town, will help link Shaoguan with the rest of China. »



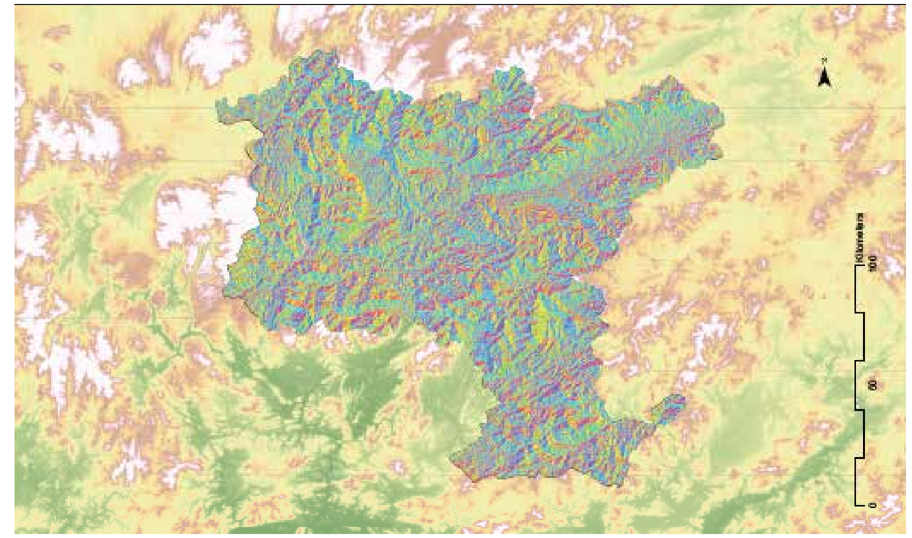
ill. 4 / CONTOURS



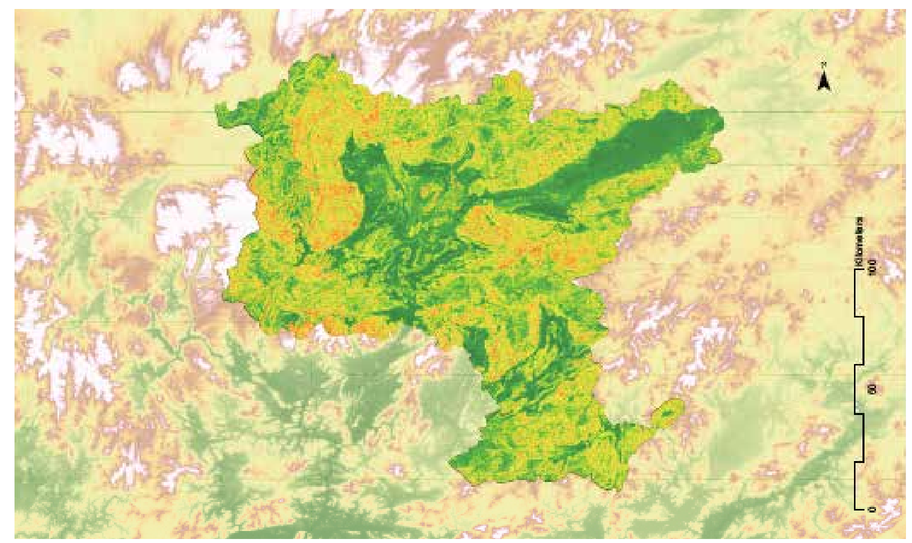
ill. 5 / RIVERS



ill. 6 / CATCHMENT



ill. 7 / ASPECTS



ill. 8 / SLOPE

CASE STUDY
FURONG NEW TOWN

Location Shaoguan, Northern Guangdong Province.
Size of catchment (s) 2652ha.

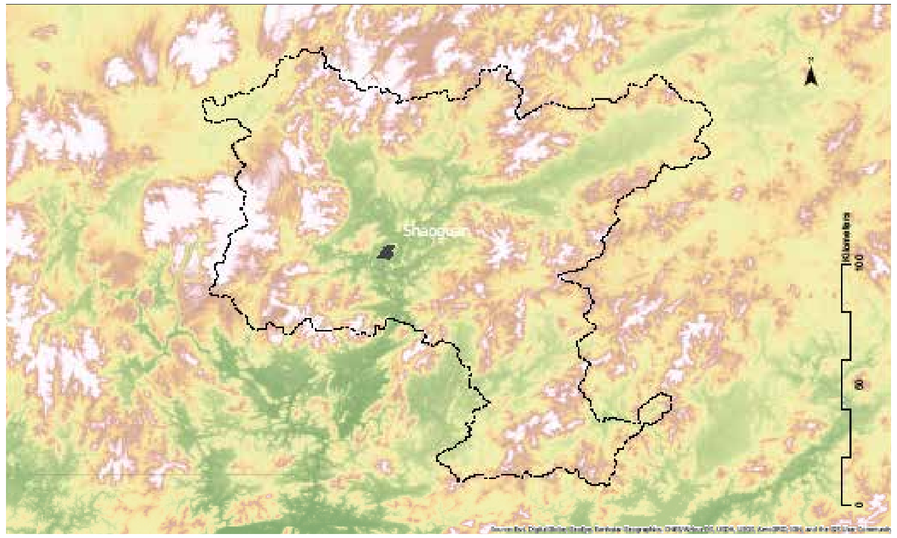
TOPOGRAPHY / The site of the new city (ill. 9) is a large valley orientated north to south (ill. 10). The catchment area is approximately 2652ha, surrounded on three sides by hills, including the Furongshan National Mining Park. The southern boundary of the valley is demarcated by the Bei Jiang River and the large island of Chetouzhou (ill.11).

VEGETATION / The existing landscape can be divided into two types; productive agricultural land, mostly paddy fields and fishponds, and remnant native vegetation. The surrounding hills are not cultivated and are colonised by broadleaf rainforest species, plus exotic species such as pine and eucalyptus.

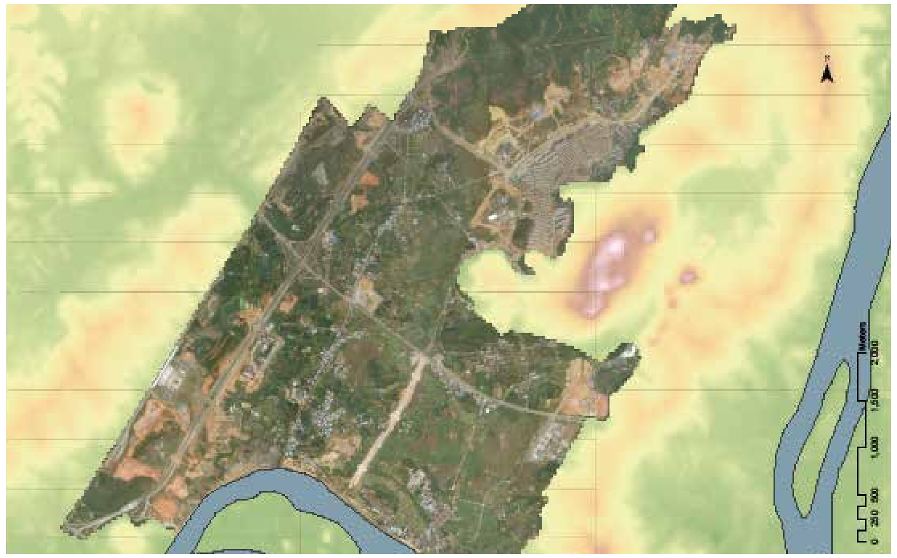
HYDROLOGY / The city site occupies two catchment systems (ill.12). The major catchment system occupies about two thirds of the city site, from the surrounding hills to the river. The other catchment system is on the western edge of the city plan and encompasses the discharge point of the neighbouring catchment. Each catchment has a major stream system, with associated overland flow-path networks. The northeast system is the most fully developed with an extensive network stretching deep into the catchment. The two catchments discharge into the Bei Jiang, the outlets are located close to one another (ill.13).

The existing hydrological system retains the natural hydrological pattern in the surrounding hills, but has been completely modified in the valley by manmade interventions – agricultural fishponds and paddy fields. Recent flood control along the Bei Jiang includes a concrete flood-protection wall along the river and a large dam located upstream of the site.

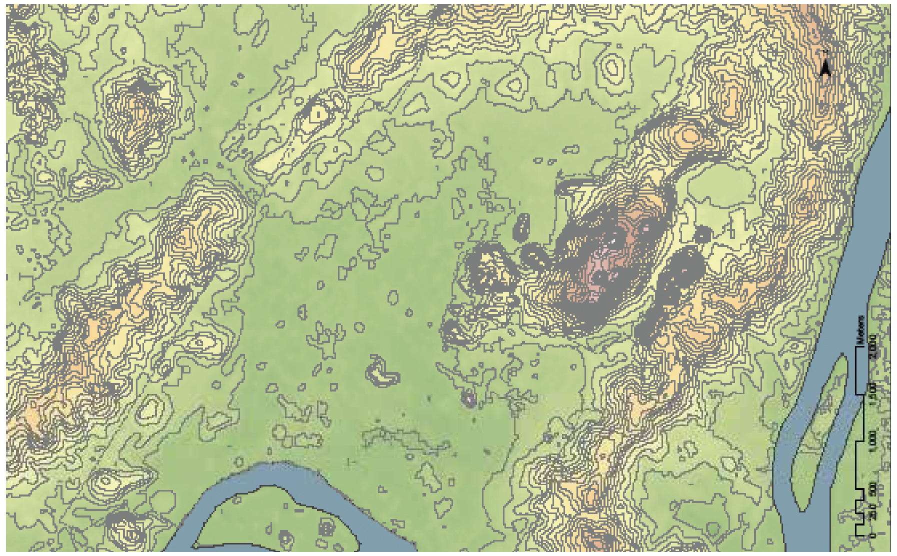
ASPECT AND SLOPE / The aspect of the site is north-south, aligning with the surrounding hills (ill.14). The slope of the site is mostly 0-5 degrees, with higher elevation in the hills (ill.15). »



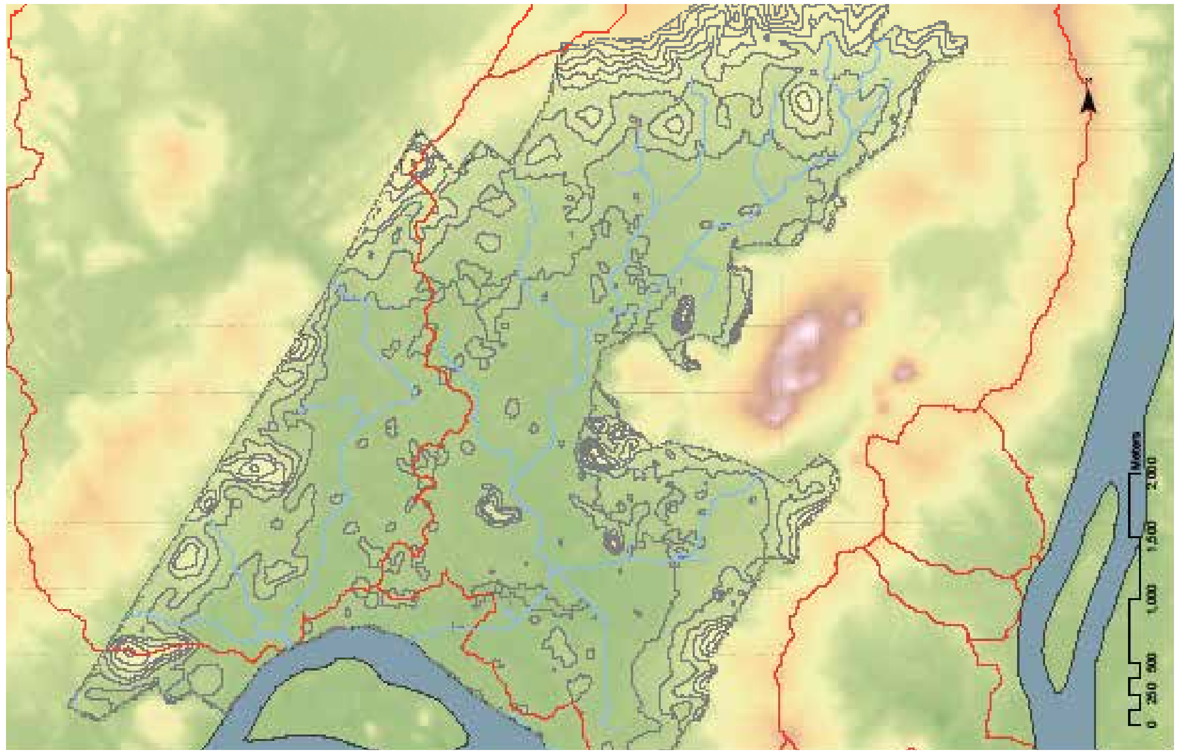
ill. 9 / LOCATION AND BOUNDARY OF SITE



ill. 10 / AERIAL PHOTO

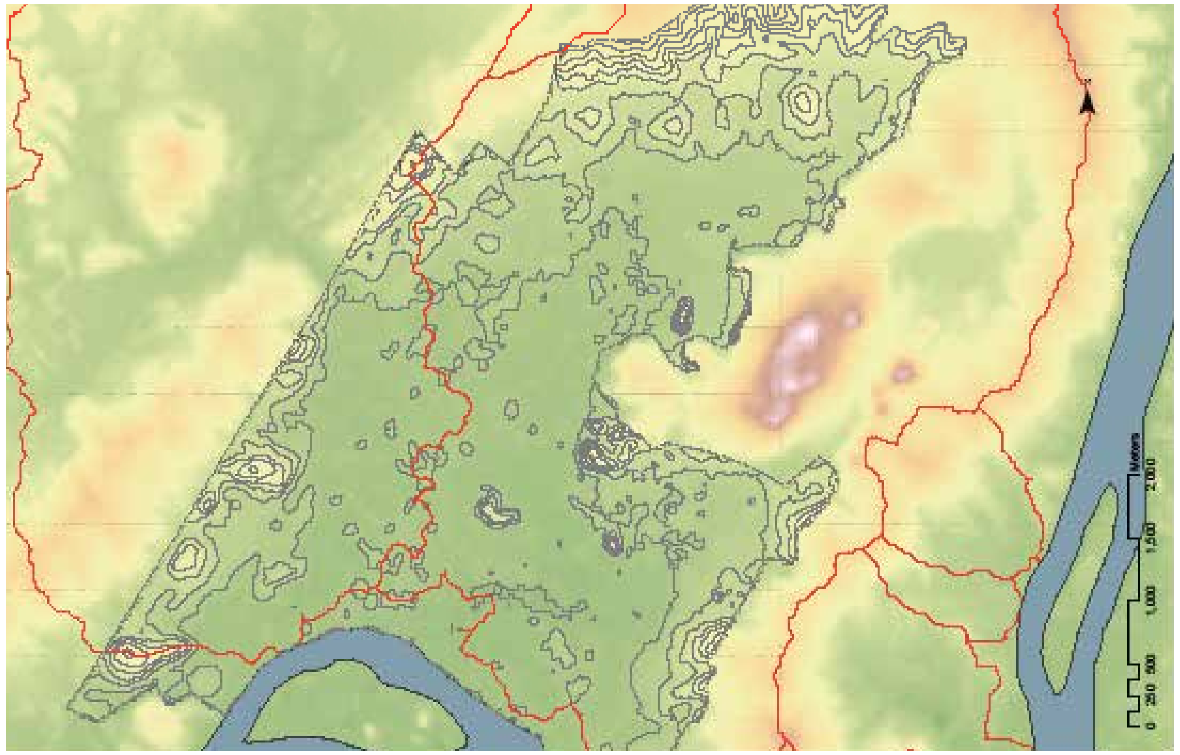


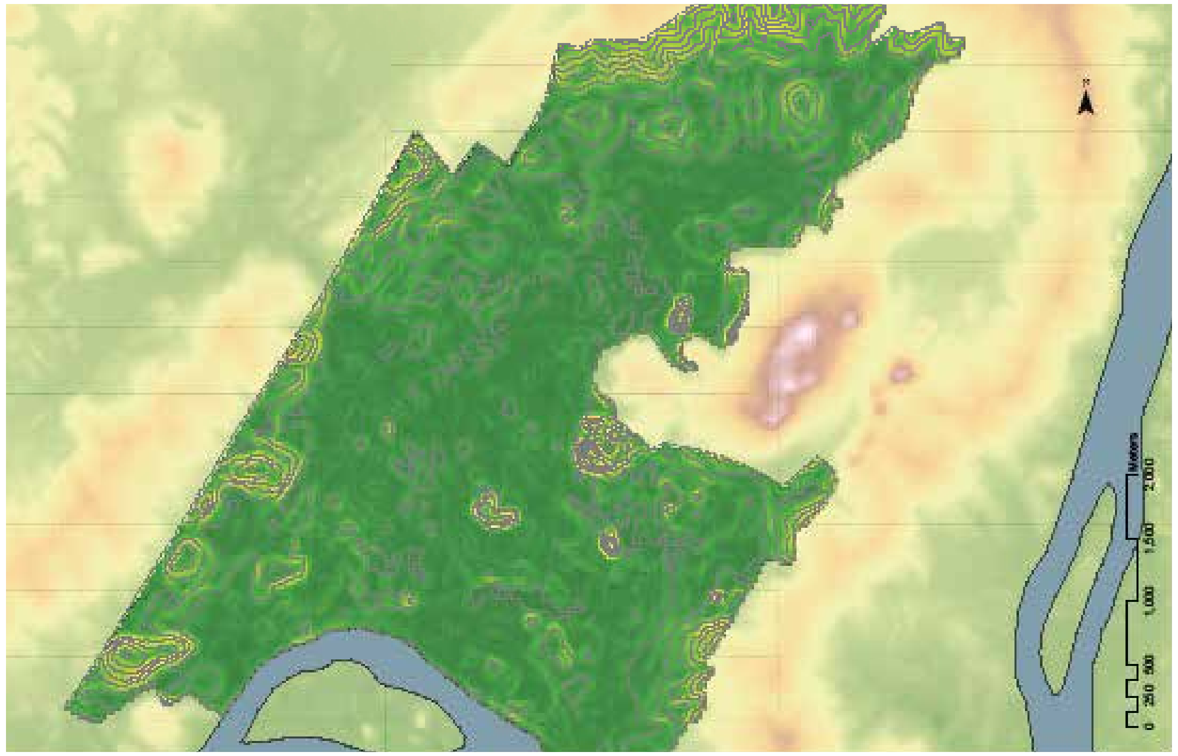
ill. 11 / CONTOURS



ill. 12 / OVERLAND FLOW PATHS

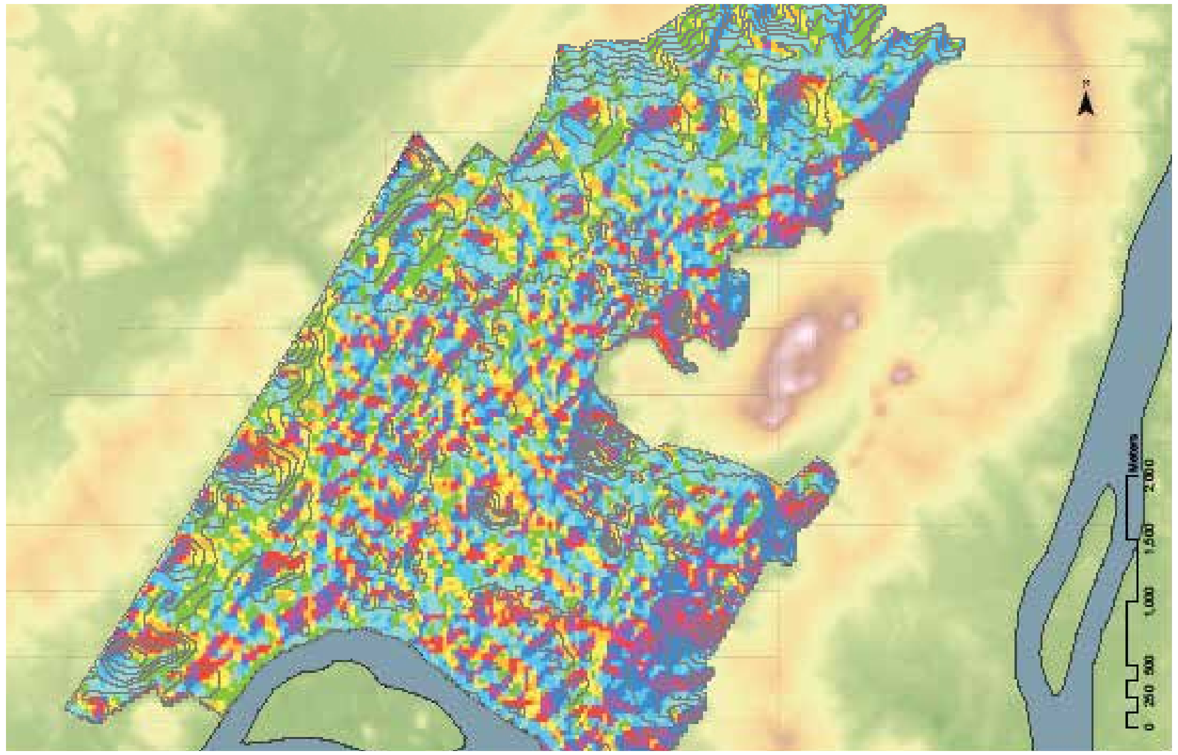
ill. 13 / CATCHMENT

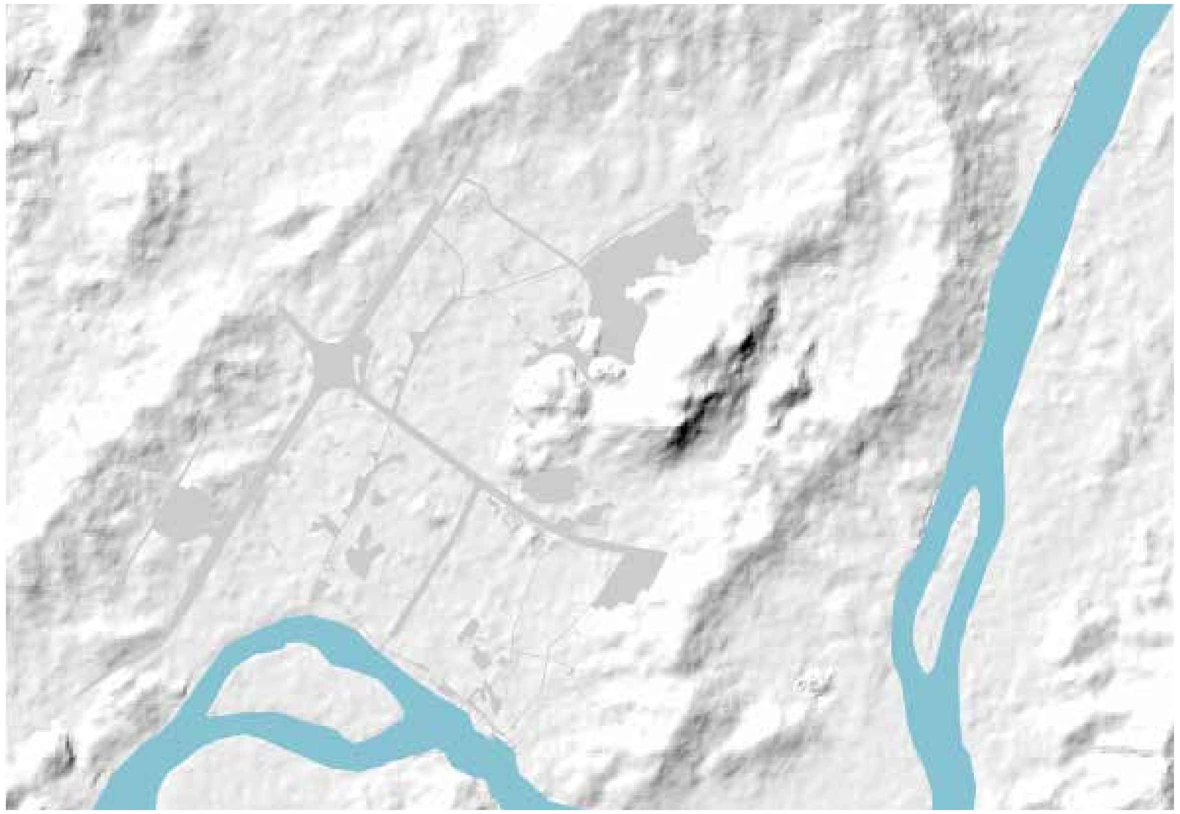




ill. 14 / ASPECTS

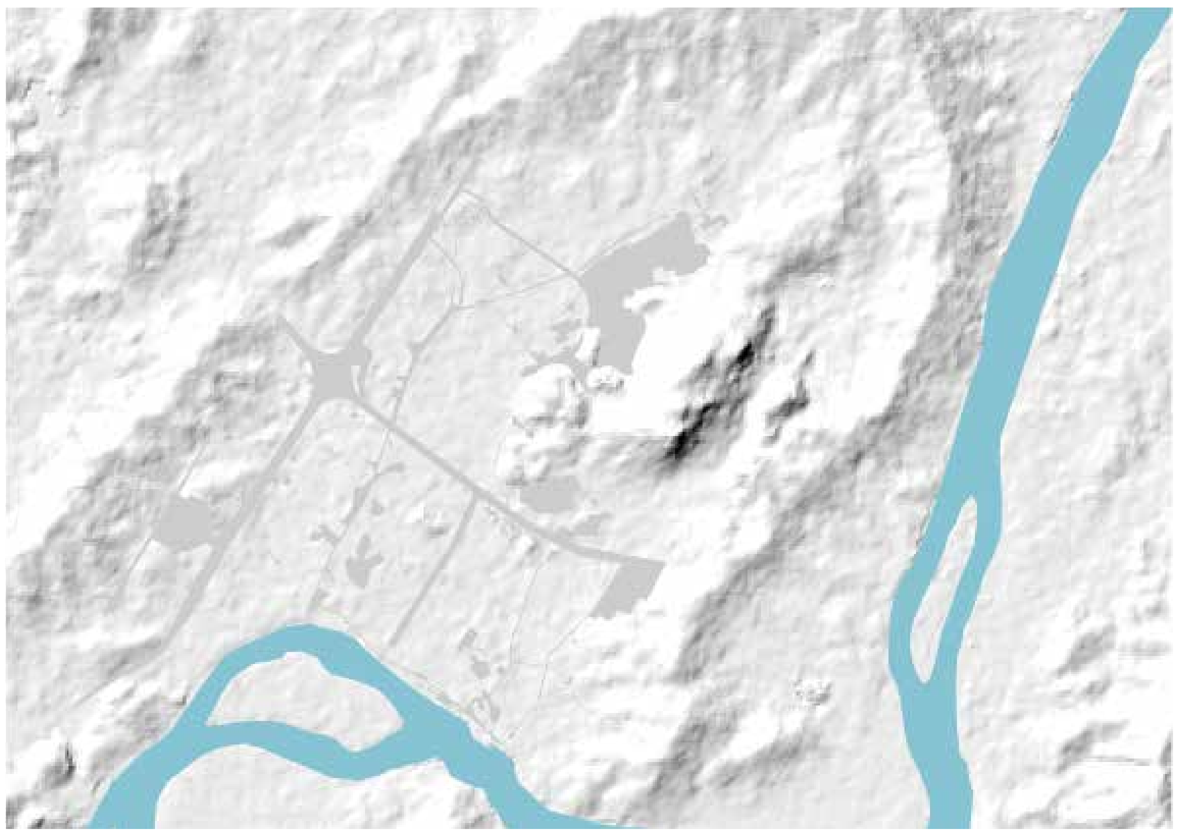
ill. 15 / SLOPE





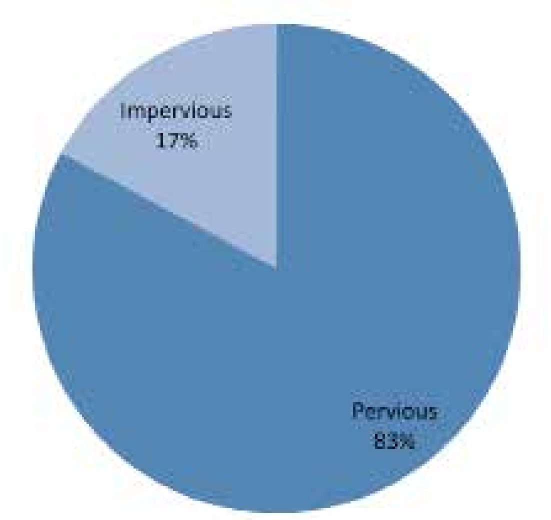
ill. 16 / ORIGINAL SITE - IMPERVIOUS SURFACES

ill. 17 / ORIGINAL SITE - PERVIOUS SURFACES



LAND USE / The existing landscape can be divided into two types; productive agricultural land, in the valley and uncultivated forest in the surrounding hills.

PERVIOUS/IMPERVIOUS RATIO / The Furong Catchment covers an area of 2086.69ha, of which the vast majority is pervious surface. The impervious surfaces are made up of buildings and roads (ill. 16), and farms contribute pervious surfaces (ill. 17).The percentage of pervious and impervious surface is 83% and 17% respectively (ill. 18). »



ill. 18 / ORIGINAL SITE

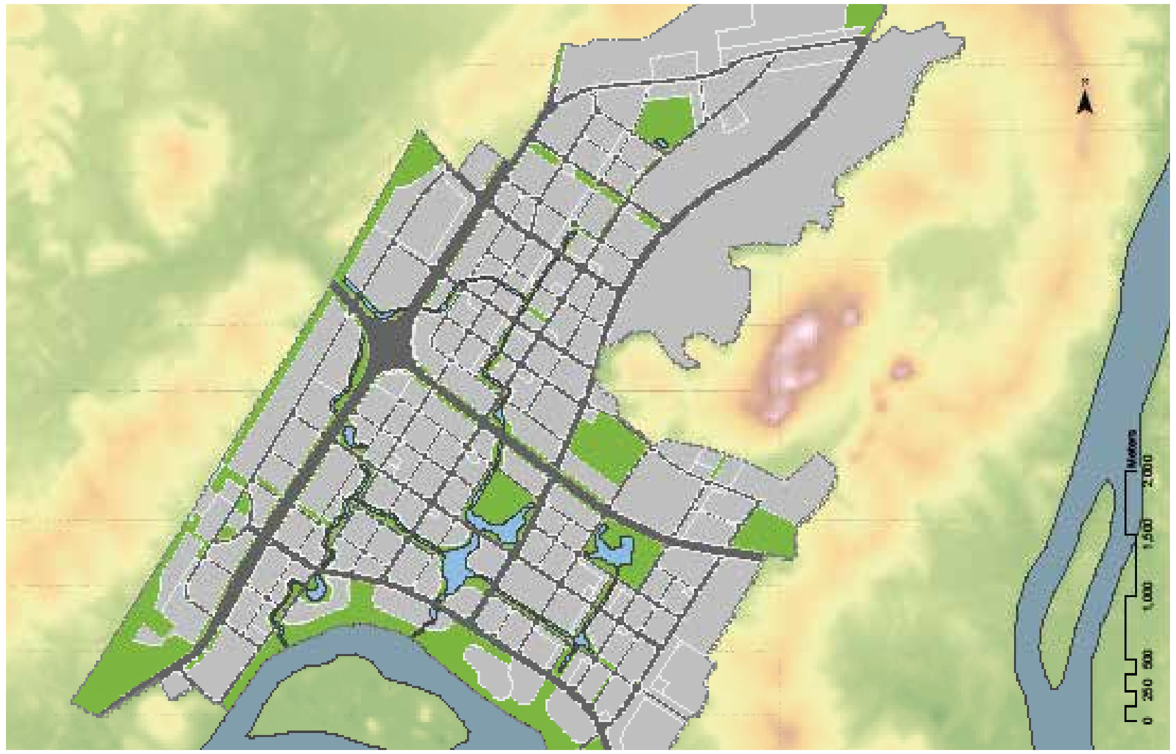
THE OFFICIAL PLAN / The new city plan occupies 1654ha of the 2086.69ha catchment. Buildings and infrastructure occupy 565ha of the site, while the remaining parks and reserves occupy 1089ha (ill. 19).

The new city plan is laid out in a grid pattern aligned to the cardinal points of the compass. The new freeway infrastructure forms a rough cross-shape within the urban plan. The northern arm of the cross, Shaoguan Avenue, runs along the western side of the city to Shaoguan. The eastern arm, Baiwang Road runs west to east through a tunnel on the eastern edge of the catchment hills to a new administration district to be built on the bend of the Bei Jing River. A railway station for the high-speed train has been built on the western side of the city adjacent to Shaoguan Avenue.

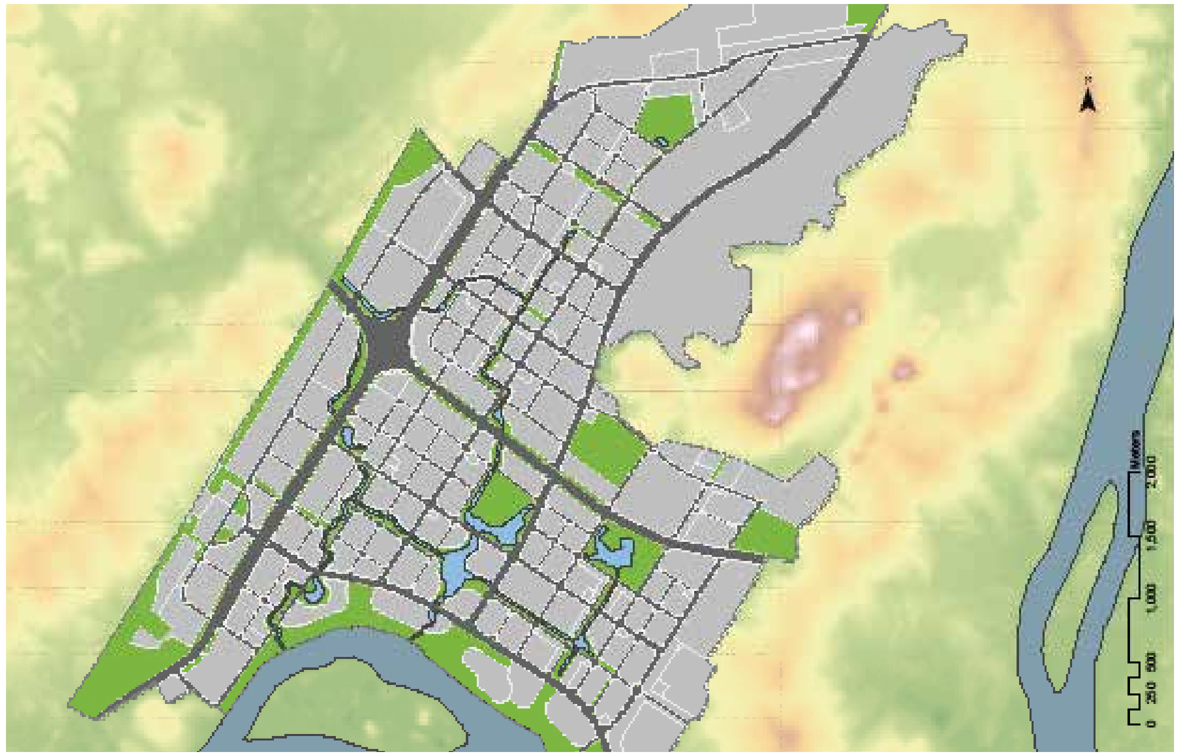
The zoning pattern of the new city is broadly determined by the new road infrastructure. To the south of the new freeway, the city is zoned for government, cultural and commercial use. The area north of the new freeway is mostly designated for residential use, with a thin corridor for commercial use running north-south. Public space and parks are allocated to blocks within the city grid. The existing stream network is channelled into a single central water feature that runs down the centre of the valley.

THE WATERFRONT / The river edge of the city is zoned as a public space. The waterfront is approximately 2km long and 500m wide, occupying a broad concave bend in the river, encompassing two stream outlets from the larger catchment. The proposed architectural/urban programme for the waterfront is for the construction of four building groups: running west to east; an open-air shopping mall, a convention centre, the preservation and restoration of an existing village and a resort/hotel. The remainder of the site zoned as a public park.

At the time of the site visit (September 2012) earth stopbanks over 2m high were being constructed on top of the existing concrete flood barrier. Concrete stormwater chambers were being built on top of the stopbanks, their location aligning with the major roads in the masterplan. »

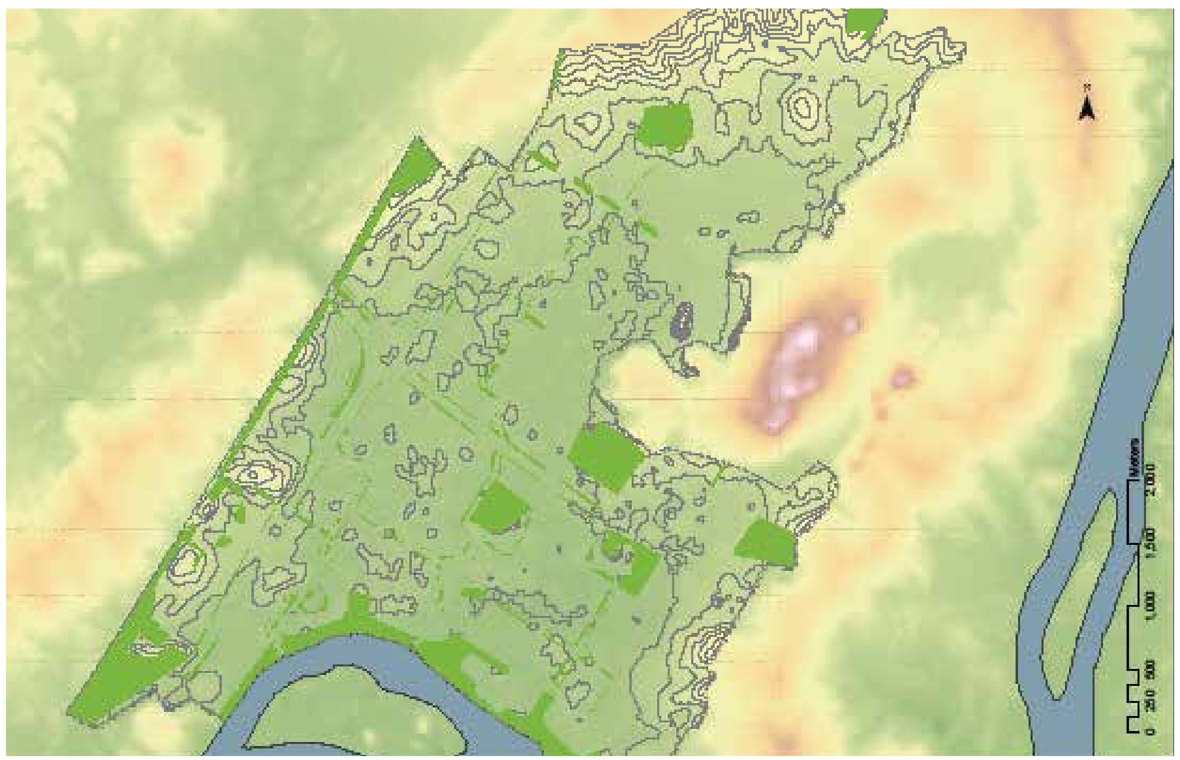


ill. 19 / PROPOSED PLAN



ill. 20 / PROPOSED PLAN - IMPERVIOUS SURFACES

ill. 21 / PROPOSED PLAN - PERVIOUS SURFACES



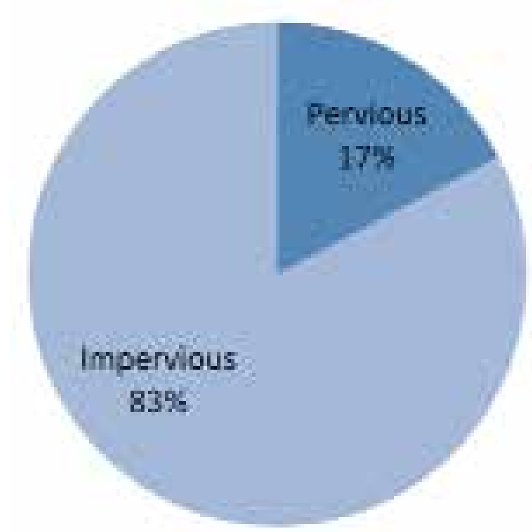
THE PROBLEM

ENVIRONMENTAL PROBLEMS / With the building of the new city, a quarter of the catchment will be rendered as an impervious surface. Two negative hydrological outcomes will result; the production of contaminated rainfall runoff that will discharge into the Bei Jiang, and an increase in the likelihood of urban flooding.

PERVIOUS/IMPERVIOUS RATIO / The Furong catchment covers an area of 2086.69ha. The new city masterplan is 82% impervious surface (1725.84ha). The impervious surfaces are made up of buildings, 1330.14ha, and roads, 395.43ha (ill 20). Pervious surfaces made up of parks, 318.88ha and water, 41.97ha (ill. 21), make up 18% of the proposed masterplan.

In the proposed masterplan the impervious surface in the Furong Catchment will increase markedly. The result of this high degree of imperviousness is that a large amount of contaminated stormwater runoff will discharge into the Bei Jiang River. Using the Rational Method the 2-year runoff discharge flow rate (m3/sec) will be 678084.8611m3/hr (ill. 22).

SOCIAL ISSUES / The construction of the residential zones of the new city to the northern part of the site may limit residents' access to the waterfront. »



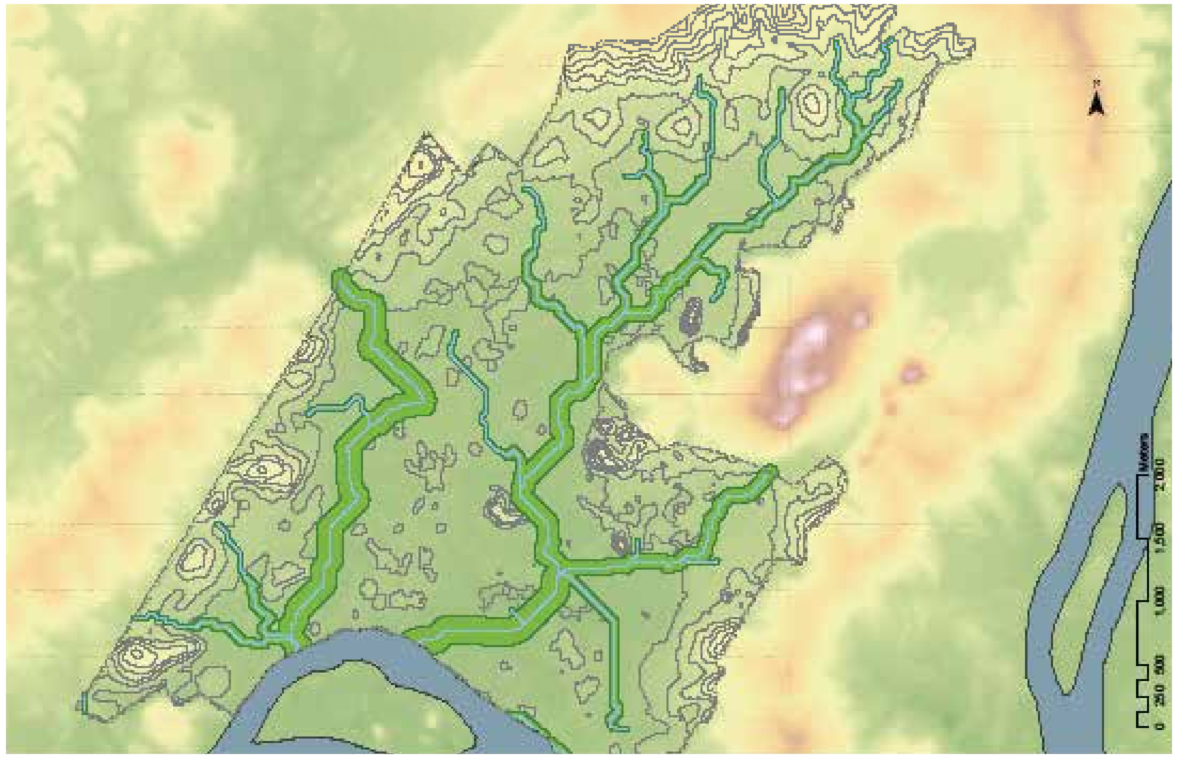
ill. 22. / PIE CHART- PROPOSED PLAN

THE SOLUTION: NATURE CITY PLAN

DESIGN METHODOLOGY / To help lessen the effects that the new masterplan will have on the existing hydrological pattern an analysis of the hydrological structure of the Furong catchment is necessary. The first step in this analysis is to use ARCHydro to map use, shape and size of the catchment. The mapping will show the catchment boundaries of the Furong New Town and the associated network of overland flow paths. Using this analysis enables the designer to understand the the ratio of impervious to pervious surface. Using the Rational Method, an understanding of the rainfall runoff under different conditions can be modelled. Through a series of iterations, such as increasing and decreasing the amount of impervious surface due to the position of the building zones, the increase and decrease in stormwater runoff can be measured.

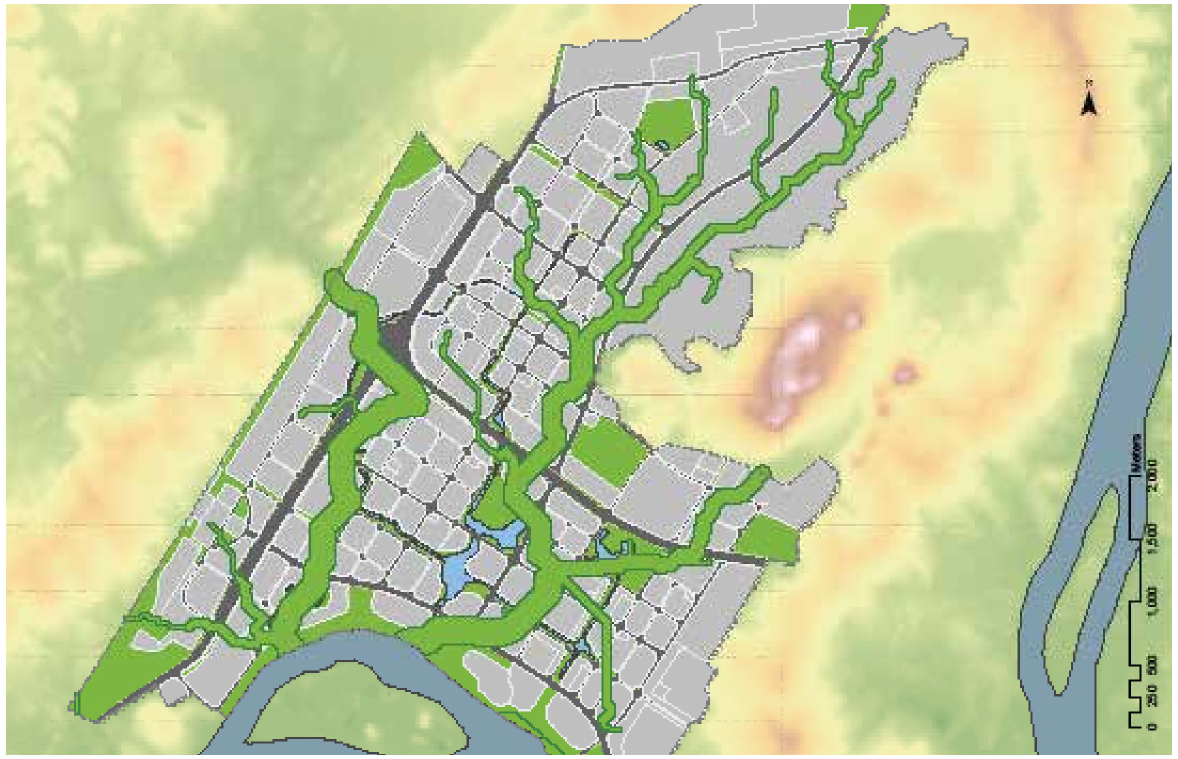
DESIGN WORK/ FURONG NEW TOWN

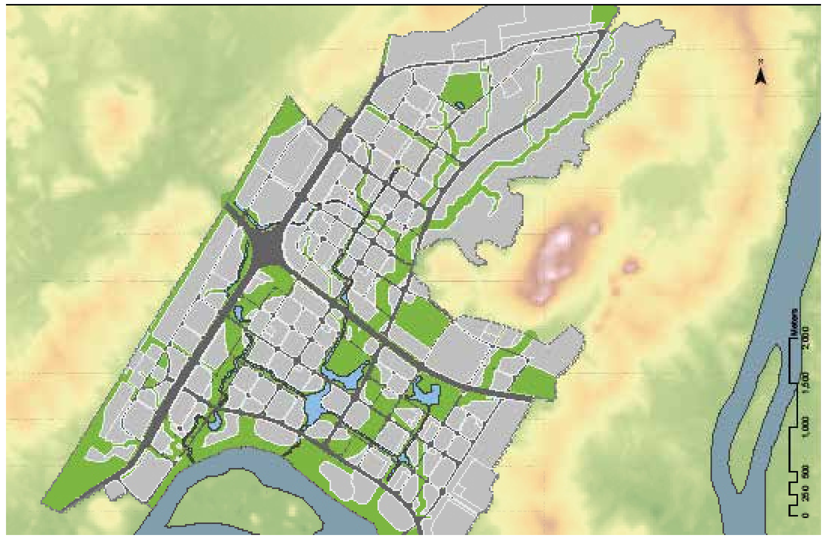
HYDROLOGY / Increasing the amount of permeable surface in the new city plan is an important way of reducing the increased amount of stormwater discharging into the river. Recognising the existing hydrological pattern of the catchment through mapping the existing streams and overland flow paths is the first step in reorganising the existing urban plan to become more responsive to the environmental issues exacerbated by the proposed plan. By buffering the stream system, the amount of pervious surface in the city can be increased (ill. 23). This action can be modelled using ARC GIS mapping. The result is a proposed amendment to the urban masterplan, removing buildings around the hydrological network (ill. 24). »



ill. 23 / STREAM BUFFER

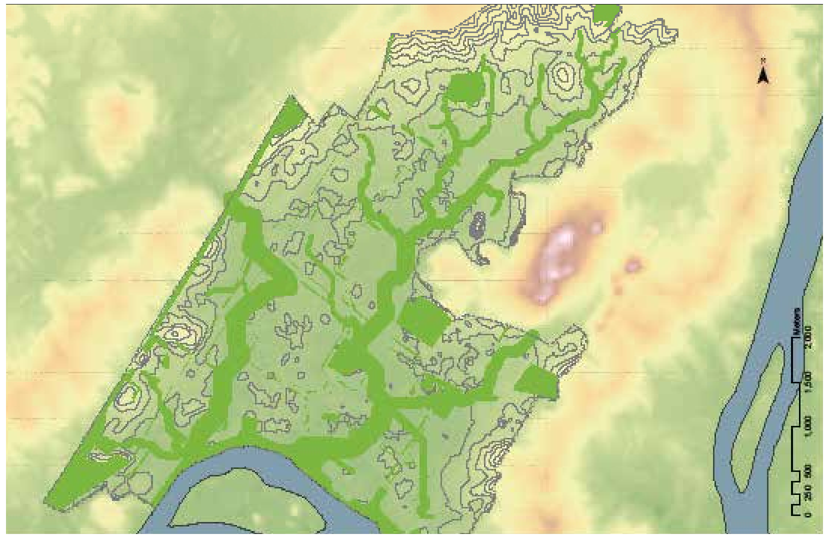
ill. 24 / NEW PLAN - PERVIOUS SURFACES





ill. 29 / NEW PLAN

ill. 25 / NEW PLAN - IMPERVIOUS SURFACES



ill. 26 / NEW PLAN - PERVIOUS SURFACES

URBAN DESIGN / The adjacency of housing to the new stream and park corridor will also help to increase the amenity value of the surrounding residential zone, whose residents can enjoy views of the water and native vegetation. The new stream corridors link the river to the hinterland, giving citizens the opportunity to walk and cycle along the corridor to the park space in the surrounding hills or the new riverside waterfront (ill. 29).

PERVIOUS/IMPERVIOUS RATIO / The Furong catchment covers an area of 2086.69ha. Amending the existing city masterplan to the Nature City plan to allow for the stream network means decreasing the total impervious surfaces to 66% (1371.24ha). The impervious surfaces are made up of buildings, 975.81ha, and roads, 395.43ha (ill. 25). In the Nature City plan, pervious surfaces increase markedly to 34% (715.45 ha), made up of parks, 672.78 ha, and water, 62.77ha (ill. 26). The result of this increase in perviousness is a reduction in the amount of contaminated stormwater runoff discharging into the Bei Jiang River.

Using the Rational Method, the two-year runoff discharge flow rate (m3/sec) will be 615370.8131m3/hr (ill. 27). For a full comparison of the effects of the Nature City plan to the existing masterplan, see the discharge chart (ill.28). »

ENVIRONMENTAL AND SOCIAL IMPLICATIONS OF THE NATURE CITY PLAN

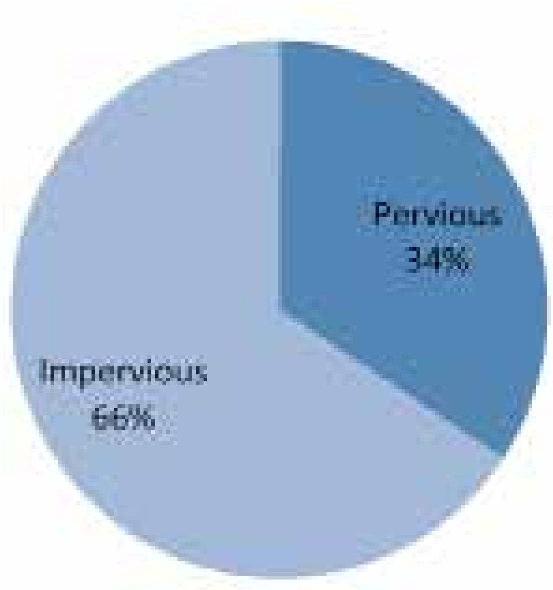
STREAM NETWORK / The buffer zone can also have a number of other uses, such as allowing for the location of structural stormwater cleaning instruments; in particular, wetlands and rain gardens, which can all be installed within the new stream buffer zone. This stream zone can form a deep connection from the river's edge to the surrounding hills. This new linear park could be planted with native species, forming an ecological corridor from the river to the hills (Ill.30).

WATERFRONT / The new waterfront design could also help in the remediation of the contaminated stormwater caused by the construction of the new city of Furong. By situating structural water-cleaning devices in the public space of the new waterfront, stormwater could be cleaned before being discharged into the river. Devices could include a swale, located at the junction of the city grid and the waterfront site, to accept, attenuate and treat contaminated stormwater from overland flows from the city. A constructed wetland, occupying most of the public space of the waterfront site, could take stormwater from the two existing streams and the new piped infrastructure, and subject the contaminated water to cleaning before discharge into the river.

The public space of the waterfront would then become a shifting temporal landscape that displayed various hydrological conditions according to the seasons; a dry landscape in winter, a wet landscape in summer. The building programme would be aligned with the new, environmentally-driven process. Each building group – the mall, convention centre, hotel and village – is treated as a self-contained entity. This hermetic quality is emphasised topographically by locating each building group on one of a set of 'islands', surrounded by different water conditions according to the seasons (Ill 31).

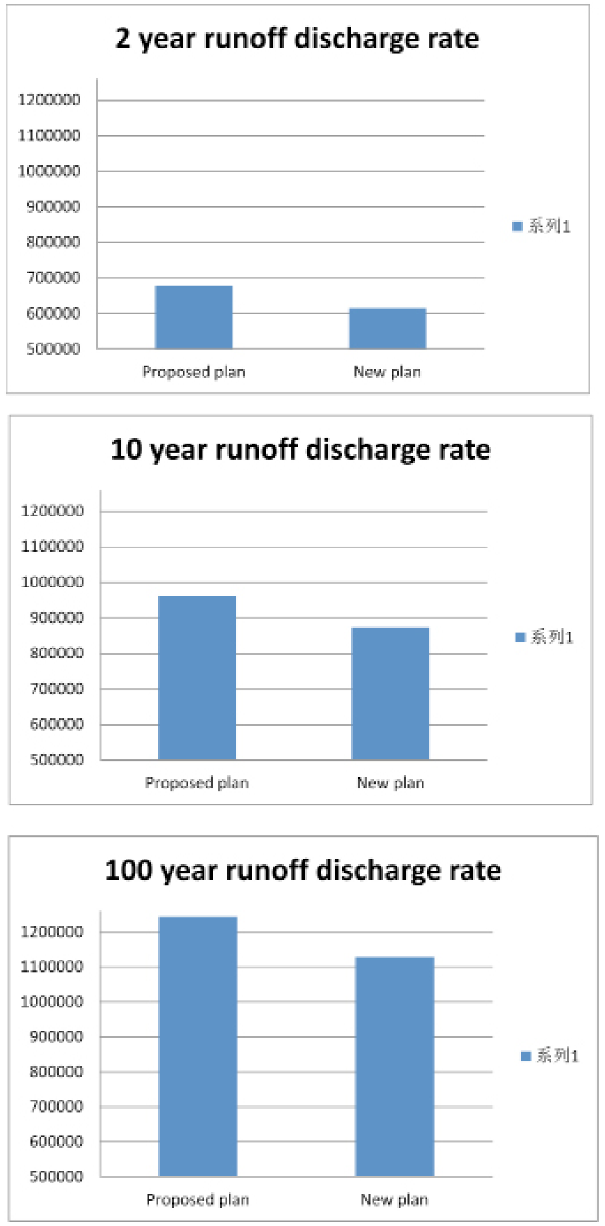
SUMMARY

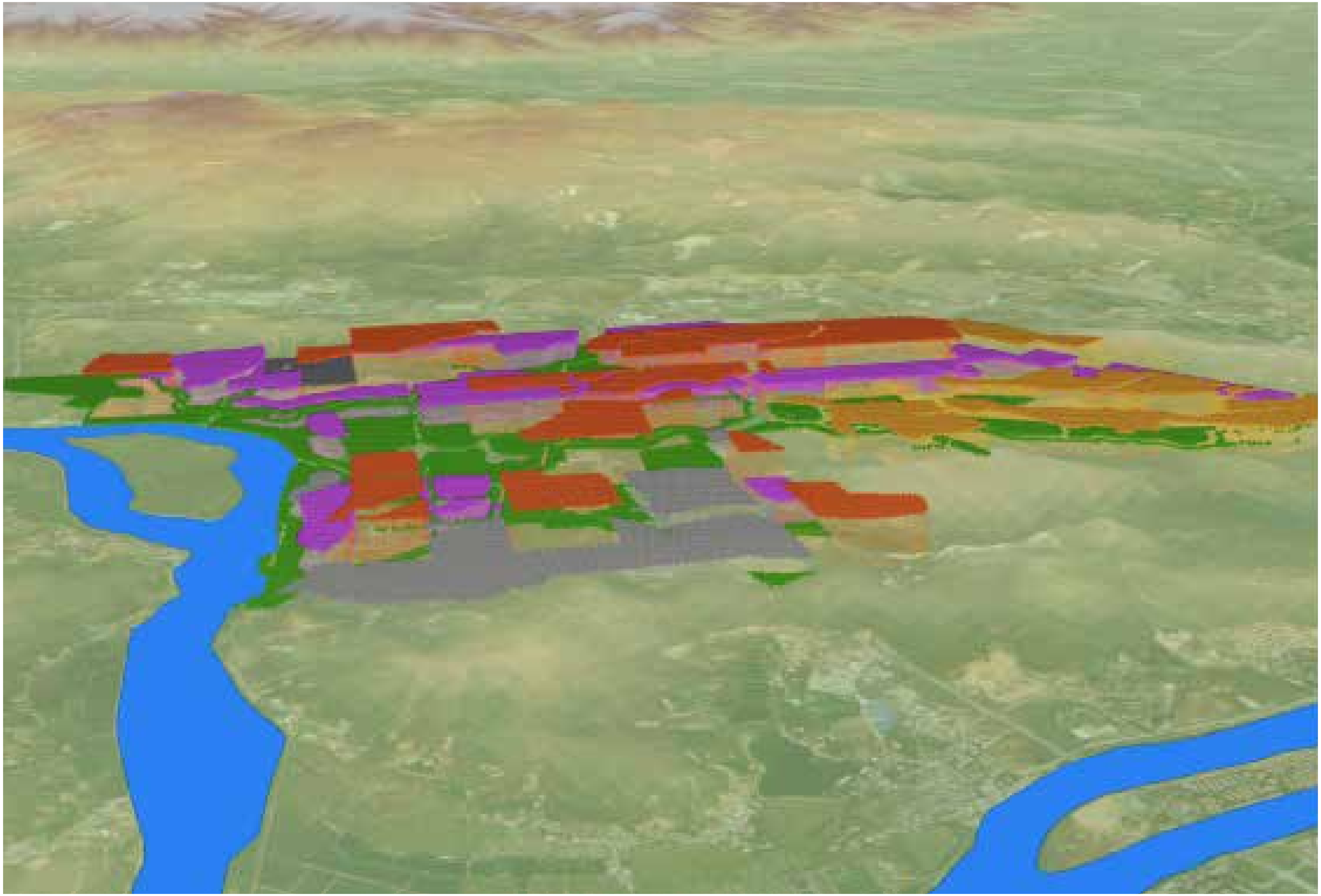
By locating and establishing the existing hydrological network as a new park zone, the threat of urban flooding posed by the intensification of impervious surfaces within the Furong catchment is lessened. The removal of buildings that are located in the new park can be remediated by simply intensifying areas of the masterplan that are outside the stream and overland flow-path network. ■



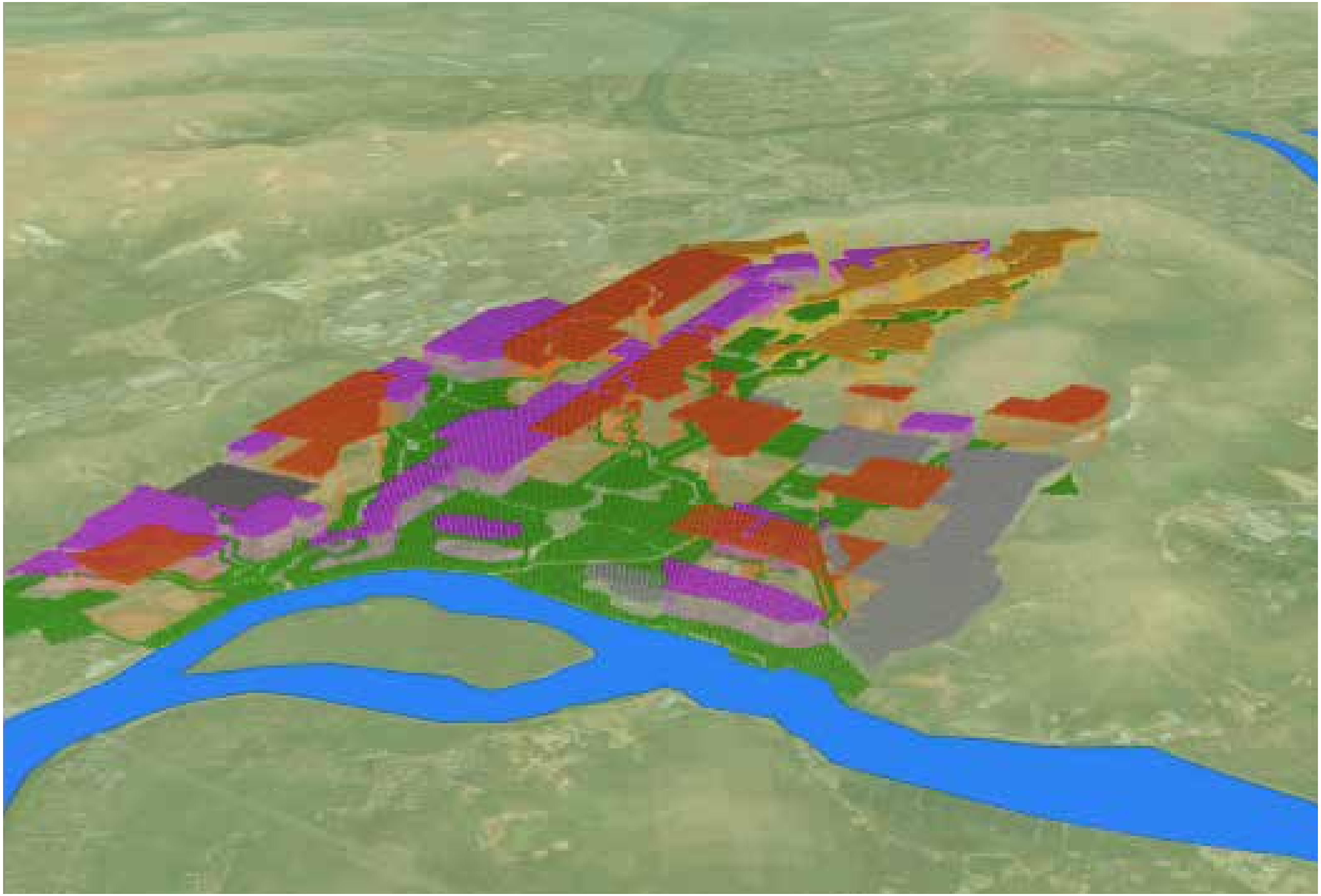
ill. 27 / NEW PLAN

ill. 28 / STORMWATER DISCHARGE CHART





ill. 30 / PERSPECTIVE 1



ill. 31 / PERSPECTIVE 2

STUDY THREE. **BROWNFIELD / NEW ZEALAND**

WYNYARD QUARTER. FREEMANS BAY

BACKGROUND TO THE STUDY

The Wynyard Quarter is a new urban waterfront being built in the Freemans Bay catchment in the centre of Auckland City (ill.1). Auckland, or Tāmaki Makaurau (ill.2), is situated on an active volcanic field located on an isthmus, between the Pacific Ocean and the Tasman Sea. This unique landscape is made up of over 50 volcanic vents that form a unique topography, both watery and hilly. Lakes and basins were formed where water and a volcanic eruption joined together. Auckland's unique landforms, the volcanic cones, were created from eruptions building hills of magma.

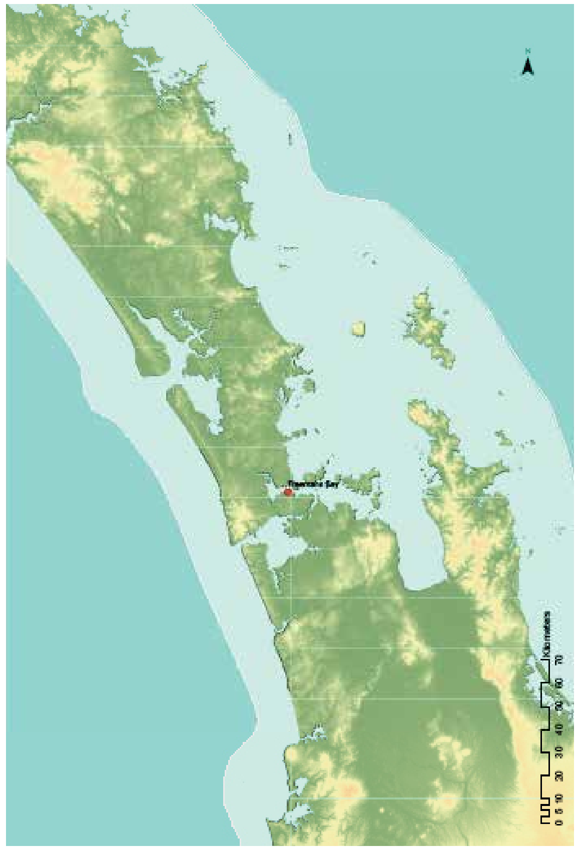
Freemans Bay is made up of two parts, an inner-city suburb (ill.3) and a large area of reclaimed land. The original landscape is made up of a number of valleys that run in a north-south direction. Ridges that are now roads define the edges of the suburb. To the west; Shelly Beach Road, Jervois Road, Ponsonby Road, then Karangahape Road to the south and Hobson Street on the east side. The original shoreline is defined by three roads; to the west Beaumont Street, Victoria Street in the middle, then Halsey Street on the eastern side. Freemans Bay is one of a series of three large urban valleys running north-south that form the core of the Auckland CBD (ill.3). These three valleys and headlands once opened on to three bays – Freemans Bay/ Waiatarua, Commercial Bay/ Te One Panea and Official Bay /Te Hororoa. The second part of the catchment is reclaimed land. This reclamation was carried out in two parts; the first was the filling of Freemans Bay and the construction of Victoria Park, in the late 19th century. The second was the construction of the Wynyard Point reclamation in the early 20th century as an industrial port and warehouse zone (ill. 4).

Historically the Freemans Bay catchment was dominated by two streams (ill.5). The Waikutu, on the southwest side of the catchment, discharged into Freemans Bay near to where College Hill Road starts the ascent to Ponsonby. The Tunamau Stream was located on the southeastern side of the catchment, where Western Park is now located. The Tunamau discharged into the bay at the bottom of what is now Franklin Road.

The hydrological pattern – the streams and associated overland flow paths – make up 29 sub-catchments within the greater catchment (ill.6). However, the native hydrological system has long since been subsumed by a conventional piped network that now discharges into the sea from a single point at Wynyard Quarter.

The aspect of the catchment is north-facing, with a series of valleys running north with faces opening to the east and west (ill.7). The average slope in the catchment is 5-10 degrees, but some slopes are up to 40 degrees (ill.8). »

ill. 1 / LOCATION IN NEW ZEALAND



ill. 2 / LOCATION IN AUCKLAND REGION

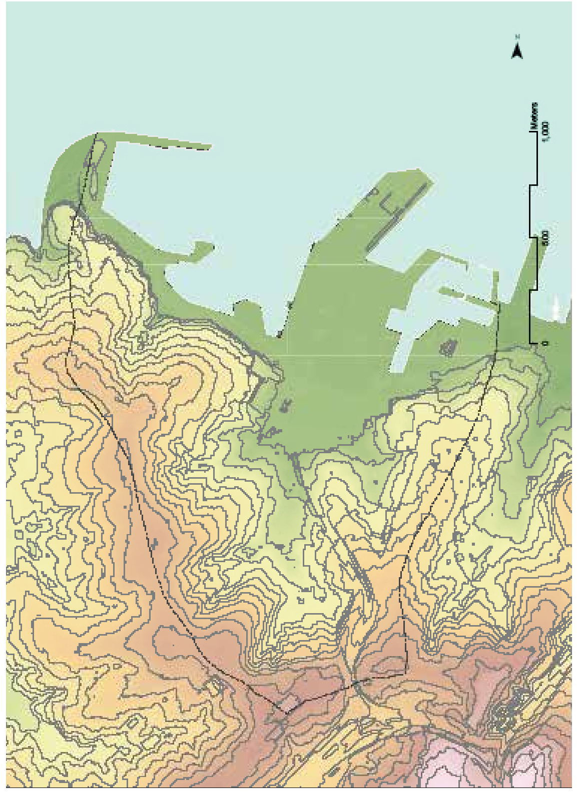
Freemans Bay has two important parks; the first one is Western Park, one Auckland's earliest, built in 1873. It was planted as an arboretum with a selection of mostly-European tree species. The park is 8ha, running in a north-south direction, and encompasses one of the major valleys in the catchment. The other park is Victoria Park, 12ha, built on reclaimed seabed in 1905. This park was designed for a more active programme with sports fields and a large playground and kindergarten. The Freemans Bay catchment covers an area of 244ha, of which 72.7% is impervious surface (178ha). The impervious surfaces are made up of buildings, roofs (64ha), roads, driveways and footpaths (114ha).) Pervious surfaces comprised of park and domestic gardens make up 27.3% (66ha) of the catchment. The result of this high degree of imperviousness is large amount of contaminated storm water runoff discharging into the harbour.

Māori traditionally used the bay for fishing and shellfish gathering, as evidenced by the alternative names for the bay, Wai Kōtoa (the place where cockles are harvested) and Te Koranga (a scaffold, or racks, where fish could be preserved by dried). Under European occupation, the bay became an early industrial area for saw milling. Felled native trees were floated in log rafts from as far afield as the Coromandel to be sawn into timber. Workers were accommodated in rudimentary dwellings, close to the sawmills. The industrialisation of Freemans Bay continued in the 19th century with the construction of brickworks, shipyards and a foundry. The bay was also the location for municipal services, a morgue, a night soil dump, and the council rubbish incinerator, built in 1905.

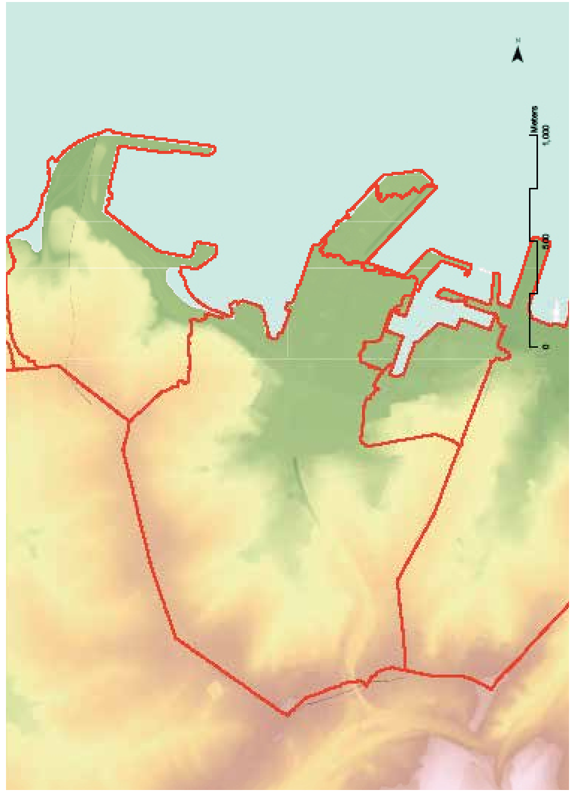
There are two parts to the Freeman Bay catchment, the first, an affluent gentrified suburb, the other, a highly contaminated reclaimed industrial site. Peter Walker, an American landscape architect, was commissioned in 2003 to create a masterplan to develop the Wynyard Point. Of the approximately 38.8ha encompassed by the masterplan, 5.8ha is to remain as a base for existing marine-related industries, mainly on the Westhaven Marina side. The main body of the site is a development zone of approximately 21ha. The conceptual basis of the masterplan was the establishment of two axes that connect the Wynyard Quarter to the CBD.

The first axis is north-south from the existing Victoria Park to the northern tip of the Wynyard Quarter. The second axis runs west-east, from the Wynyard Quarter to the CBD via Quay Street. This plan was modified in 2007 by a local Auckland architectural practice, Architectus. »

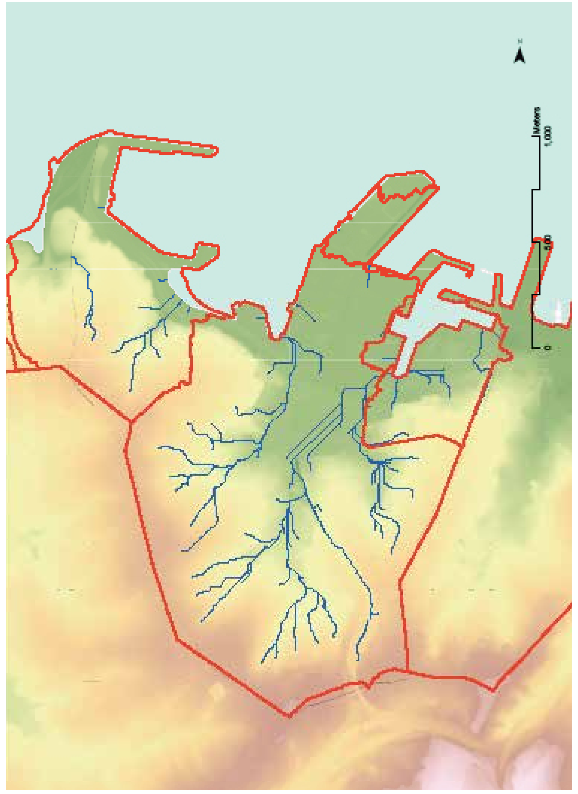
ill. 3 / AERIAL PHOTO



ill. 4 / CONTOURS

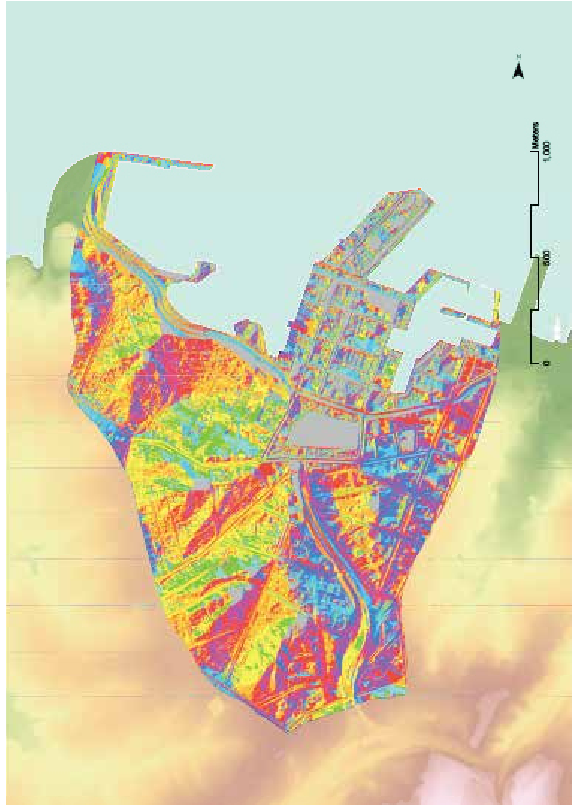


ill. 5 / CATCHMENT

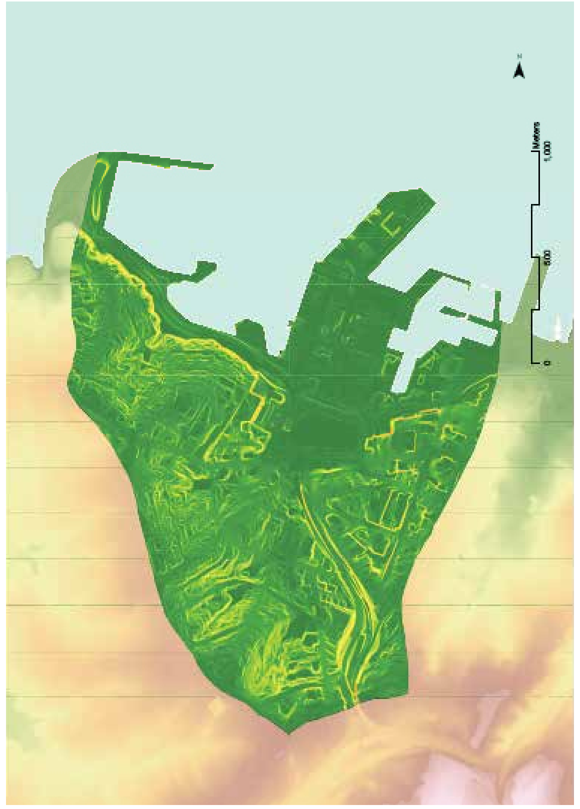


ill. 6 / OVERLAND FLOW PATHS

ill. 7 / ASPECTS



ill. 8 / SLOPE



CASE STUDY
WYNYARD QUARTER

Location Freemans Bay, Auckland, New Zealand .
Size of catchment (s) 38.8ha.

TOPOGRAPHY / The Wynyard Quarter is a flat site, built of reclaimed material, two metres above sea level (ill. 9). The site is made up of two parts, the first is a square-shaped 450 x 580m block, oriented north-south and bounded by Fanshawe Street to the south, Hamer Street and the Westhaven Marina to the west. Most of the yacht, black boat haul out and maintenance facilities are located on this edge. Halsey Street, with the old America's Cup bases and the Viaduct Basin development, runs along the eastern edge. Jellicoe Street defines the northern edge with the new North Wharf development.

The second part of the reclamation veers towards the northeast in a rough 480 x 170m parallelogram. The site is bounded by an extension of Hamer Street to the west side and Brigham Street on the east, running parallel with Wynyard Wharf. This site is where most of the existing bulk-fuel-storage tanks are still located (ill.10). As a reclaimed site, the topography is mostly flat with some small local declinations (ill 11).

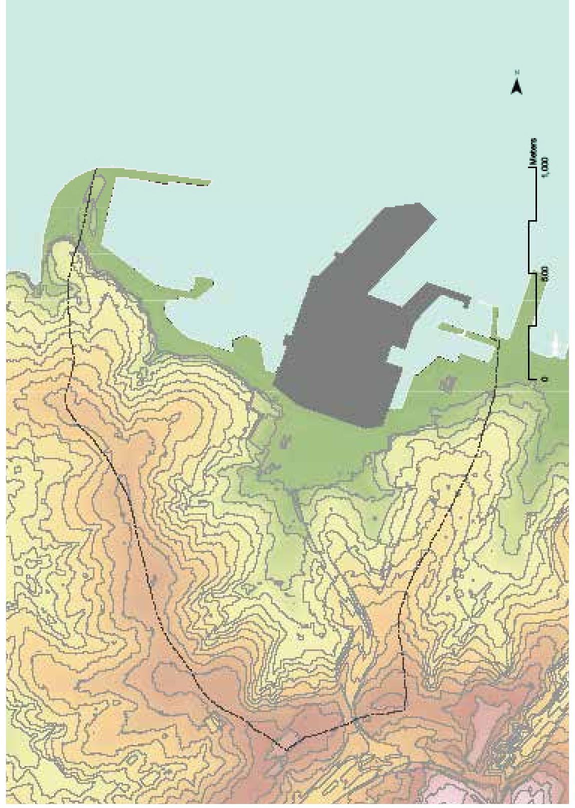
VEGETATION / Wynyard Quarter has no vegetation, indeed after a number of years of use as an industrial fuel-storage area, with many spillages, the ground is highly contaminated, making it impossible even for the growth of adventurous vegetation.

HYDROLOGY / Wynyard Quarter is a highly impervious industrial site. The overland flow path network (ill.12) is confined to the periphery of the site with a series of overland flow paths from the interior to the littoral. The paths form a series of twelve sub-catchments (ill.13).

ASPECT AND SLOPE / Since the site is, for all intents and purposes flat, the aspect and slope of the site is negligible (ill. 14 15).

LAND USE / Wynyard Point (rebranded as Wynyard Quarter in the 1990s) is the northern point of the Freemans Bay reclamation, situated between the Westhaven Marina and the Viaduct Harbour. Wynyard Quarter was used for warehousing, the fishing industry and most importantly as an industrial fuel store. The fuel store, or tank farm, was a major feature of the site. Over the last 20 years Wynyard Point has been undergoing a slow redevelopment from an industrial wharf and tank farm to a new consumerist waterfront development.

PERVIOUS/IMPERVIOUS RATIO / The site is highly impervious. The catchment area is 38.8 ha, with roads and buildings occupying 35ha (ill. 16), leaving 3.8ha of the site as pervious surface (ill. 17) – a ratio of 90% impervous to 10% pervious (ill. 18). The yearly rainfall is 1137mm. The result for the two-year runoff discharge flow rate from the existing Wynyard Quarter site is .82m/sec; the storage volume required to treat this is 4412.29 m3. »

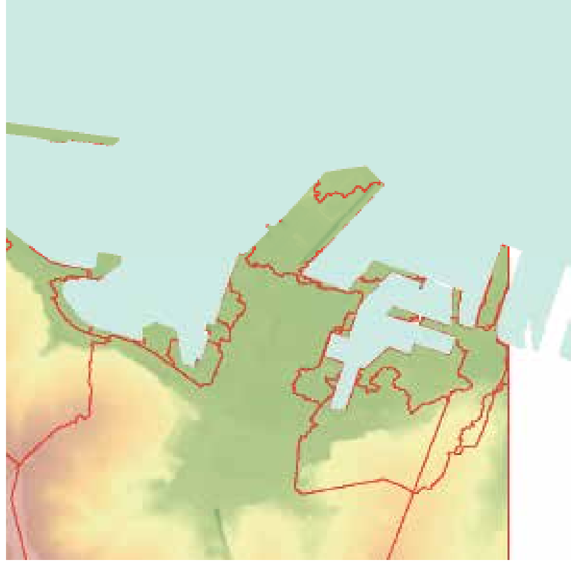


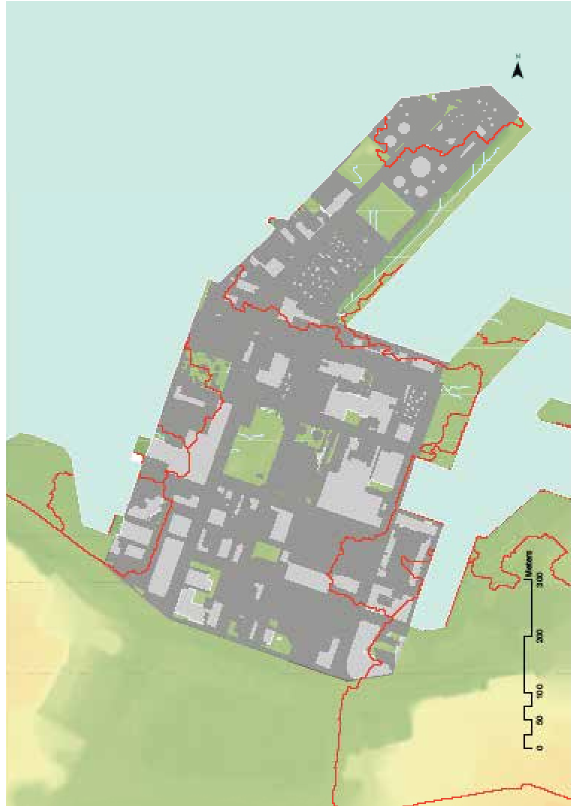
ill. 9 / LOCATION AND BOUNDARY OF SITE

ill. 11 / CONTOURS

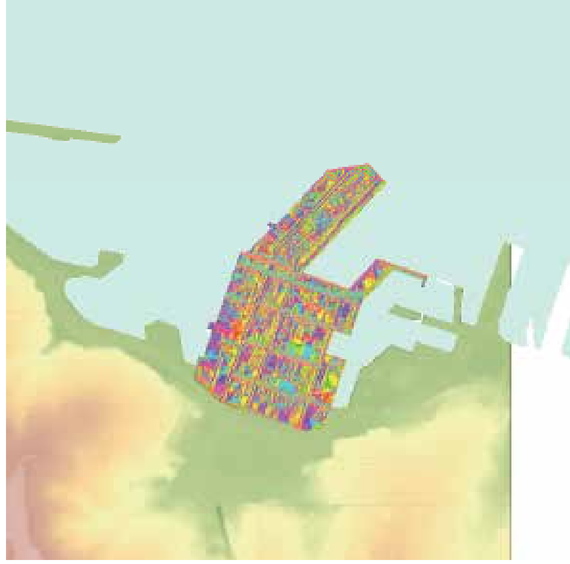
ill. 10 / WYNYARD QUARTER AERIAL PHOTO


ill. 12 / OVERLAND FLOW PATHS


ill. 13 / CATCHMENT

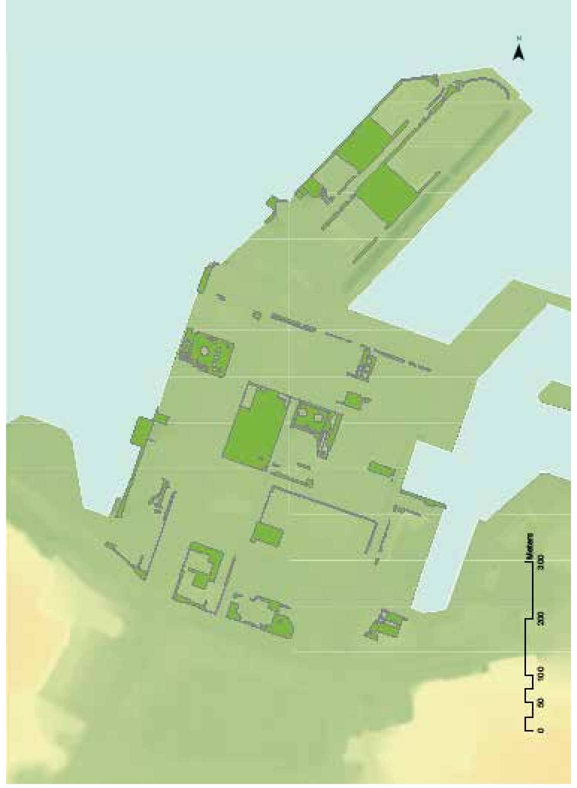

ill. 16 / IMPERVIOUS SURFACES

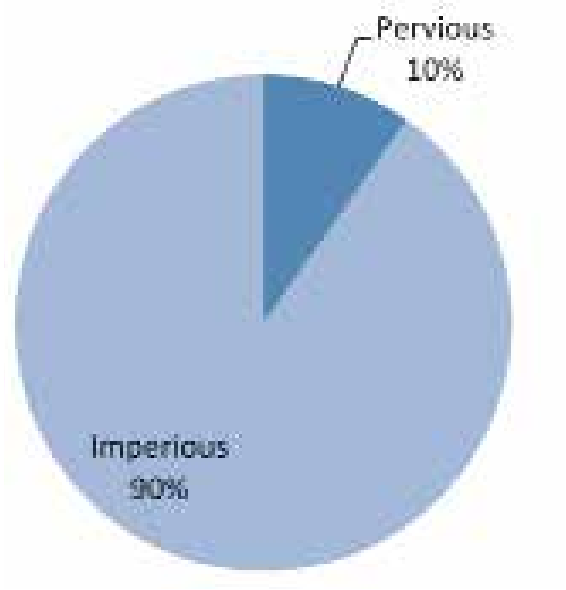
ill. 14 / ASPECTS



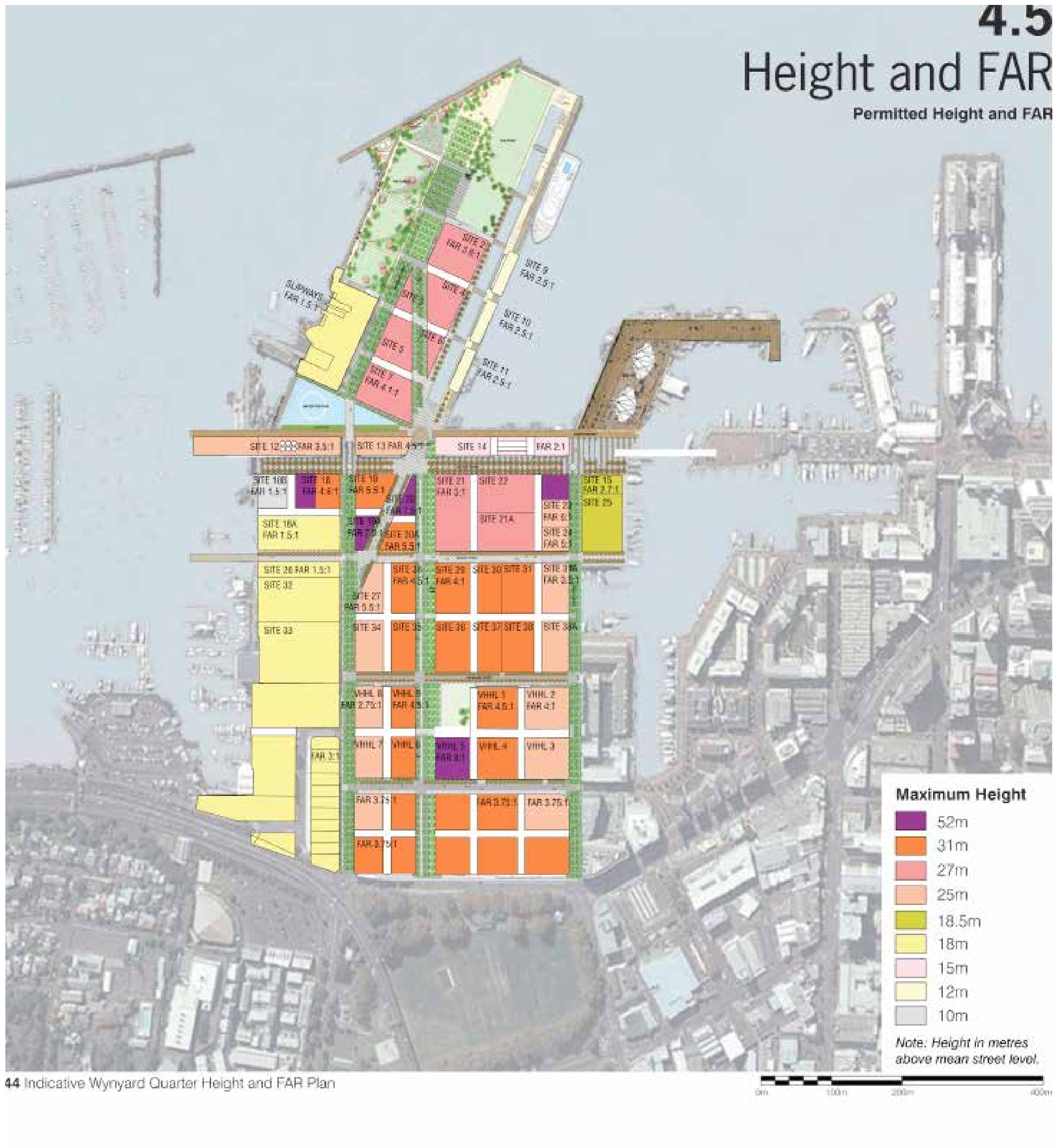
ill. 15 / SLOPE

ill. 17 / PERVIOUS SURFACES





ill. 18 / ORIGINAL SITE



ill. 19 / PROPOSED PLAN - HOW MUCH OF THIS TO SHOW?

THE OFFICIAL PLAN / Like many industrial waterfronts zones around the world the Wynyard Quarter is being transformed into a consumerist wonderland, powered by conventional real estate imperatives.

The masterplan for the new development breaks the site into three zones (ill.19). The first is the Point Precinct, at the northern end of the site. Four large blocks of buildings are proposed to occupy the southeastern part of this site, with three smaller blocks on Wynyard Wharf. The ground floors of these blocks are devoted to entertainment and retail, with commercial use on the first floor. Residential use is proposed for the upper storeys of the larger blocks; commercial use is proposed for the upper storeys of the smaller blocks. The resulting build out is entertainment and retail, 17,010sqm, commercial, 22,230sqm, and residential 186,400sqm.

The middle zone, the Jellicoe Precinct, has a more complex social and building programme, that relates to its role in the masterplan as part of an urban axis linking the Wynyard Quarter to the Auckland's CBD. Jellicoe Street is lined with two rows of buildings; on the north side are repurposed warehouses, and on the southern side of the road, buildings of up to 52m high are proposed. The GFA of this zone is 225,66sqm devoted to entertainment and retail, 49,105sqm for commercial, and 138,386sqm for residential.

The Central Precinct is the largest zone, running from Jellicoe Street to Fanshawe Street; a third of this site is owned by another party, Viaduct Holding Group. This zone is devoted to mostly residential and commercial use, with a small percentage of retail use. The proposed development is 37,125sqm for entertainment and retail, 515,250sqm for commercial and 138,386 for residential.

The total GFA for the Wynyard Quarter is entertainment and retail 76701 sqm, commercial 586,585 sqm, and residential 453,661sqm giving a total build out of 1,115,947sqm.

The two main areas of public space in the waterfront development of the Wynyard Quarter masterplan are North Wharf, located at the end of the west-east axis linking the site to the city, and Point Park, at the northern end of the north-south axis, linking the site to Victoria Park. The North Wharf zone is configured as two east-west thoroughfares; the northern one is a pedestrian promenade running alongside the harbour, and the southern one, Jellicoe Street, sandwiches an active zone of restaurants, bars and public spaces. The other major public space is Point Park. This is a proposed large park located at the tip of the Wynyard Quarter, with work due to start on this project in 2025 when the current storage-tank leases expire. »

THE PROBLEM

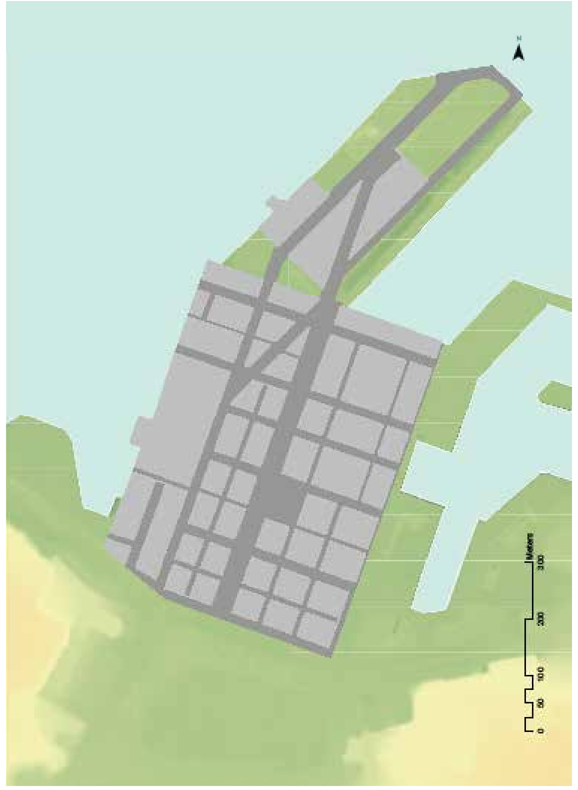
ENVIRONMENTAL PROBLEM / The Wynyard Quarter masterplan proposes the construction of over one million square metres of new building, infrastructure and associated public space.The result will be a densely urbanised zone with a high degree of impervous surface producing a large amount of contaminated run off (ill. 20).

To remediate this effect a structural stormwater treatment strategy has been adopted. Two specific techniques have been introduced to ameliorate the production of contaminated runoff. The first are linear rain gardens running between the street and pedestrian footpath. These vegetated strips have been intensively planted with a selection of coastal native species, from ground covers to shrubs and trees. The road gradient is constructed to channel runoff into the rain gardens, where they pass through a constructed filtration layer before being discharged into a conventional stormwater drainage system. However, the rain garden runoff in Jellicoe Street undergoes a further cleaning through a constructed wetland that is part of the North Wharf public space programme. The treated runoff is then discharged into Westhaven marina

PERVIOUS/IMPERVOUS RATIO / The ratio of surfaces is 69% impervous to 31% pervious (ill.21, 22, 23). The result for the two-year runoff discharge flow rate from the completed Wynyard Quarter development will be .72m/sec; the storage volume needed to treat this is 3903.36 m3. This represents a decrease in runoff compared to the existing site, mainly due to the design of the Point Park, a large area of pervious surface that will help absorb some of the stormwater runoff.

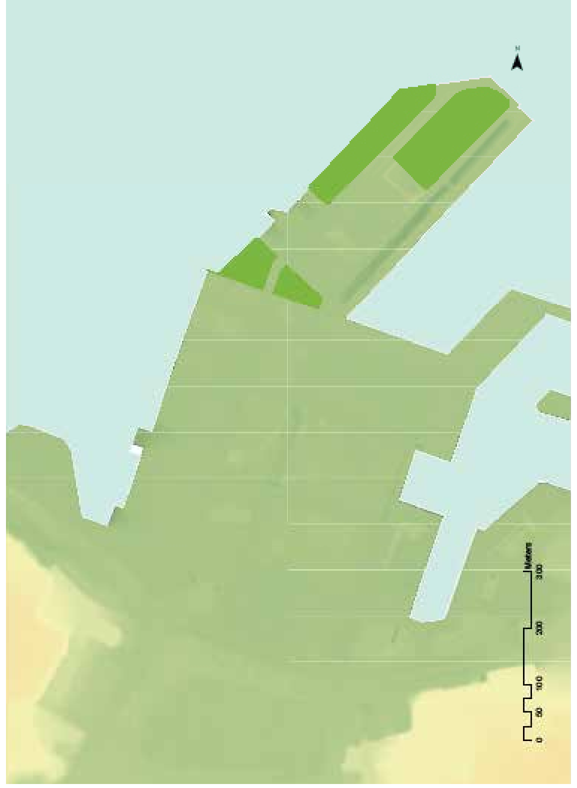
SOCIAL ISSUES / At the time of writing, Auckland is undergoing a housing crisis, or to be more accurate, a housing shortage crisis. Reasons for this crisis are varied and complex, but a combination of speculative pressures from a macroeconomic setting since the Global Financial Crisis that include quantitative easing and very low interest rates have lead to the availability of easy credit. Combined with a sustained growth in immigrantion to New Zealand and especially Auckland, this has led to both a shortage in housing and, perhaps more importantly, a shortage of affordable housing. The Wynyard Quarter development has deliberately included a high proportion of residential space as part of the master planning. However the provision of social housing, or affordable housing, in the residential section has been deliberately elided. The residential component of the housing has been consciously aimed at the top end of the market. »

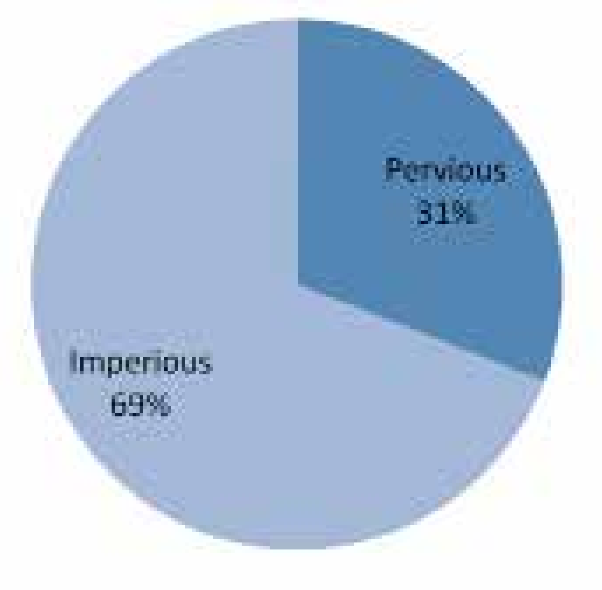
ill. 20 / STORMWATER PHOTO



ill. 21 / PROPOSED PLAN - IMPERVIOUS SURFACES

ill. 22 / PROPOSED PLAN - PERVIOUS SURFACES





ill. 23 / PROPOSED PLAN

THE SOLUTION: NATURE CITY PLAN

DESIGN METHODOLOGY / With the proposed masterplan there has been some diminution of contaminated runoff from the site, however there will still be a .72ml/sec flow into the harbour. How can this amount of contaminated stormwater entering the Waitematā Harbour be restricted while at the same time keeping the expected real estate return of the Wynyard Quarter masterplan? The use of structural stormwater devices such as rain gardens, green roofs, and wetlands can help but is there room for these devices within such a dense and impervous masterplan?

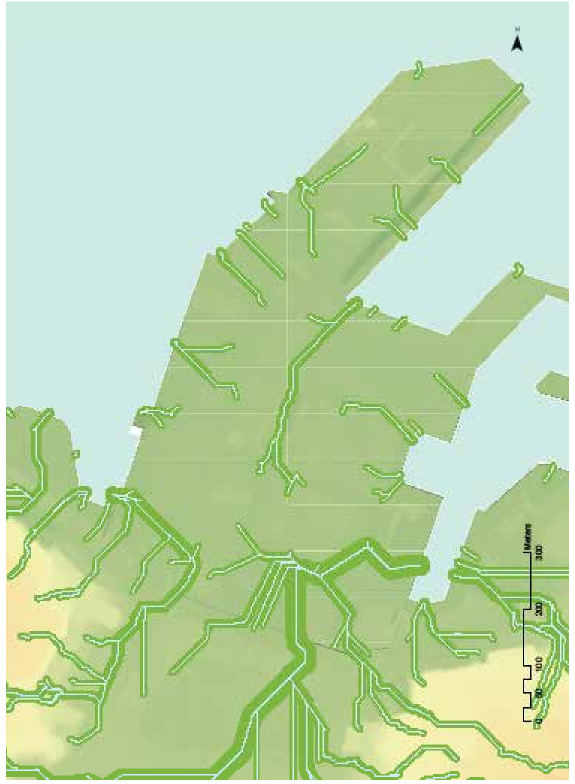
The concept of hydrological neutrality (as detailed in the previous chapter) offers a way of developing an urban masterplan that reduces the amount of stormwater discharge and obviates the necessity for any stormwater treatment devices, by decreasing the amount of impervious surface. To accomplish this goal, only 15% of the catchment can be an effective impermeable surface. That is, only 15% of runoff from impervous surface can discharge directly into a receiving environment rather than being mediated by a treatment device of some kind.

To reach a goal of 85% permeable surface in an urban situation is extremely difficult; the prevailing existing urban layout in most cities, an infrastructure grid with an intensive building programme, usually precludes any radical rethinking of the urban form. And if we look at retrofitting the existing city to achieve this solution we are confronted by a number of substantial obstacles. Established business and real estate interests inevitably preclude any of the necessary radical adjustments.

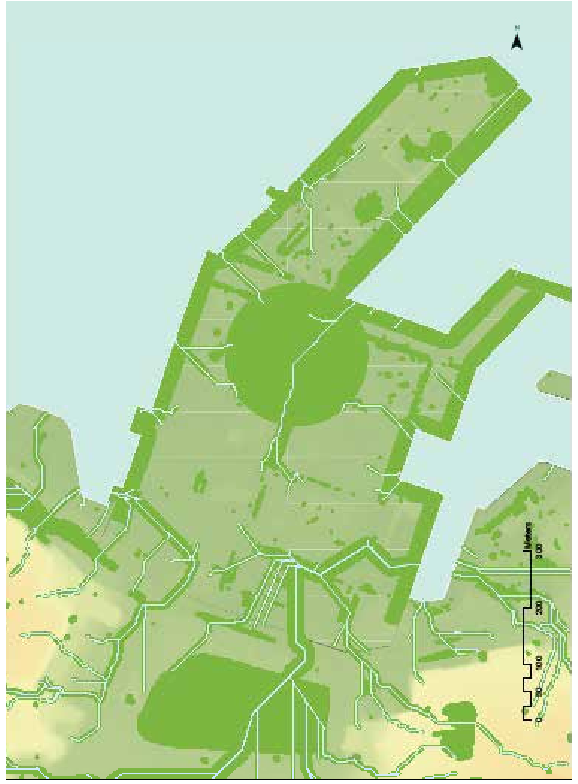
However, the typical waterfront site does give an opportunity to pursue this notion. Many waterfront development sites are abandoned brownfields and often in large area parcels, so a more radical consideration of urban form is possible than under the normal property constraints of contemporary city real estate.

DESIGN WORK / THE WYNYARD QUARTER CATCHMENT

HYDROLOGY / If we wish to decrease the production of urban run off without using structural stormwater remediation techniques then the first move is to increase the amount of land that will absorb rainfall. What criteria will assist the choice and location of this land? Using ARCHydro (the function of this is described in a previous chapter), a hydrological analysis of the Wynyard Quarter sub-catchment system reveals a dense overland flow-path network from the interior of the site to the periphery. The network is made up of 12 sub-catchments, with 10 overland flow paths with two or more streams and 15 overland flow paths with a single stream (ill. 24). Protecting these overland flow paths with a 25m buffer ensures a protected water network and an increase in pervious surface. Protecting the harbour-edge environment is also critical, and establishing a buffer zone of 25m, gives a protected coastal edge zone (Ill 25). This new hydrological network not only increases the pervious surface of the site, it also allows for the planting of native species. These planted buffers can then have a number of functions. Runoff from impervous surfaces can be redirected into this zone, cleansing and retarding contaminated run off. The buffer zones can also act as flood corridors



ill. 24 / STREAM BUFFER



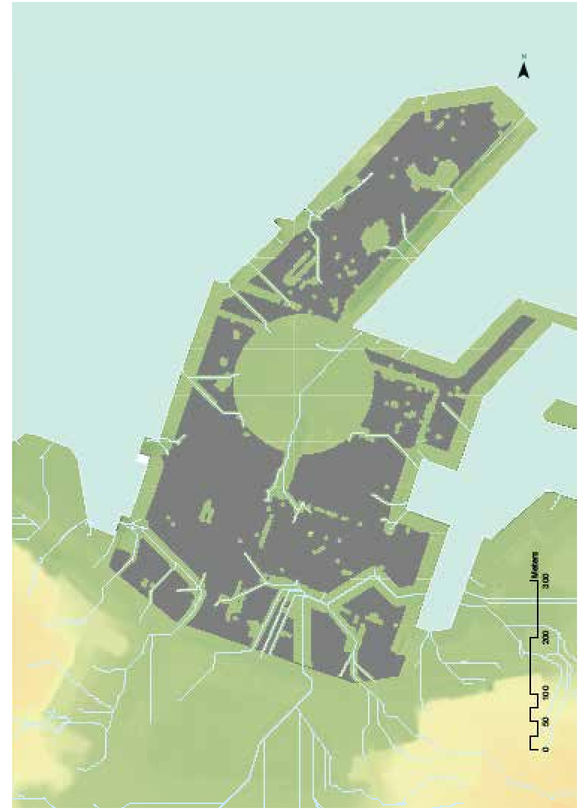
ill. 25 / COASTAL BUFFER

critical, and establishing a buffer zone of 25m, gives a protected coastal edge zone (Ill 25). This new hydrological network not only increases the pervious surface of the site, it also allows for the planting of native species. These planted buffers can then have a number of functions. Runoff from impervious surfaces can be redirected into this zone, cleansing and retarding contaminated run off. The buffer zones can also act as flood corridors for sudden storm events. Increasing the area of native planting can establish an island of indigenous ecology, linking to other islands and thus increasing the biodiversity of the city.

As well as the transformation of the hydrological network of the site, roading and buildings must be reduced to 15% of the 35.5ha site, that is, 5. 325 ha of impervious surface; 85% of the site (20.2ha) must remain permeable.

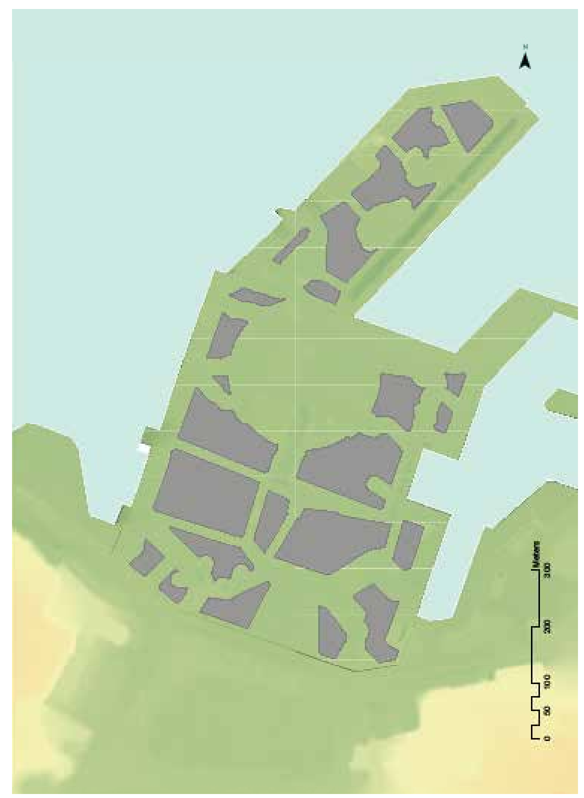
URBAN DESIGN / To accomplish the goal of a hydrologically neutral site, the Wynyard Quarter urban masterplan cannot remain in a gridded block form. However, to keep the same Gross Floor Area (GFA) the building footprint must necessarily shrink while the building form must become denser, i.e. become taller. To accomplish this task the Floor Area Ratio, (FAR) of the overall GFA of the proposed Wynyard Quarter development must be manipulated. If we wish to make a hydrologically neutral development, then the required impervous surface area is 5.3ha. By dividing the total GFA of the planned buildings (1,115,947sqm) by 15% of the site, an average building height of 63 m or 21 storeys (at 3m) is derived.

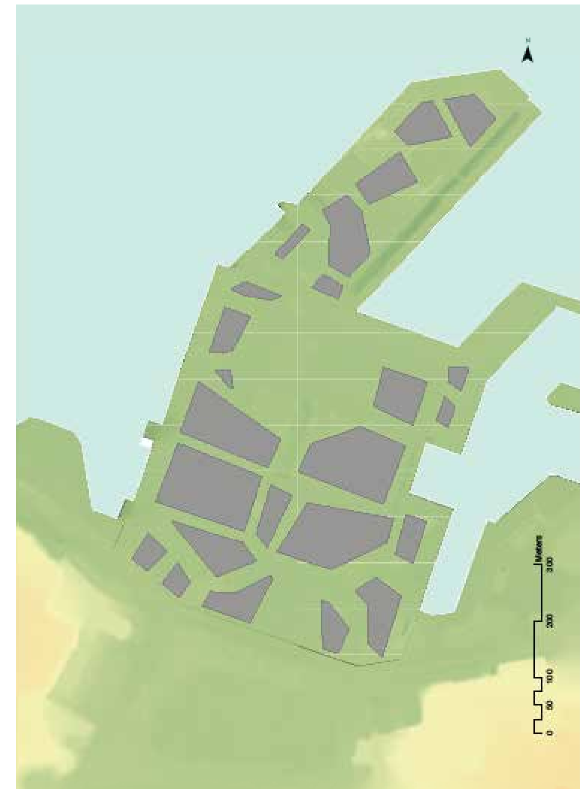
Locating the building footprints can be determined by utilising areas of the site that are not occupied by the buffered hydrological network in the coastal zone and the overland flow path network (Ill. 26, 27). Mapping the zones outside of the hydrological network of 5.3ha initiates an exploration of new building masterplan. (ill.28). By first extruding this simple pattern and undertaking some architectural manipulation of volumes, the building blocks assume the form of a spine of seven mini blocks along the Point Precinct with two mega blocks on the west and east side of the body of the site. The outline of the blocks is smoothed, giving a gross footprint of 4.3 ha or 25 stories (Ill. 31 32). »



ill. 26 / URBAN DESIGN – POTENTIAL BUILDING FOOTPRINT

ill. 27 / URBAN DESIGN – POTENTIAL BUILDING FOOTPRINT

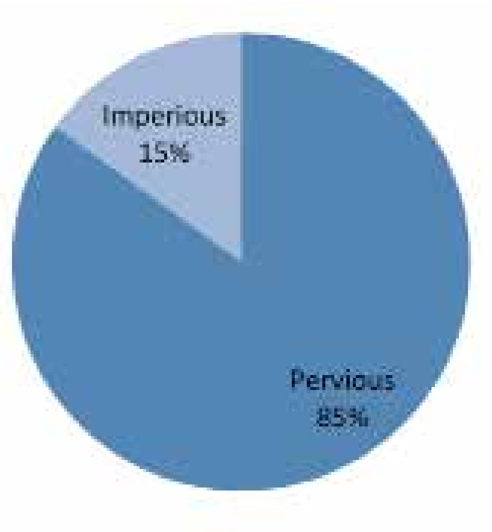




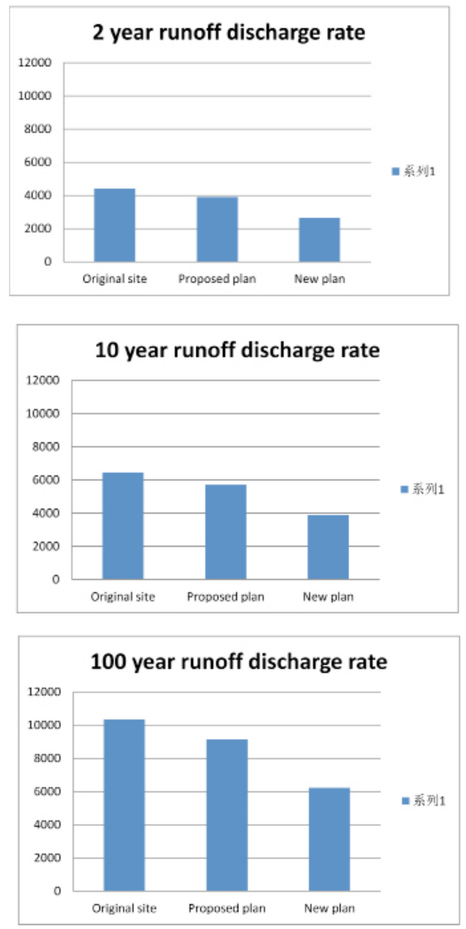
ill. 28 / FINAL BUILDING FOOTPRINT

31 / PERSPECTIVE 1

32 / PERSPECTIVE 2



ill. 29 / NEW PLAN



ill. 30 / STORMWATER DISCHARGE CHART

PERVIOUS/IMPERVOUS RATIO / The site is now highly pervious with the ratio of impervous to pervious surface almost reversed from the existing site. All the roads and buildings now occupy 5.82ha, leaving 32.98ha of the site as pervious surface, a ratio of impervous to pervious of XXX (ill 29). The hydrological result of this design work is that the two-year runoff discharge flow rate from the hydrologically neutral Wynyard Quarter development plan will be .49m3/sec. The chart (ill. 30) shows the 2, 10 and 100 year discharge flow rates and the treatment volume size.

ENVIRONMENTAL AND SOCIAL IMPLICATION OF THE NATURE CITY PLAN

The challenge of a brownfield inner city waterfront development is ensuring no contaminated runoff is produced. This study suggests that by protecting the underlying hydrological network and the coastal environment through manipulation of the required FAR, a new hydrologically neutral masterplan can be developed. The results of the design work show that when the building footprint of a waterfront development shrinks drastically, the area of pervious surface increases. Manipulating the required FAR results in the shape of the urban development being manipulated to form taller buildings. The resulting area of pervious land can then be used for a number of functions. Goals for urban sustainability through the development of specific urban ecosystems can be developed, with the restoration of native habitats, both terrestrial and aquatic, and the positioning of urban habitat patches (ill 33).

SUMMARY

The increase of open space and denser housing will lead to more public space. This is a different kind of space from a conventional urban public space defined by building within a traditional city plan. Rather this space is free, unbounded, connected to natural systems and the rhythms of hydrological events on the littoral of land and sea. ■

ill. 33 / PERSPECTIVE 3

STUDY FOUR. BROWNFIELD / PEOPLE'S REPUBLIC OF CHINA

JINAN

BACKGROUND TO THE STUDY SITE

Jinan, a sub-provincial city, is the capital of Shandong Province in the People's Republic of China (ill 1,). It is located in Northern Shandong Province (ill. 2), in a transition zone between the Mount Taishan foothills and the Huang He River plain (ill. 3). The terrain of the city can be divided into three zones: an alluvial plain zone to the north (ill 4) ; a piedmont zone in the middle; and mountain range zone to the south. The total area of Jinan City is 8177.21km^2, about 40% of the city is located on the alluvial plain while the rest is in the foothills of the Taishan range.

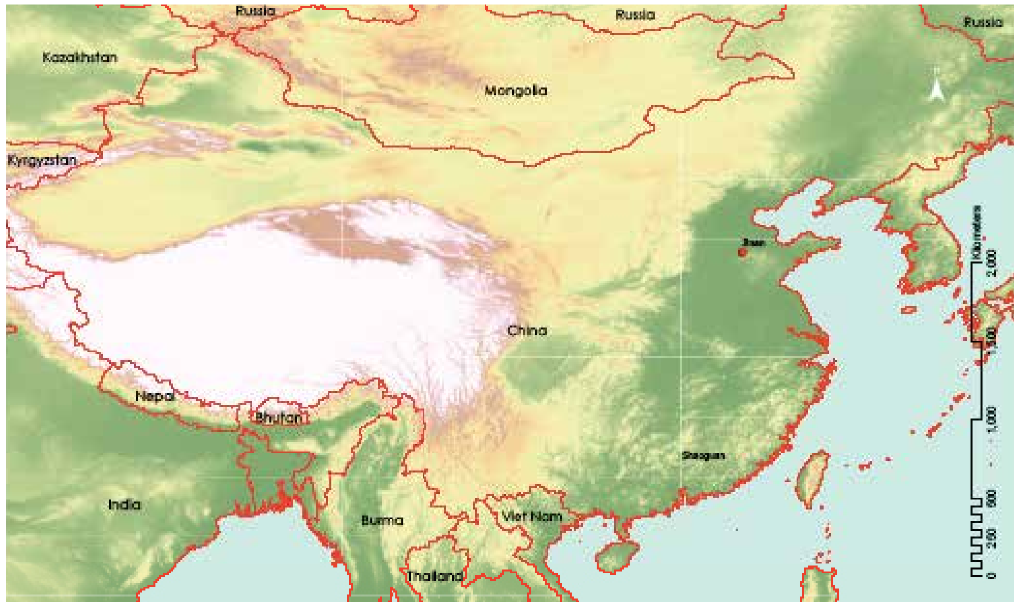
Jinan has a semi-humid continental climate with four well-defined seasons. The rainy season is in summer; rainfall in Jinan is higher than in other cities in northern China. Due to the particular topography (Jinan is surrounded by hills in three directions) hot air-flows accumulate within the city. This causes high temperatures and humidity in summer. The major permanent rivers in Jinan are the Huang He, the Xiaoqing and the Tuhai (ill.5). Major seasonal rivers include the Jinyangchuan and the Jinxiuchuan Rivers in the mountains. There are four major catchments (ill 6). Jinan lies on a Karst aquifer. Water flows from the southern mountains into an underground system. When blocked by an impervious diorite layer, the underground water comes to the surface as springs in the city and surrounding regions. This phenomenon has given rise to the city's sobriquet, the Spring City. The four main groups of springs are the Baotu, Heihu, Wulong and Zhenzhu. To ensure a constant urban water supply and maintain the flow of the springs, Jinan has closed many of the groundwater wells and uses surface water as a resource. Large reservoirs have been built to the south, west and north of the city to ensure fresh water supply all year round.

According to the climatic data from 1951 to 2015, the average annual rainfall in Jinan is 72.8 days, and 672.7mm. The average rainfall over 50 mm is in the months from June to September: the month with maximum rainfall is July (201.3mm); the second heaviest rainfall is in August (170.3mm).

The terrain of Jinan in the south is higher than in the north, with an elevation variation of 260m. The aspect of the site is mostly northerly with a marked east-west orientation of the surrounding foothills (ill 7). The slope of the site is mostly from 0-5 degrees except in the foothills (ill.8).

The native vegetation in the mountainous areas of the province is very sparse due to many centuries of deforestation. The main species in the lower slopes of the mountains are a typical mixture of deciduous and evergreen trees such as oak, maple, ash, chestnut, and elm, with thuja, platycladus and cotinus spp.

Early settlement in Jinan can be dated back 4000 years. Jinan became the capital of the region in the Han Dynasty (206 BCE-220 CE), and grew to become an important cultural and economic centre in Northern China. In 1994, Jinan was upgraded to a sub-provincial city, and contains 10 county-level divisions and 146 township divisions. The urban pattern of Jinan City follows the urban typology of many cities in the Huang He Delta. The old city was surrounded by an artificial moat on three sides with the Daming, a large lake, located at the northern side of the city. This water boundary acted as a mechanism to control flooding from both Huang He and the Taishan mountains. »



ill. 1 / LOCATION IN CHINA

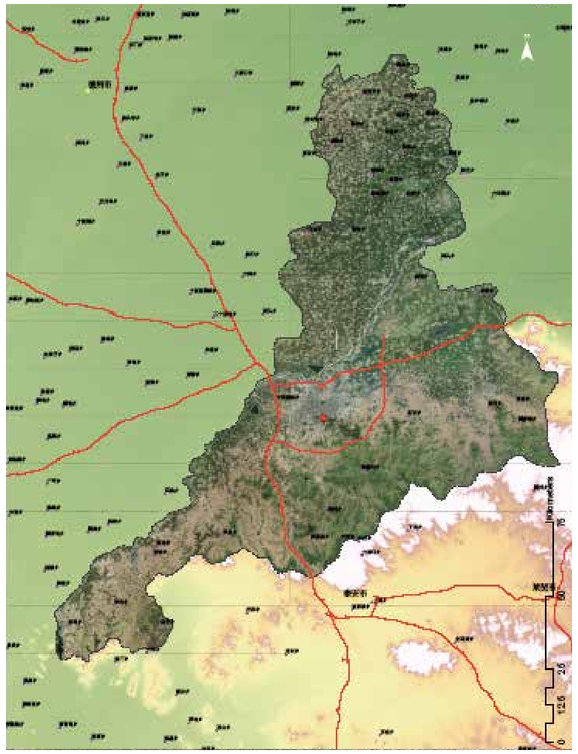
ill. 2 / LOCATION IN SHANDONG PROVINCE

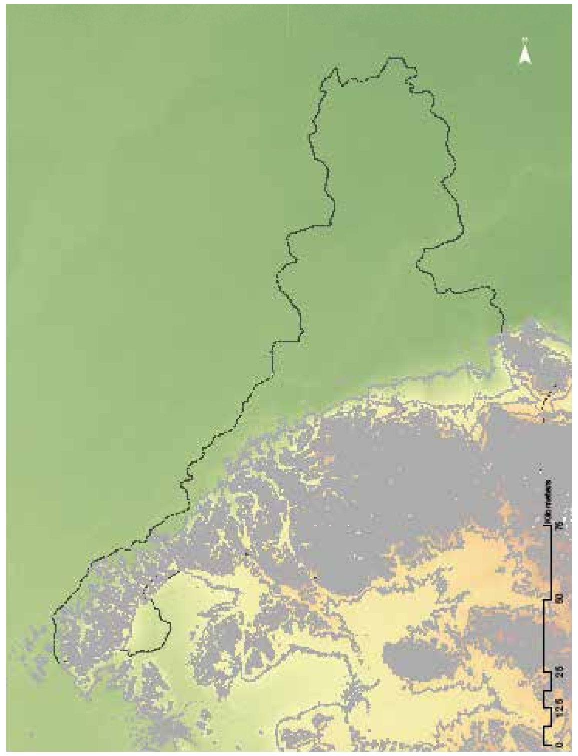
In the 19th century, a railway was built, connecting Qingdao with Jinan. In 1904, Jinan was opened to foreign trade through the building of the Jiaoji (Jinan to Qingdao) and Jinpu (Tianjin to Pukou) railways. A commercial zone was constructed to the west of the existing city around the new railway station. A model city was formed with a post office, town hall and churches. The new city colony was laid out in a grid pattern with a small central park; most of the buildings were warehouses for goods from the surrounding countryside or manufacturing workshops. Goods, both raw and processed, were quickly and efficiently exported to the rest of the world through Qingdao. In the late 20th century, Jinan saw a massive urban expansion with the construction of a new administrative and business city to the east. Expansion of the city also took place in the west and south. Unfortunately the southern expansion into the foothills of the Taishan ranges has lead to both an obvious environmental degradation of the original limestone foothills and the compromising of the indigenous drainage networks.

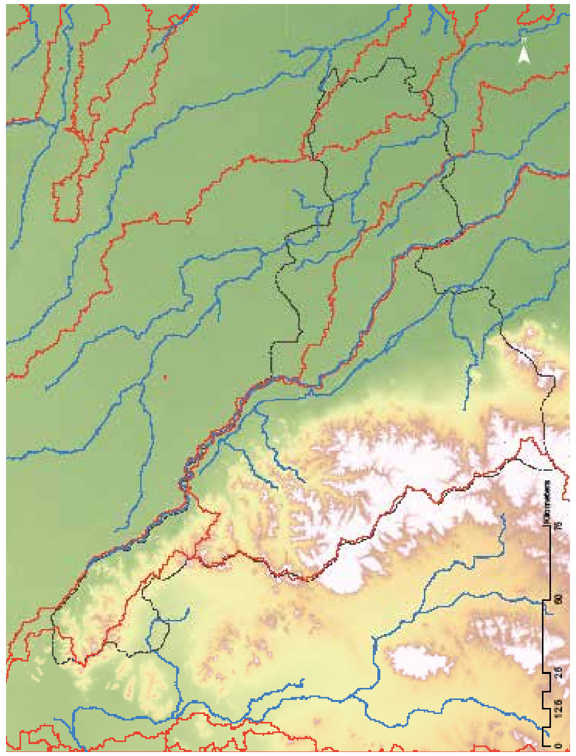
With the rapid urbanisation of Jinan City, the underlying hydrological pattern of the city's drainage system has been forgotten. The rapid building programme has both covered pervious surfaces and piped and channelled existing stream networks. These measures have often been undertaken in a contingent and piecemeal fashion without understanding the consequences for the city. The significance of this work has had tragic consequences for the city, with a number of serious floods

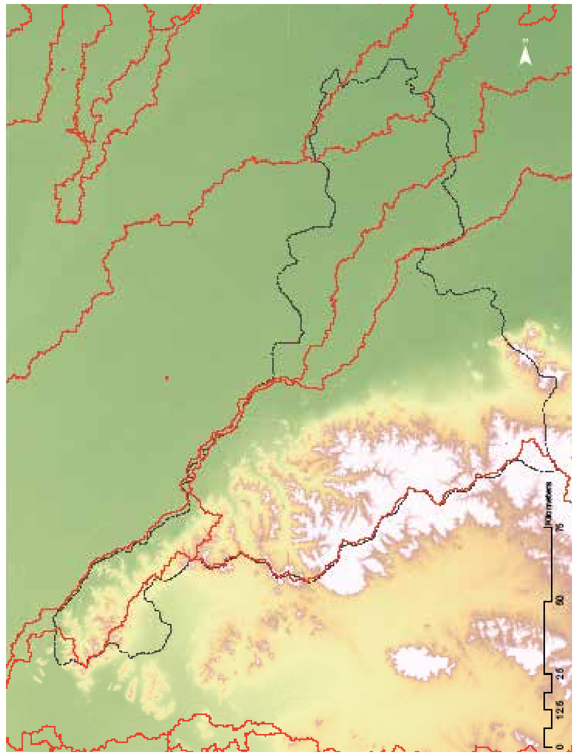
Urban flooding is not an isolated event but has become a growing phenomenon in many Chinese cities. With the construction of new cites, existing hydrological systems have been forgotten, existing hydrological control system like lakes and moats have been neglected.

This has lead to the Sponge City initiative, promoted by the Chinese government to improve water absorbency and to avoid flooding in urban areas. In 2015, guidelines for the building of Sponge Cities were issued by the State Council. The goal is to construct the city in a way that allows rainwater to be naturally stored, purified and absorbed (The State Council of the People's Republic of China, Oct 16, 2015). The target is to collect and use 70% of runoff, with the aim that 20% of urban areas in China achieve the goal in 2020 and 80% in 2030. Jinan was one of the sixteen pilot cities chosen in 2015 to explore and demonstrate this new model of urban flood control. » **

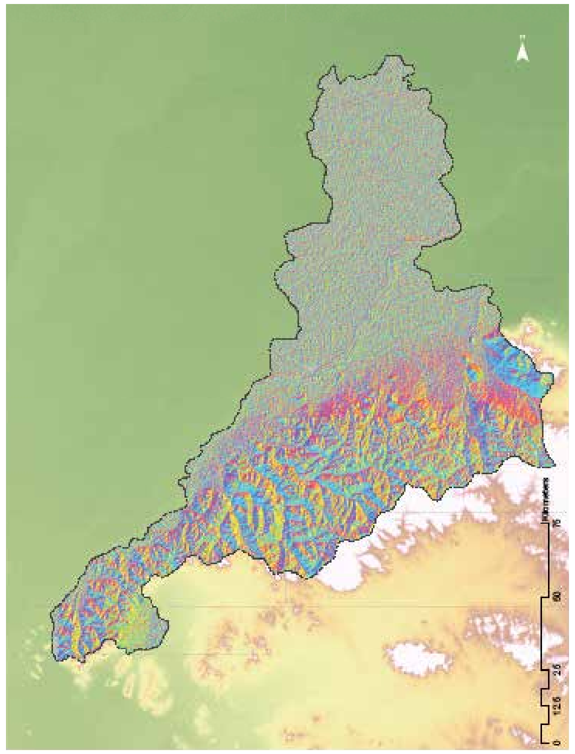

ill. 3 / LOCATION IN JINAN


ill. 4 / CONTOURS

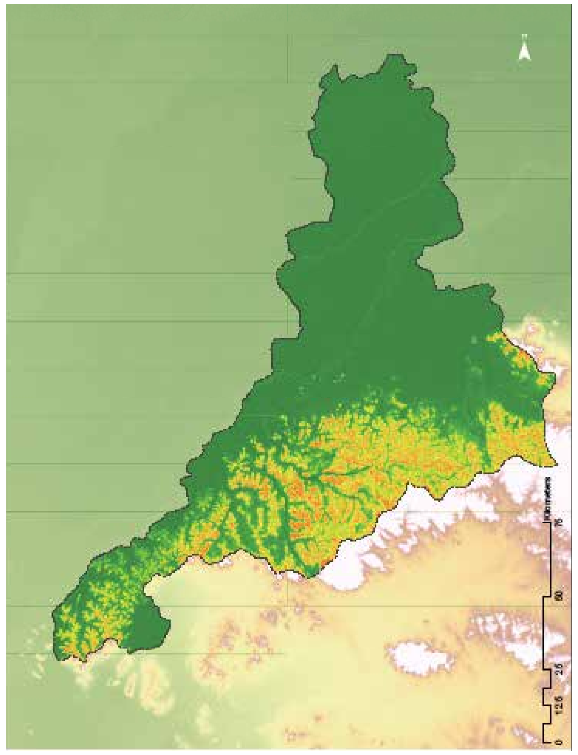

ill. 5 / OVERLAND FLOW PATHS


ill. 6 / CATCHMENT

ILL. 7 / ASPECTS



ill. 8 / SLOPE



CASE STUDY
THE XINGLONG CATCHMENT

Location Jinan, Shandong Province, People's Republic of China.
Size of catchment (s) 3663ha.

TOPOGRAPHY / The Xinglong Catchment is located to the south of the old city of Jinan (ill. 9). The site is in the foothills of Mount Taishan and discharges into the Xiaoqing and the Huang He Rivers. The catchment is dominated by one large valley that runs in a north-south direction between the western edge of the foothills, the Qianfoshancun and an isolated foothill, Yingxiongshan (ill.10). These are classified as scenic areas and nature reserves.

VEGETATION / The dominant flora is remnant native vegetation, a result of heavy deforestation. In contrast, the flat valley floor is heavily urbanised from recent development (ill.11). Two large green zones can be also found in the valley, Quancheng Park and Hanjiao Hotel and garden complex; both are located between the two foothills.

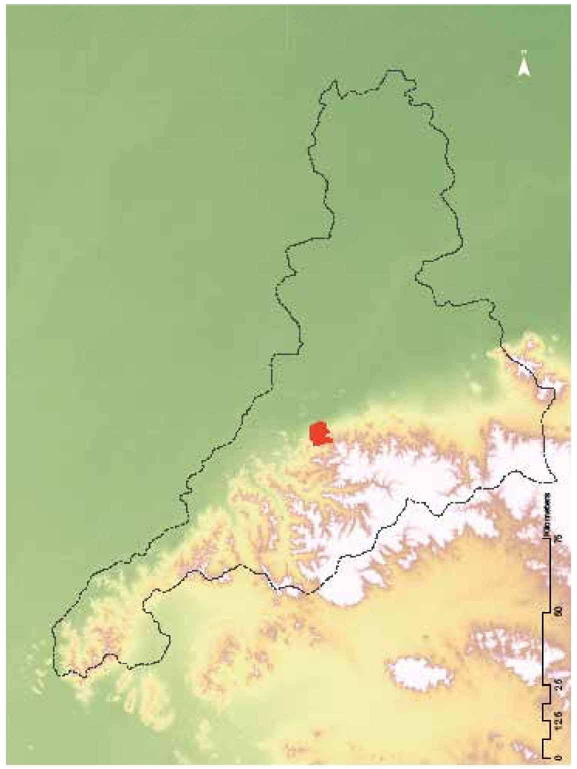
HYDROLOGY / The main overland flow-path for the catchment is located in the centre of the valley (ill.12). Two subsidiary flow-paths are located on the west side of the Yingxiongshan, the other on the eastern side of the Qianfoshancun. The three flow-paths meet on the southern side of the old city in Quancheng Square (ill.12). There are two major sub-catchments (ill.13). The hills within the catchment retain their natural hydrological pattern, however the original river and streams of the valley catchment have been heavily modified by the construction of an urban stormwater infrastructure, a combination of piped infrastructure and channelling. The two streams in the central part of the catchment have been canalised and flow adjacent to Yuhan Road and Shungeng Road before disappearing into the underground piped system of Wenhua West Road.

LAND USE / The total land area of the catchment is 3663ha. The dominant land use is residential apartments. Business and commercial buildings are mainly located along Jingshi and Yuhan Roads, two arterial thoroughfares across the catchment. Due to its mountainous character, the Xinglong Catchment contains more green spaces than other parts of urban Jinan.

ASPECT AND SLOPE / The aspect and slope of can is shown in ill. 14 and ill. 15.

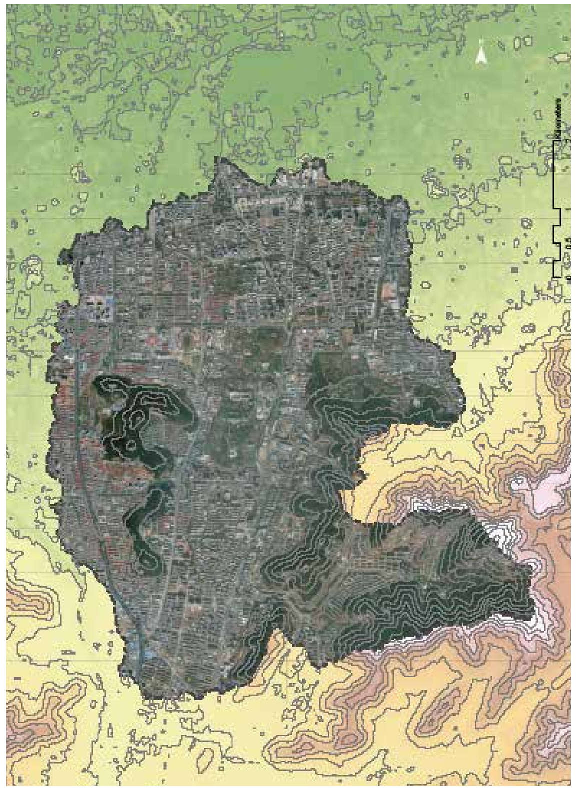
PERVIOUS/IMPERVIOUS RATIO / The Jinan Catchment covers an area of 3663ha. The existing city catchment has 69% impervious surfaces (2517.80ha) (ill.16) and 31% pervious surfaces (1145.07ha) (ill.17). The higher-than-normal amount of pervious surface is a result of the surrounding hills being included in the catchment.

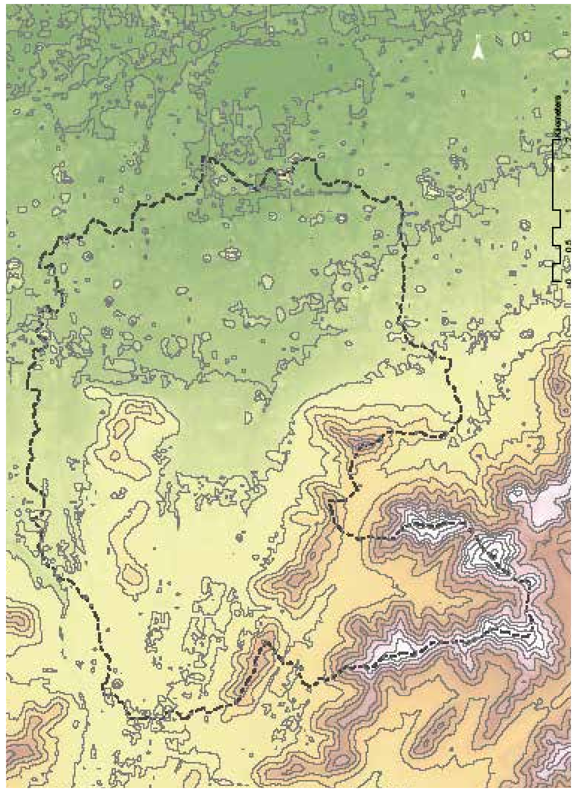
Using the Rational Method the two-year runoff discharge flow rate (m3/s) will be 974427.1951m3/hr (ill.18). »



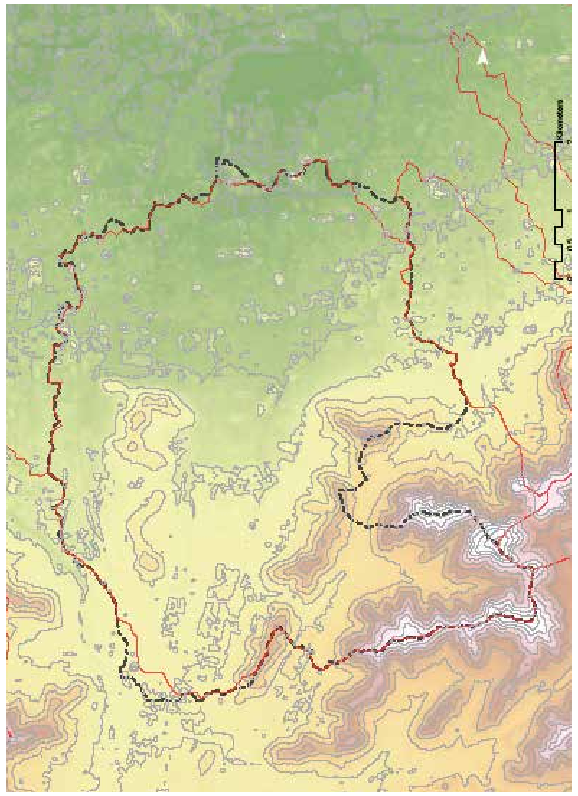
ill. 9 / LOCATION AND BOUNDARY OF SITE

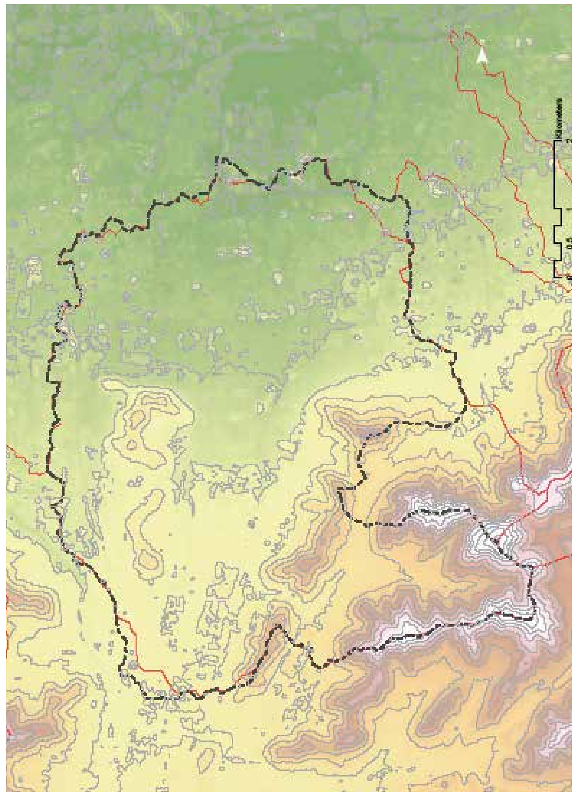
ill. 10 / AERIAL PHOTO

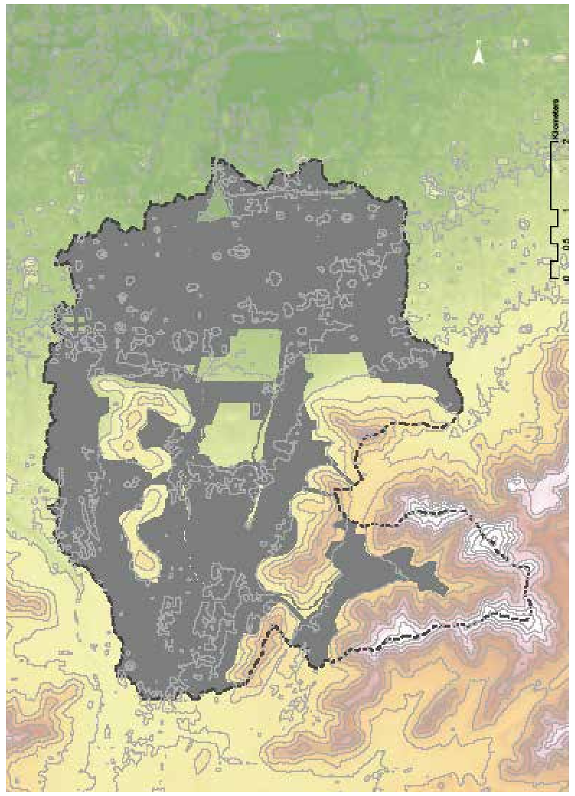


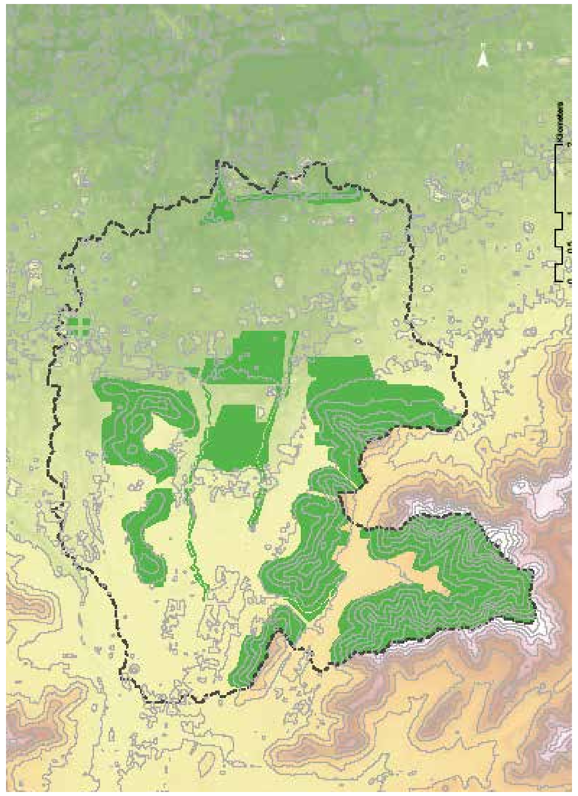


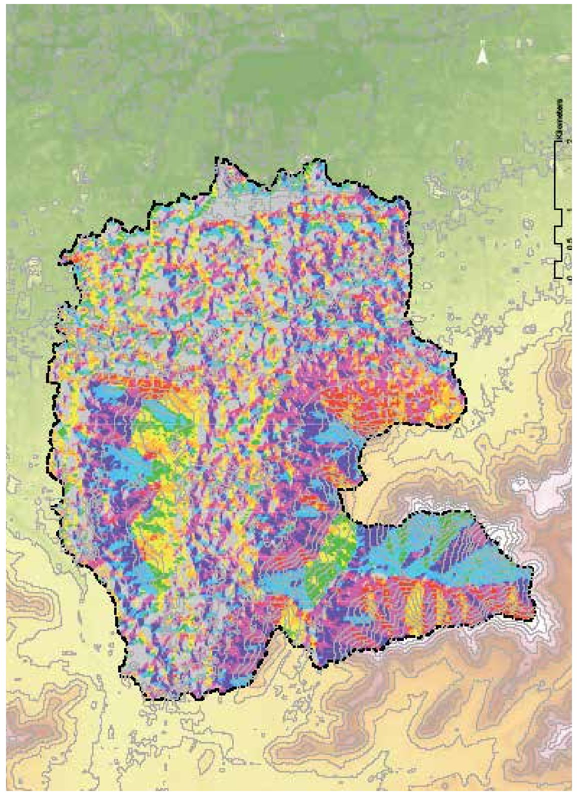
ill. 11 / CONTOURS

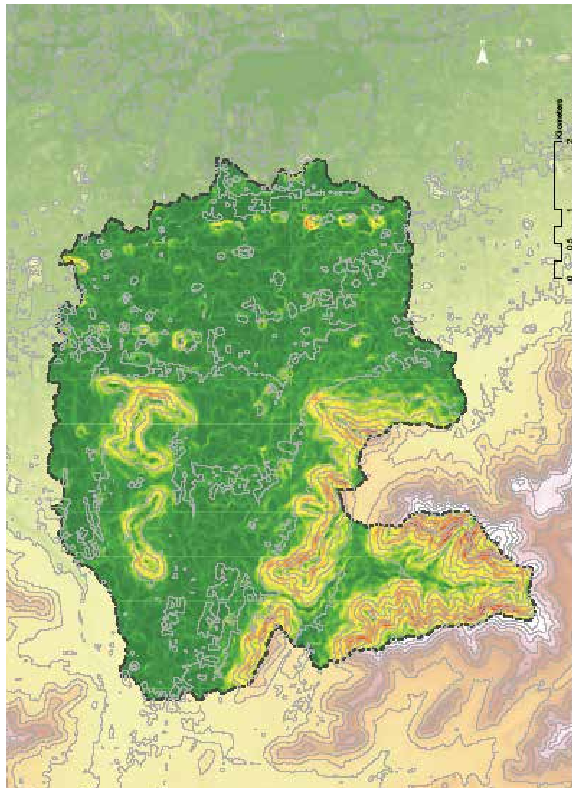

ill. 12 / OVERLAND FLOW PATHS

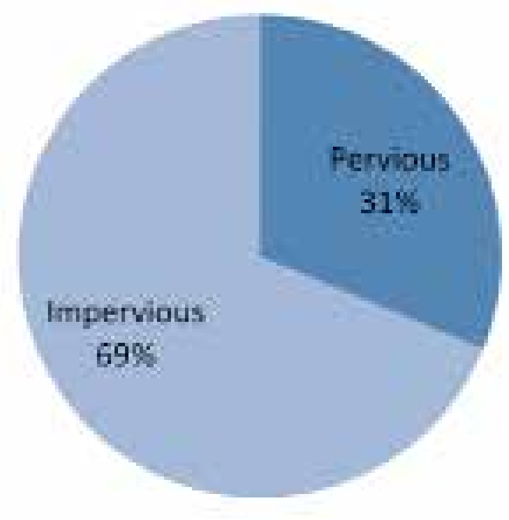

ill. 13 / CATCHMENT


ill. 16 / IMPERVIOUS SURFACES

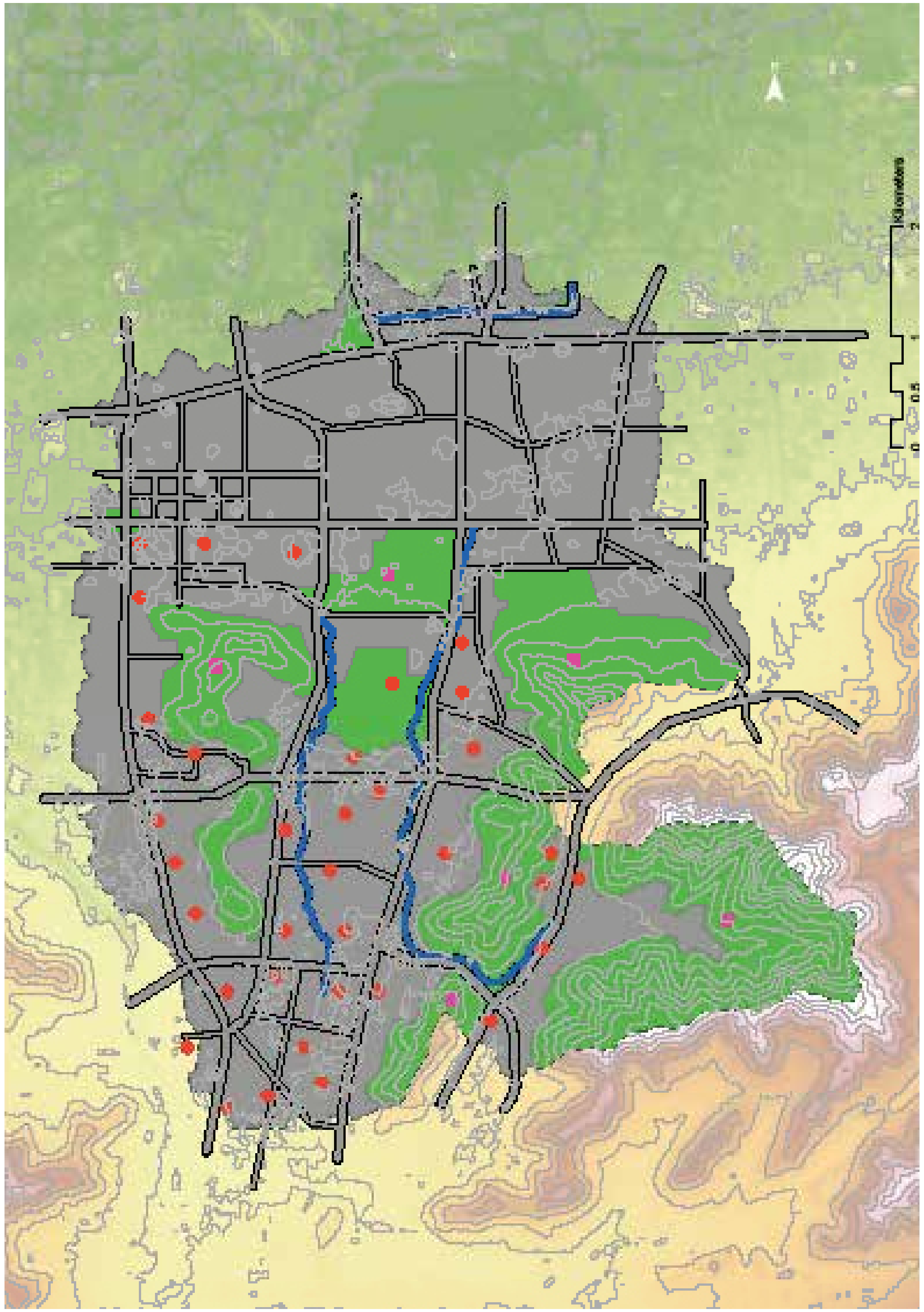

ill. 17 / PERVIOUS SURFACES

ill. 14 / ASPECTS


ill. 15 / SLOPE




ill. 18 / PROPOSED PLAN



ill. 19 / PROPOSED PLAN

THE OFFICIAL PLAN / The official plan was developed in response to a catastrophic event on July 18th 2007, when 180mm rain fell within three hours, causing a flash flood. The main economic damage was the flooding of Quancheng Square and the underground Yinzua Shopping Centre.
The reason for this damage was the location of Quancheng Square at the end of the Xinglong Catchment. Due to the large amount of impervious surface, buildings and roads, runoff within the 36km2 catchment accumulated in a very short time, causing a flood at the discharge point of the catchment.

The area south of Quancheng Square was chosen as one of the first pilot projects for the Sponge City initiative. The project plan divided the area into six sub-areas, and proposed a number of stormwater control goals and criteria. The storm water control methods include; the construction of water tanks to detain stormwater, permeable paving to absorb stormwater, rain gardens and water ponds to both detain and clean stormwater (ill.19).

ENVIRONMENTAL PROBLEM

The proposed study area of the Jinan South Sponge City pilot project is based on administrative boundaries of the urban site. This has lead to an engineering-driven solution that addresses the city hydrological condition defined by a collection of discrete urban blocks. An urban catchment analysis reveals that the chosen study area is actually split between two catchments, thus runoff will spread beyond the study area's boundary. This leads to a difficulty in assessing and managing the movement and accumulation of stormwater runoff within the study area.

Our research suggests that any study area for flooding remediation should be based on a catchment analysis. Through GIS analysis, the catchment boundaries and the hydrological pattern, including overland flow paths, water flow and intensity, can all be modelled. This data can contribute solutions to the critical problem of flooding in Jinan. »

THE SOLUTION: NATURE CITY PLAN

DESIGN WORK / THE XINGLONG CATCHMENT

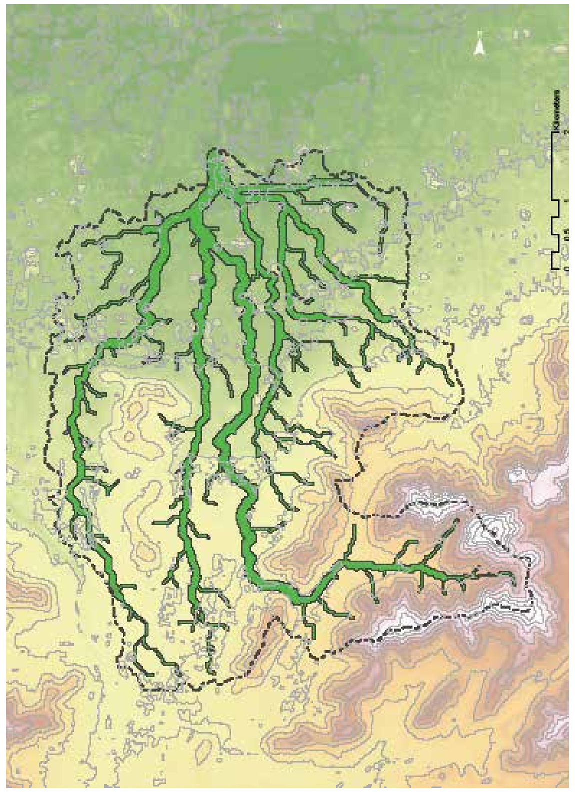
HYDROLOGY / Increasing the amount of permeable surface within the existing urban catchment is an important way of reducing the buildup of urban runoff. Reducing the runoff at the head of the catchment is a good start in avoiding a repetition of the devastating flood of 2007. However, increasing permeable surfaces within an existing city, with complex infrastructure systems and multiple owners, is fraught with difficulties. By mapping the existing flow paths over the existing plan, city authorities and interested stakeholders can use this mapping to guide urban development in the future. For example, this data could inform the location for any new development, which could be guided away from the location of an overland flow path.

Using GIS analysis, the contours, slope, aspect and underlying hydrological pattern of the two catchments can be modelled. The overland flow-paths within the catchment can be mapped and classified to identify the main streams within the site. A 30-100m buffer zone along the stream edges should be protected as green space (Ill. 20). To store stormwater, two large-scale retention ponds would be built along the stream route

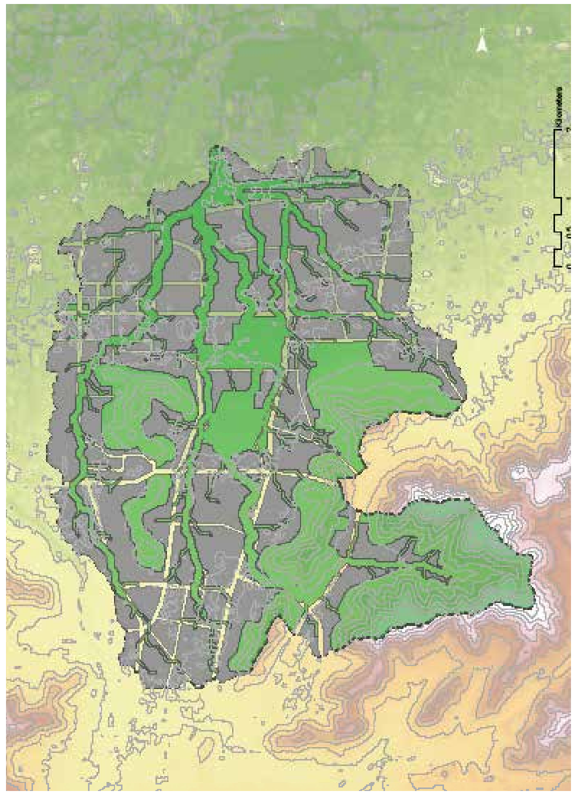
URBAN DESIGN / This stream network could be used as a park system and be revegetated with native plants (ill 21). This park network will make a deep connection between the surrounding hills and the city centre. The new park system will be regenerated over the next 50 years, accompanied by urban renewal. The park system also provides space for natural stormwater treatment devices, such as wetlands, rain gardens and swales.

PERVIOUS/IMPERVIOUS RATIO / The Xinglong Catchment covers an area of 3663ha. The proposed city plan results in a decrease of impervious surface to 59% (2167.68ha) (ill.22), increasing the permeable surfaces to 41% of the existing plan (1495.19ha) (ill.23).

Using the Rational Method, the two-year runoff discharge flow rate (m3/s) will be reduced to 911611.1m3/hr (ill. 24, 25). »

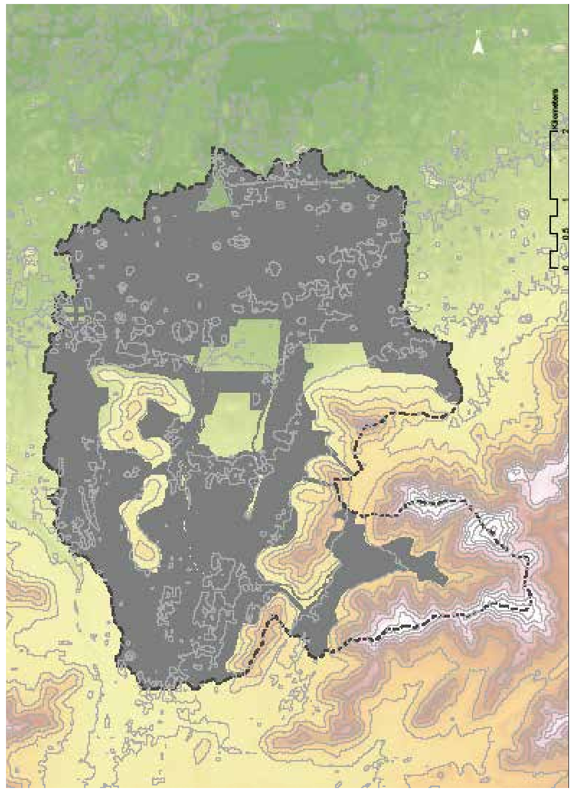


ill. 20 / STREAM BUFFER

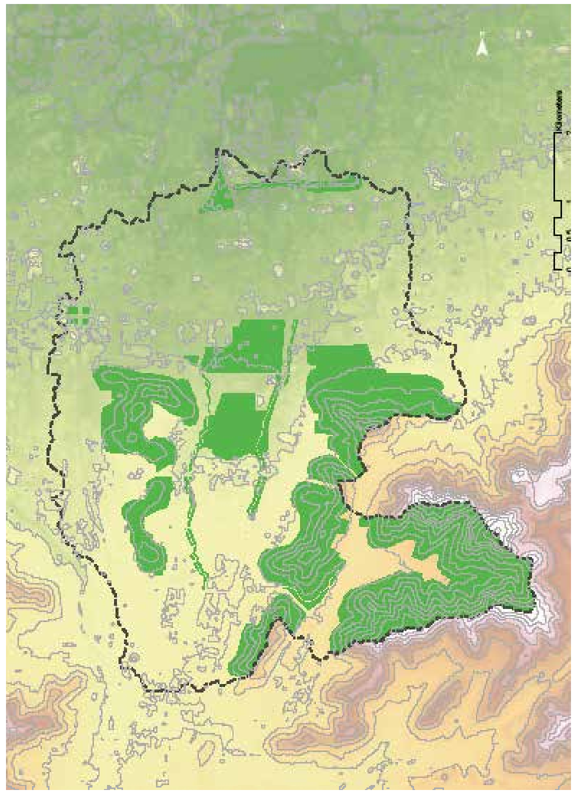


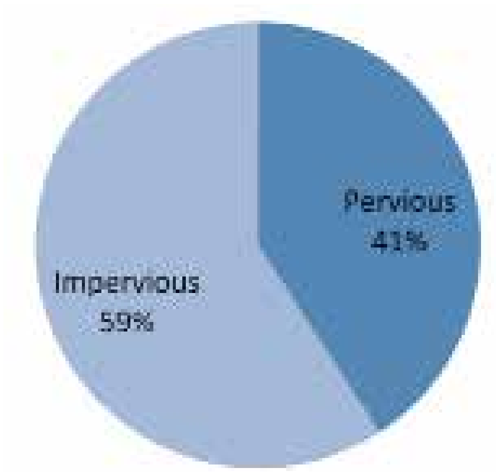
ill. 21 / STREAM BUFFER OVERLAP LAND USE

ill. 22 / NEW PLAN - IMPERVIOUS SURFACES

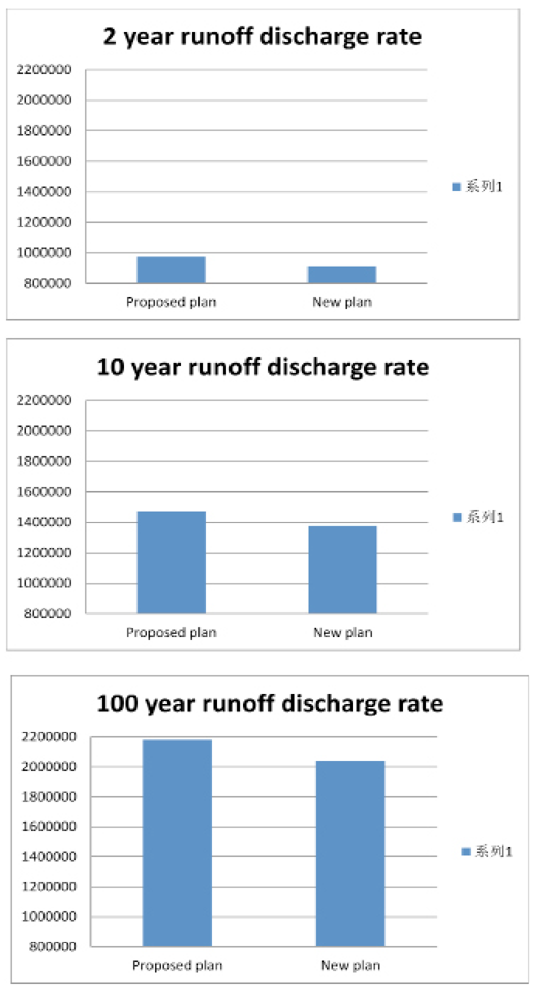


ill. 23 / NEW PLAN - PERVIOUS SURFACES

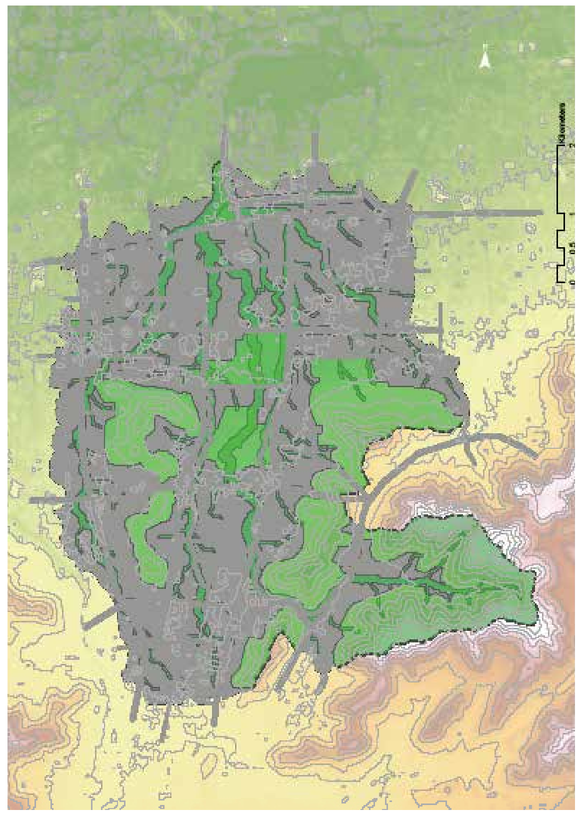




ill. 24 / NEW PLAN



ill. 25 / STORMWATER DISCHARGE CHART



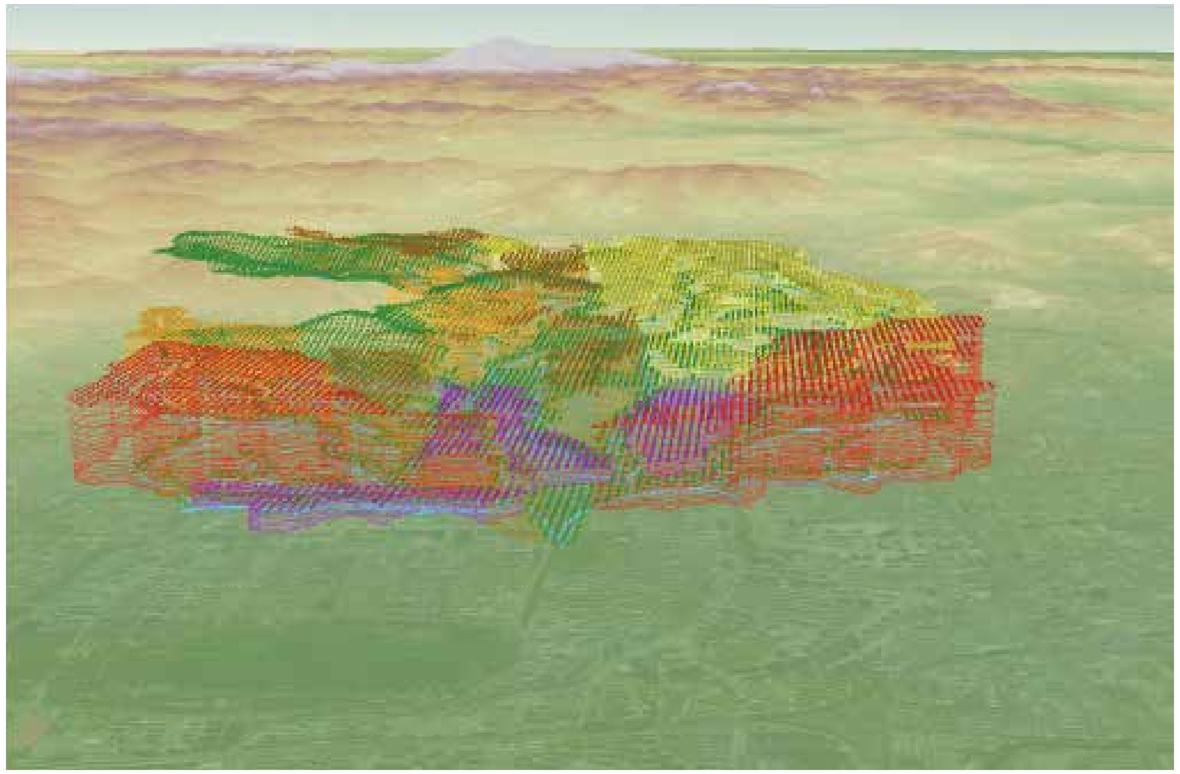
ill. 26 / NEW PLAN

ENVIRONMENTAL AND SOCIAL IMPLICATION OF THE NATURE CITY PLAN

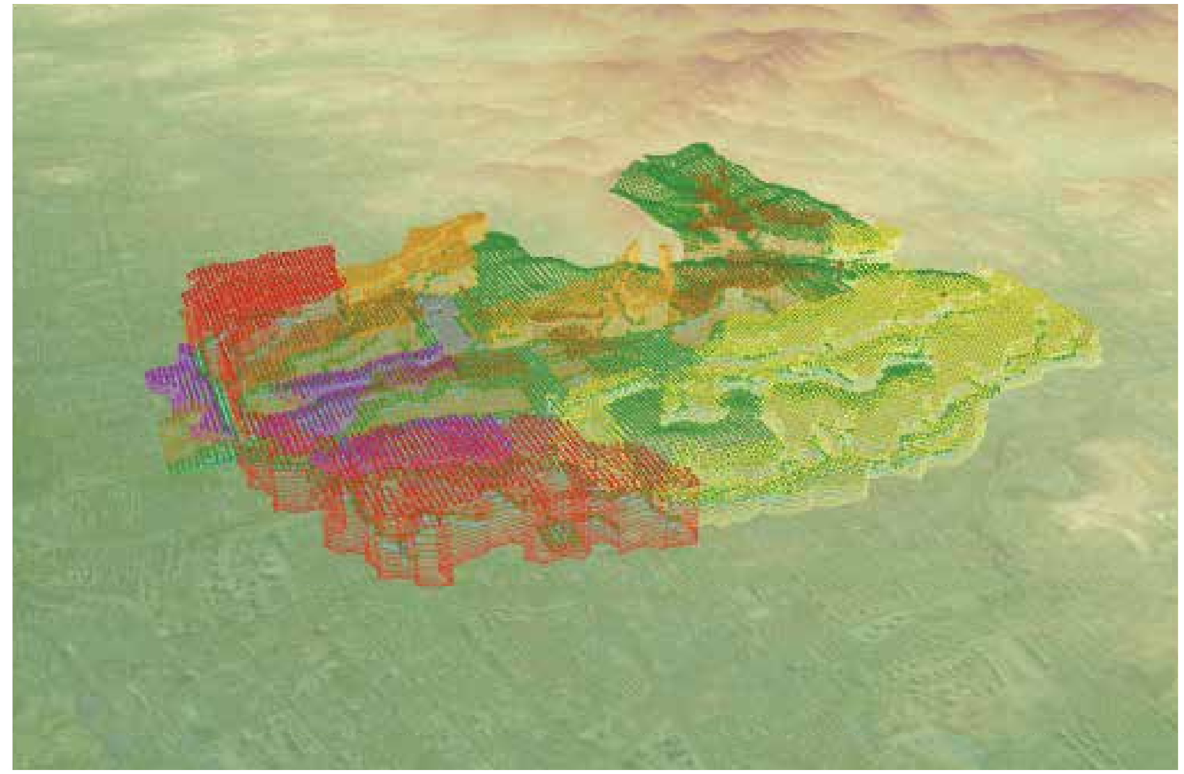
By retrofitting the existing urban catchment, a new park network could absorb rainwater and reduce flood risk. Through revegetation of streams and construction of retention ponds, stormwater can be treated, stored and reused as a water resource. The increased land value around the new park system will make up for the lost building area, and create new investment opportunities to help construction of the park system (ill. 26, 27, 28, 29).

SUMMARY

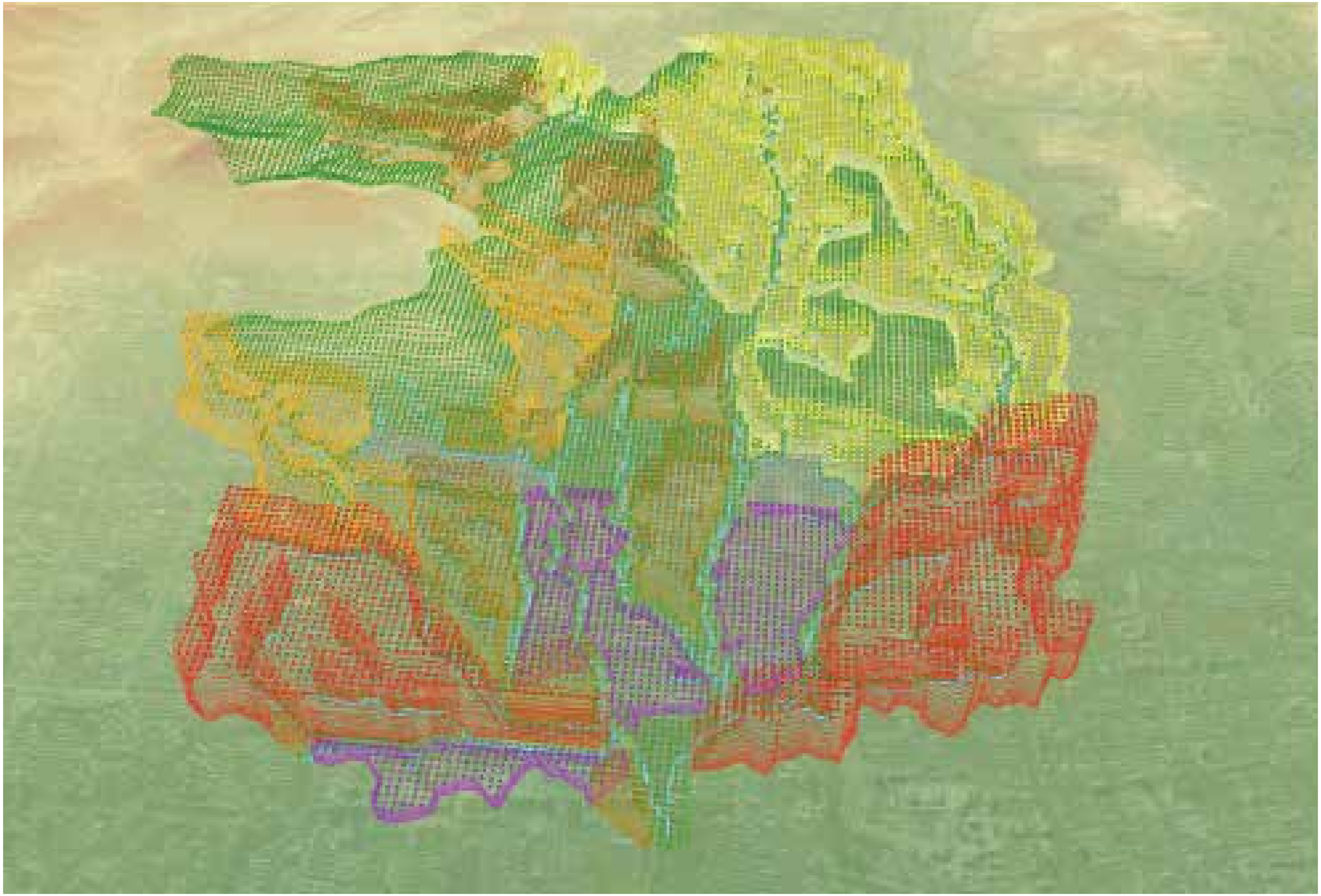
While the Jinan site is highly complex with many competing stakeholder interests, the hydrological mapping demonstates in a clear graphic manner the way in which flooding within the catchment is generated. Any future urban development decisions within the catchment can be measured for the impact on the potential for future flooding. ■



ill. 27 / PERSPECTIVE 1



ill. 28 / PERSPECTIVE 2


ill. 29 / PERSPECTIVE 3

CASE STUDY SUMMARY

The first three case studies, Whenuapai, Furong New Town and the Wynyard Quarter, demonstrate that conventional urban planning – the grid-and-block master plan – while providing a knowable urban solution in terms of social amenity and real estate return, is responsible for serious environmental problems. These problems are a loss of ecological biodiversity and an increase in both the production of stormwater and the pollution of waterways.

However by understanding the ecological dynamics of the catchment, a new kind of urban plan can be developed. The Whenuapai case study demonstrates that through a negotiated and informed trade-off between increasing building density and increasing pervious surfaces, a lessening in the pollution of the upper Waitamatā Harbour could occur. The second greenfield case study in Furong New Town, Shaoguan, showed how the conventional masterplan could be retained but modified by the inclusion of the underlying hydrological network. This leads to a hybrid masterplan, one that accommodates both the metrics of typical Chinese masterplanning with an alleviation of the accompanying environmental problems.

The two brownfield case studies demonstrate how the methodology might be adapted to cope with the exigencies of the built-up urban site. The Wynyard Quarter project is perhaps the most radical exploration of the interception of a complex inner city site with the logistics of hydrological neutrality. By following the catchment process, the implications for urban form are pushed in a radical new direction. The citizens of the new development are connected to the natural world, aware of the new rhythms of water and plants

The last case study demonstrates some of the limitations of the methodology. While the other three studies are either empty sites or, in the case of the Wynyard Quarter, a site owned by one stakeholder, the Jinan site is a complex web of owners and stakeholders encompassing a number of different landscapes waterways, and different urban conditions. Here the analysis is not so much a design tool as a policy guide. Future decisions about the urban development of the catchment can be guided by the landscape analysis. The implication of either building in the catchment or creating more pervious surfaces can be modelled, and the implications for stormwater runoff understood. (END)

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