SuDS in Cardiff Schools

Feasibility Study

Acknowledgements

This Feasibility Study is the result of funding from a Natural Resources Wales' (NRW) grant scheme to support the development of small-scale, retro-fit, sustainable drainage solutions in Wales.

The report was written by Trees for Cities with technical consultancy from the Civil Engineering and Landscape Team, Havant Borough Council - Owen Davies lead Project Engineer and Steve Mountain, Civil Engineering Team Leader.

Thank you to Cardiff Council's Flood and Coastal Risk Management team, Simon Dooley, Team Leader and Sarah Rees, Lead Officer who provided their time, steer and support.

Thank you to staff and pupils at each of the schools featured in this report for affording us their time and access to their school premises. Thanks also to the pupils who provided us with enthusiastic early thoughts and inspiration through engagement workshops and activities.

St Illtyd's Catholic High School, Rumney, Bryn Celyn and Pen-y-Groes, Pentwyn, St Cadoc's Primary School, Llanrumney, Glyncoed Primary School, Pentwyn and Pen Y Bryn Primary School, Llanrumney.

Contents

1 Introduction

Natural Resources Wales (NRW) has funded[1] this feasibility study to support the use of retrofitted sustainable drainage systems (SuDS) in five Cardiff schools where surface water flooding has been identified as a problem. Each school has been selected by Trees for Cities[2] (TfC) because of their strategic location in areas defined as being at medium to high risk of surface water flooding. This is demonstrated on NRW's[3] Surface Water Flood Risk Plans. In addition, each school receives a high proportion of pupils from the 20% highest areas of deprivation in Wales.

TfC already has a long-term relationship with schools in Cardiff where they have delivered tree planting, food growing and educational green retrofit projects since 2019. The need to address surface water in many of these locations is a frequently identified problem. This feasibility study demonstrates how TfC carried out a simple site assessment and SuDS selection process to result in Conceptual Plans. The Concept proposals illustrate options and choices, using SuDS as nature-based solutions[4] to surface water flooding. Each site's proposals are tailored to the specific needs of each school and tested using flood risk and benefits tools to quantify improvement, should the proposals be implemented.

In addition to the above we have used our findings to set out simple SuDS selection criteria that identifies different SuDS components and tests their pros and cons against a range of challenges, opportunities, risks and adaptations that are common occurrences in many school playgrounds in Cardiff and across Wales.

This document sets out clearly illustrated ideas and opportunities for SuDS by introducing how retrofit SuDS interventions could be suitable for other schools facing similar problems.

SuDS Tree Pit & Rain Garden Rathfern Primary School – Trees for Cities

[1] https://naturalresources.wales/about-us/news-and-blogs/news/new-grant-scheme-searches-for-innovative-solutions-to-sustainable-drainage/?lang=en

[2] https://www.treesforcities.org/our-work/schools-programme

[3] https://naturalresources.wales/flooding/check-your-flood-risk-by-postcode/?lang=en

[4] https://naturalresources.wales/about-us/what-we-do/strategies-plans-and-policies/benefits-of-nature-based-solutions/?lang=en

2 Aim of this Feasibility Study

The aim of this feasibility study is to support NRW identify common surface water flood risk solutions for schools across Wales and Cardiff, using SuDS as a nature based, efficient and effective option.

This feasibility Study reviews and identifies replicable opportunities for small-scale, retro-fit, nature-based solutions to localised surface water flooding in a range of school scenarios and tests these on 5 different schools to the north-east of Cardiff city centre. The scope of recommended works remains within each identified school site boundary, focusing on identifying localised problem areas. Proposals have regard to nearby surface water problems, as well as current and emerging surface water strategies. The recommended site selection, problem analysis, SuDS selection processes and concept design proposals can serve as a blueprint for replication elsewhere in Wales.

To achieve this aim, the feasibility study examines and recommends interventions at Concept level for sustainable drainage/surface water management.

The Feasibility Study aims to demonstrate how SuDS can:

- Utilise rainwater as a resource
- Offer resilience to existing sewerage networks by reducing quantity & slowing flow
- Help to retain water on site through creative interventions
- Improve water quality
- Increase levels of biodiversity and amenity
- Create educational and playful spaces along with multiple other benefits including those for education, play, maintenance and thermal comfort purposes.

Illustrated conceptual landscape proposals demonstrate in simple graphics and language how these problems can be addressed by integrating good principles of surface water management and landscape design. SuDS visual examples are used throughout the report to demonstrate how they could look if adopted.

Examples of Disconnected Down pipes and Raised SuDS Planters via Wendy Allen Design

3 Who Is This Document For?

The target audiences for this feasibility Study are NRW, our five selected Cardiff schools, other Cardiff Council schools, Cardiff Council and other Welsh Local Authorities, local SuDS Approval Bodies (SABs), local education departments, Welsh Water and potential funders who seek to understand better how simple retrofit SuDS can be installed in school playgrounds to improve resilience against surface water flooding.

With predictions for future flood risk in Cardiff looking bleak it is in everyone's interest to review efficient and cost-effective options for flood risk management on Cardiff's school estates. By using SuDS, Cardiff Council and other authorities listed above, can potentially inform and educate on flood risk through constructive interventions and positive educational messages.

This report will provide NRW with steer needed to support surface water flood risk management on Cardiff's and other local authority's school estates, using clearly illustrated ideas with opportunities identified to introduce SuDS in other schools facing similar problems.

The report aims to communicate the following to our audience:

- Retrofit SuDS is an easy and inexpensive win win for all parties
- Pupils can gain greater awareness of the environment
- Staff can gain curriculum & hands-on teaching resources
- Wider school community can be better engaged in future proofing their schools e.g. Parents, PTA
- Local Authorities can be supported to meet flood risk & climate change strategies
- Lead Local Flood Authorities (LLFAs) supported in their responsibilities for reducing and managing surface water
- NRW can use this report to improve awareness of problems and potential opportunities at local level through ongoing strategic overview and support.

Examples of Dished Channels via Robert Bray Associates

4 What Are SuDS?

SuDS is an abbreviation of the term Sustainable Drainage Systems. These are systems of interconnected landscaped interventions designed to mimic natural drainage by managing surface water run-off on the surface and as close to its source as possible. By using natural interventions SuDS uses the ground like a sponge that can absorb and store water, allowing it to permeate into the ground, whilst added trees and vegetation can collect rainfall on their leaves and absorb water through evapotranspiration. These natural features create rougher surface areas that block the steady movement of surface water to slow down its flow. Ensuring surface water can follow a designed and well-planned meandering route to its outlets can significantly take pressure off piped storm water systems' capacity in times of heavy rainfall. Surface water can be better utilised if retained or stored on the surface, allowed to slowly infiltrate and evaporate to support and invigorate green spaces, trees and other vegetation.

Using SuDS recognises that surface water is a valuable resource and not a waste product.

Wales[5] has led the way in the UK in their adoption of SuDS through the planning system whereby all new developments are now required to include SuDS. Cardiff CC demonstrably supports retrofitting SuDS into its existing urban spaces e.g. Greener Grangetown plan[6] and Wood Street. [7]The need to apply similar surface water management processes to Cardiff CC's schools' estate is becoming increasingly evident as can be demonstrated on the NRW surface water flood risk plans.

Examples of Trees & Bioretention Systems / Rain Gardens in Cardiff's Public Realm, Greener Grangetown & Wood Street Courtesy Arup

CIRIA's 4 key pillars of SuDS sets out the integrated benefits that underpin water quantity and quality with spatial and environmental benefits of amenity and biodiversity. This means that

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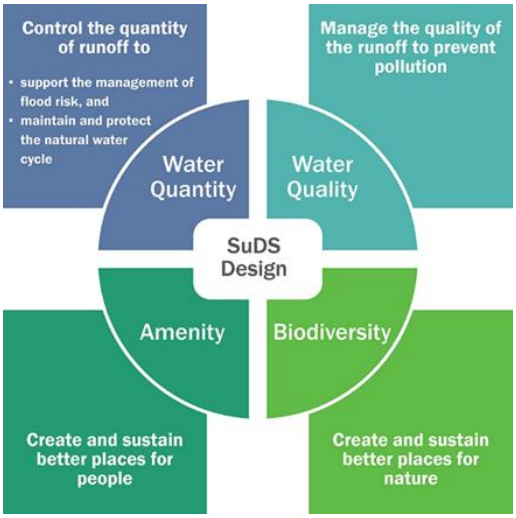
[5] https://naturalresources.wales/guidance-and-advice/business-sectors/planning-and-development/advice-for-developers/sustainable-drainage-systems-suds/?lang=en

[6] https://www.arup.com/projects/greener-grangetown/#:~:text=Greener%20Grangetown%20is%20a%20sustainable,improve%20cycling%20and%20pedestrian%20infrastructure.

[7] https://greenblue.com/gb/case-studies/wood-street-cardiff/

SuDS can bring multiple other benefits beyond that of below ground drainage pipes, whilst still performing the task of moving water away from places where it is detrimental to how that site is being used.



CIRIA SuDS Manual[8]

Trees for Cities / Arup

[8] https://www.ciria.org/CIRIA/CIRIA/Item_Detail.aspx?iProductCode=C753

5 Why Do We Need SuDS?

A combination of factors is contributing to higher risks of surface water flooding that negatively impacts the day-to-day activities of urban populations and the efficiency of their essential infrastructure, businesses, buildings (including schools) and urban spaces. An unreferenced £200 million cost of flooding to Cardiff[9] per year was raised in the Senedd in November 2024 with SuDS discussed as a viable option in that Q&A.

SuDS present a visible more cost-effective option to manage localised flood risk by being easier to install and manage than below ground drainage pipes. Visibility and accessibility of SuDS on the surface means opportunities to flexibly increase volume can be considered efficiently if needed, with maintenance problems identified and rectified more quickly.

Strategic causes of surface water flooding are due to the following interrelated factors:

Urbanisation	Population Growth	Climate Change
• More people living in towns and cities • More demand for space • Reduced land permeability due to increased development • Decreased areas of trees and other vegetation • Increased fragmentation of greenspaces and habitat	• Increased water demand • Increased demand for development land	• More intense rainfall • Higher temperatures • Stressed greenspaces

[9] https://www.theyworkforyou.com/senedd/?id=2024-11-13.2.627862#:~:text=In%20total%2C%20flooding%20is%20estimated,Diolch%20yn%20fawr.

6 National Statutory & Planning Context

The Flood and Water Management Act, introduced in 2010, places a duty on Cardiff Council to act as the Lead Local Flood Authority and prepare a 'Local Flood Risk Management Strategy'[10]. Cardiff Council declared a climate emergency in 2019 acknowledging that it has responsibilities to protect and enhance the environment.

Flooding is a known risk to communities in Cardiff and is a key strategic priority for Cardiff Council. Cardiff[11] is predicted to be Britain's most at risk city for flooding according to recent research into predicted climate change and flood risk (ref Fathom[12]), Trees for Cities has consulted with Cardiff Council flood risk team on this feasibility report to support their remit to respond to surface water flooding, assist in preventative measures, and to maintain drainage systems, as well as to provide guidance and steer to those affected where possible.

The 2014 version of Cardiff Council's strategy is presently under review and an updated version for 2025[13] is imminent. In the draft strategy for all of Cardiff, Action CDF A8 States" Provide education facilities with presentations and resources around flooding and climate change to feed into the new curriculum". Specifically for the area closest to our 5 schools, the River Rhymney catchment area the Action RHY2 states "Climate Change and Flood Risk School Talks". We anticipate that the creation of a new Welsh curriculum Activity Booklet on SuDS and water resources alongside this feasibility study, the engagement and workshops we have already carried out with our five schools, will support this planned Action (see Appendix E).

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[10] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.cardiff.gov.uk/ENG/Your-Council/Strategies-plans-and-policies/Documents/Flood/Local%20Flood%20Risk%20Management%20Strategy.pdf

[11] https://www.fathom.global/newsroom/flood-risk-in-uk-an-interview-with-sky-news/

[12] https://nhess.copernicus.org/articles/23/891/2023/#section5

[13] https://www.cardiff.gov.uk/ENG/Your-Council/Have-your-say/Live-Consultations/flood-risk-strategy/Documents/APPENDIX%20A%20ACTION%20PLAN.pdf

7 Methodology

Five schools to the east of Cardiff were selected and individually assessed against mapped identification of surface water flooding.

Site Selection Criteria

- Located in areas of High – Medium risk of flooding from Surface water and small water courses.
- Sufficient space available for SuDS interventions
- School community is engaged and supportive.

Problem Analysis

- Desk top Study
  - Assessing NRW flood risk maps, levels and historic planning applications
  - Assessing Cardiff Council Flood Risk Strategy
- Meeting with schools on site and walkabout
- Meetings with Cardiff Council flood risk team
- Site visits and ground truthing of Surface Water flood risk maps by landscape architect and drainage engineer
- See Chapter 9

Design

- Problem analysis
- Opportunity mapping
- Concept design - See Chapter 11.

Prioritisation of SuDS Locations

High, Medium and Low priorities are suggested, based on each defined problem areas and how surface water flooding impacts the day-to-day operational activities and functionality of each school.

Benefits analysis

This is a review of potential the benefits that our proposed SuDS will have on each site using the HR Wallingford[14] surface water storage estimation, SEPA's Simple Index Approach Tool [15]and the ciriabest[16] tools.

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[14] https://www.uksuds.com/

[15] https://www.susdrain.org/files/resources/SuDS_manual_output/sia_tool_draft_25locked.xlsx

[16] https://www.youtube.com/watch?v=CThoNy6uAys&t=67s

8 Overview of Selected Schools

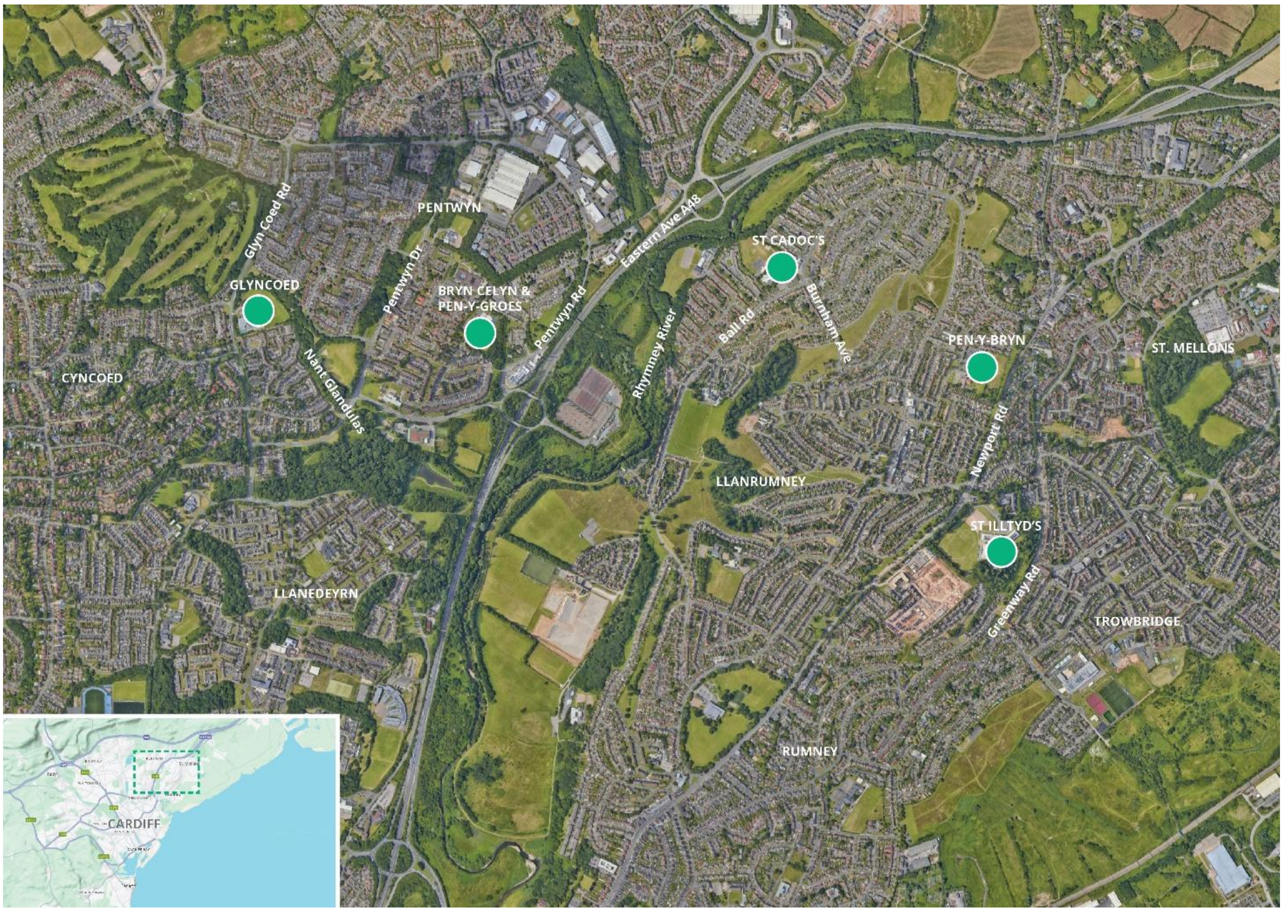


Figure 1 Location of Selected Schools

- School 01: St Illtyd’s Catholic High School, Rumney
- School 02: Bryn Celyn & Pen-y-Groes, Pentwyn
- School 03: St Cadoc's Primary School, Llanrumney
- School 04: Glyncoed Primary School, Pentwyn
- School 05: Pen Y Bryn Primary School, Llanrumney

School 01: St Illtyd's Catholic High School, Rumney

SITE CONTEXT

- General landscape falls
- NRW pluvial flooding analysis
- Existing grass
- Existing trees & planting
- 5m contours
- Building on site
- Building
- Site boundary
- Site boundary assumed (Pen-y-Bryn)

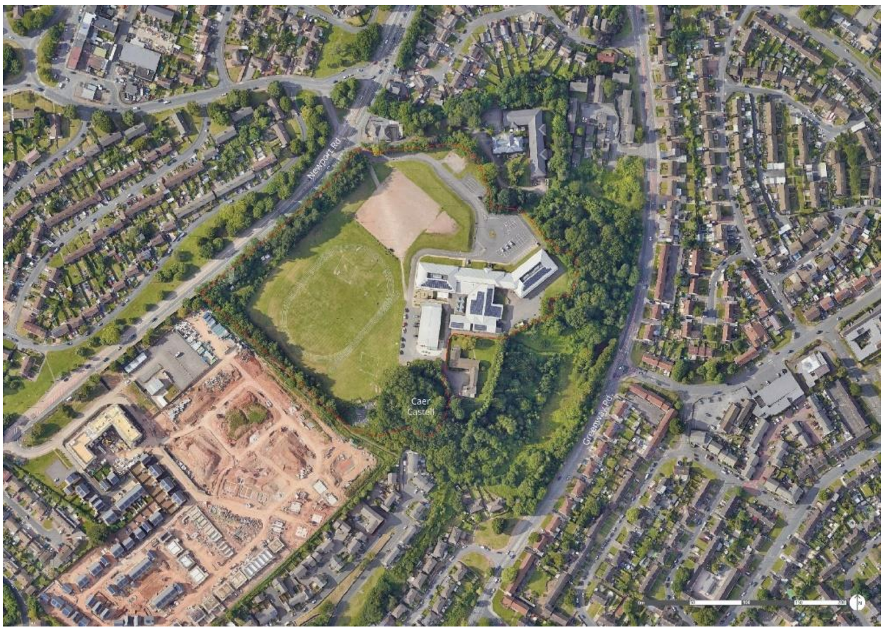


Figure 2 Site Context – St Illtyd's

- English speaking, medium secondary school for pupils aged 11-16
- 926 pupils
- 63% live in the 20% most deprived areas in Wales
- This site is classified as being at High Risk by NRW from surface water and small watercourses
- The NRW's Surface Water maps of the site illustrate flood risks adjacent to the north facing building façade and along the southern boundary adjacent to ancient monument Caer Castell
- Further surface water problems were identified when the site was ground-truthed.

Context

St Illtyd's is located in Rumney to the north-east of Cardiff city centre and is the largest site of the five. It is also the only secondary school. The site is accessed on foot and by vehicle off the B4487 Newport Road which runs along its north-western boundary. The newly developed Onsite Construction Academy is on the site's south-western boundary. Land to the south-eastern boundary slopes down from the school site, through woodland to the Greenway Road. Quarry Hall Care Home and Meadvale Road residential gardens lie on the north and north-eastern boundary of the site.

Landform

The bulk of the site lies between the 50 metre and 55 metre contours with a sharp fall on the Eastern boundary of c 20 metres to the 30 metre contour at the Greenway Road. The land generally falls across St Illtyd's from north to south. The school is built on historic farmland with heavy clay soils.

Images of St Illtyd's illustrating down pipes, extensive carparking and areas of impermeable ground with ponding

School 02: Bryn Celyn & Pen-y-Groes, Pentwyn

SITE CONTEXT

- General landscape falls
- NRW pluvial flooding analysis
- Existing grass
- Existing trees & planting
- 5m contours
- Building on site
- Building
- Site boundary
- Site boundary assumed (Pen-y-Bryn)

Figure 3 Site Context Bryn Celyn & Pen Y Groes

- Bryn Celyn is an English speaking, medium primary school for pupils that shares its site with Pen-y-Groes a Welsh speaking medium primary school
- Located to the north-east of Cardiff city centre
- Bryn Celyn has 192 pupils; 36.7% live in the 20% most deprived areas in Wales
- Pen-y-Groes has 122 pupils; 22.1% of pupils live in the 20% most deprived areas in Wales
- This site is classified as being at Medium Risk by NRW from surface water and small watercourses
- The NRW surface water flood risk maps illustrate areas at high risk of flooding to hard standing to the north of the site and adjacent to the school building and along the wooded eastern site boundary
- Further surface water problems were identified when the site was ground-truthed.

Context

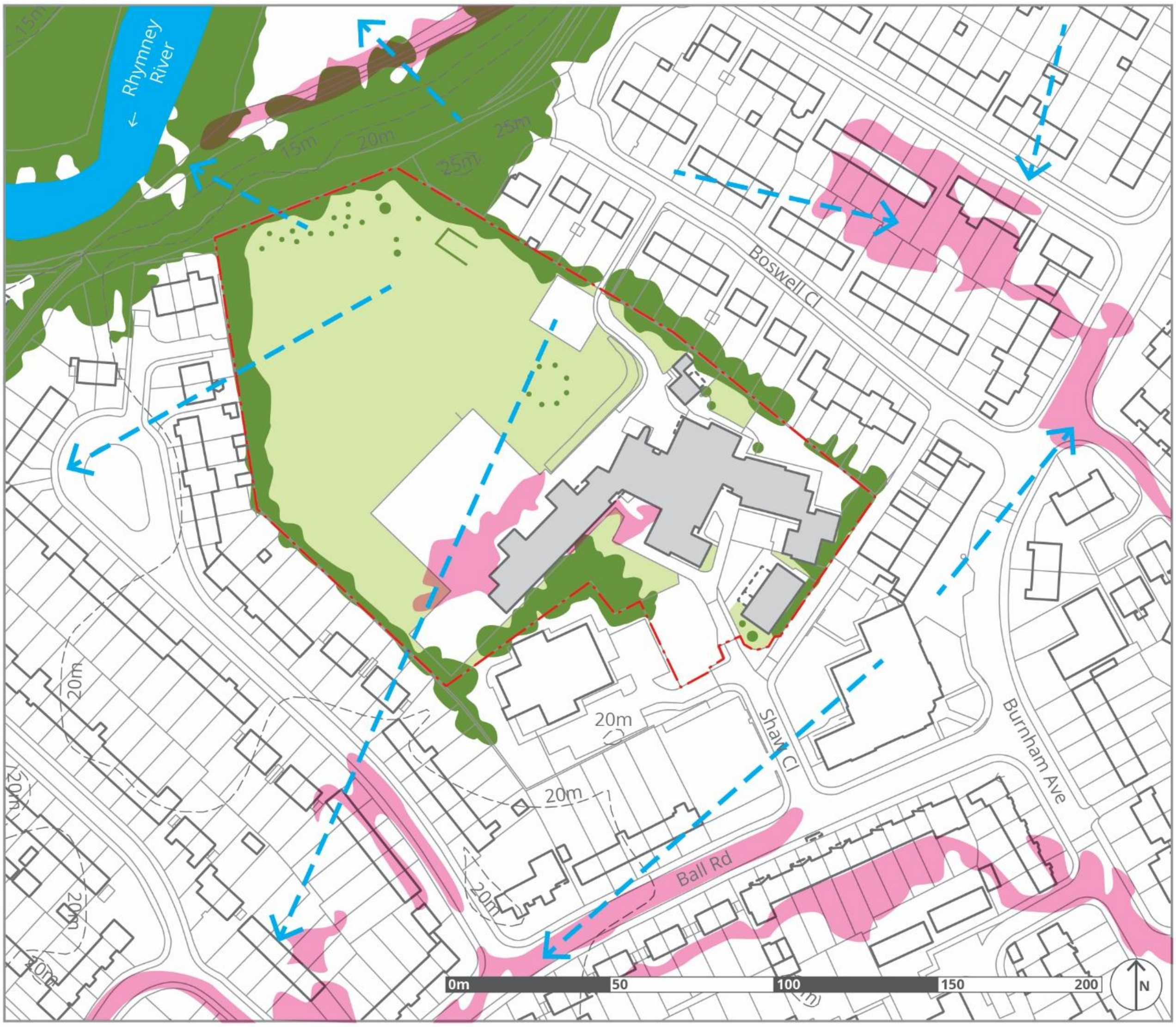
We are looking at this site as a unified and holistic exercise This shared site is situated in Pentwyn to the north-east of Cardiff city centre. It is accessed on foot and by vehicle via Glyn Collen to the north and via Bryn Celyn to the south. Residential gardens and open spaces of Glyn Collen form the northern and eastern boundaries of the site, leading to the Pentwyn Road and the parallel A46 Eastern Road. The residential gardens and open spaces of Bryn Celyn lie to the South of the site and the residential gardens of Bryn Heulog and Bryn Haidd form the western boundary.

Landform

The bulk of the site lies between the 35 metre and 30 metre contours falling north-west to south. The land falls c 5 metres from north-west to south with a sharper fall towards the site's southern-most point of c 5 metres. There are numerous constructed level changes within the school boundary, created to accommodate the school building, level play areas and sports pitches. We were informed that when significant building work happened at the school, rubble was stacked to the site's edges and covered in topsoil. The school is built on farmland with heavy clay soils.

Images of Bryn Celyn & Pen Y Groes' grounds illustrating down pipes and drainage gullies, waterlogged fields and large areas of impermeable ground with ponding

School 03: St Cadoc's Primary School, Llanrumney



SITE CONTEXT

- General landscape falls
- NRW pluvial flooding analysis
- Existing grass
- Existing trees & planting
- 5m contours
- Building on site
- Building
- Site boundary
- Site boundary assumed (Pen-y-Bryn)

Figure 4 Site Context St Cadoc's

- English speaking, medium Catholic Primary School located to the north-east of Cardiff city centre
- 335 pupils
- 80.3% live in the 20% most deprived areas in Wales
- Site classified as being at Medium Risk by NRW from surface water and small watercourses
- The NRW surface water flood risk maps illustrate areas at high risk of flooding to hard standing adjacent to the north-west face of the school building, with localised areas adjacent to the south-eastern face of the building at risk to a lesser degree
- The NRW fluvial flood risk maps illustrate the River Rhymney flood risk zone as being outside of the northern school boundary
- Further surface water problems were identified when the site was ground-truthed.

Context

St Cadoc’s is located in Llanrumney to the north-east of Cardiff city centre. St Cadocs is accessed on foot and by vehicles from Shaw Close on the southern boundary with a secondary lesser-used entrance off Bosell Close to the north.

The Rhymney River and adjacent open spaces form the northern boundary, Boswell Close leading to Burnham Avenue lies to the north-east of the site, a boxing club and a health centre on Balls Road form the southern boundary, and residential properties on Macauley Avenue form the western boundary.

Landform

The highest level on the school site sits at the northern boundary where the land falls sharply into the river valley off site. The site presents as being a generally level plain on the 20 metre contour but significant changes in levels within the school’s grounds contribute to the surface water problems across the site. The school is built on historic farmland with heavy clay soils.

Images of St Cadoc’s School site illustrating down pipes and drainage gullies, compacted ground, playing fields and large areas of impermeable ground with ponding

School 04: Glyncoed Primary School, Pentwyn

SITE CONTEXT

- General landscape falls
- NRW pluvial flooding analysis
- Existing grass
- Existing trees & planting
- 5m contours
- Building on site
- Building
- Site boundary
- Site boundary assumed (Pen-y-Bryn)

Figure 5 Site Context Glyncoed

- English speaking Primary School located to the north-east of Cardiff city centre
- 348 pupils
- 9.5% live in the 20% most deprived areas in Wales
- This site is classified as being at High Risk by NRW from surface water and small watercourses
- The NRW surface water flood risk maps illustrate areas at high risk of surface water flooding to areas of hard standing to the north and in areas to the south of the school building. The fluvial flood risk maps illustrate the Nant Glandulas flood risk zone as being outside of the north and western school boundary and therefore not a risk
- Further surface water problems were identified when the site was ground-truthed.

Context

Glyncoed primary school is accessed by vehicles and pedestrians off the Glyn Coed Road to the east of the site and by pedestrians from Hawthorns public footpath that runs along the southern site boundary. Public interconnected footpaths surround the site, linking the north and western site boundaries to residential properties of Liwyn Castan and Waun Fach.

Landform

The site sits on the 20 metre contour and is generally level with a gentle fall across the playing fields towards the Nant Glandulous boundary. However significant localised changes in levels within the school's grounds contribute to the surface water problems across the site, particularly on the southern and western boundaries where the boundaries fall sharply to at least a 1:3 slope in places. Surface water impacts the school playground from outside the southern boundary of the school and future SuDS retrofit within the school should be undertaken in conjunction with external interventions.

The school is built on historic farmland with heavy clay soils.

Images of Glyncoed School site illustrating down pipes, drainage gullies, playing fields and areas of impermeable ground with a history of ponding

School 05: Pen Y Bryn Primary School, Llanrumney

SITE CONTEXT

- General landscape falls
- NRW pluvial flooding analysis
- Existing grass
- Existing trees & planting
- 5m contours
- Building on site
- Building
- Site boundary
- Site boundary assumed (Pen-y-Bryn)

Figure 6 Site Context Pen Y Bryn

- English speaking Primary School located to the north-east of Cardiff city centre
- 249 pupils
- 55% live in the 20% most deprived areas in Wales
- This site is classified as being at Medium Risk by NRW from surface water and small watercourses flooding
- The NRW surface water flood risk maps illustrate an area at high risk of surface water flooding on areas of hard standing to the north of the school building
- Further surface water problems were identified when the site was ground-truthed.

Context

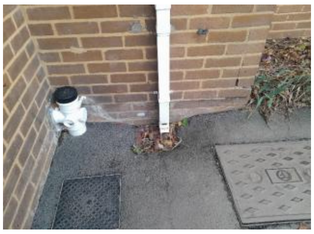
Pen Y Bryn primary school is accessed by vehicles and pedestrians through separate entrances off the Dunster Road to the west of the site. Residential properties of Elgar Crescent form the northern boundary, The B4487 Newport Road lies on the eastern boundary and the construction site for a new early years centre (EYC) sits on the southern boundary. The school's former forest school area in the south-eastern corner of the site is now fenced off and we have excluded this in our proposals as it will form part of the new early years centre's space. A number of fruit trees that the pupils planted were recently relocated to retain in the school grounds.

Landform

The site sits between the 45 and 50 metre contour and is generally level with a gentle fall north-east towards the Newport Road boundary. There are few notable changes in levels within the school's grounds which may contribute to areas of standing water. Existing drainage infrastructure may not have sufficient capacity or surface falls to cope with prolonged and heavy periods of rainfall. The school is built on historic farmland with heavy clay soils.









9 Problem Analysis

This report focuses on the key problem of surface water flooding in 5 selected Cardiff schools and reviews how this is impacts their day-to-day activities.

Each Site Analysis plan illustrates ground-truthed areas where surface water is actually causing a flooding problem. The areas are noted against locations of surface water flood risk identified on NRW's strategic surface water flood risk maps. The Site Analysis Plans also illustrate contours and the general movement of surface water, areas of trees and vegetation, and permeable and impermeable surfaces, all of which influence existing surface water problems and have the potential to be manipulated as part of an integrated solution to this problem. This section considers a range of identified issues on each site that are likely to have a cumulative impact on surface water flooding.

Summary of Common Problems

The identified solutions to the problems assessed on each site can be tested against different SuDS components. Using criteria that are bespoke to each site's specific conditions, each defined problem was matched to relevant SuDS components with the aim of designing a connected solution for each site.

The most significant cause of surface water problems, common to all 5 schools, are large areas of impermeable surfaces. This means that there is insufficient permeable ground for surface water to infiltrate. Rainwater that lands on these impermeable surfaces (paving and roofs), either flows to below ground pipes or overflows where drainage pipes exceed their designed capacity. These pipes may be blocked or even located in the wrong location. In many places there is no drainage at all where water is puddling.

Between a third and a half of the area of each school is an impermeable surface (including roofs).

Combined areas of impermeable roof and ground level surfaces on each school are:

- 34.52% (c1/3) surface of site at 01 St Illtyd's
- 32.58% (c1/3) surface of site at 02 Bryn Celyn / Pen Y Groes
- 40.52% (c<1/2) surface of site at 03 St Cadocs
- 27.83% (c>1/4) surface of site at 04 Glyncoed
- 43.54% (c<1/2) surface of site at 05 Pen Y Bryn

(see Appendix B for detailed calculations for each site)

All schools are built on former farmland and each site has heavy clay soils. The soil is easily compacted when utilised for sports and play, causing water to run off the surface and fail to infiltrate into the ground naturally, despite appearing to be green and porous.

The main causes of surface water flooding on each site were noted as:

- Large areas of impermeable surfaces that incorporate raised walls and edges e.g. access roads, car parking and other vehicular infrastructure
- Large areas of impermeable roofscapes

- Compacted clay soils
- Buildings blocking the natural flow of surface water and creating pinch points
- Existing drainage infrastructure – down pipes and gullies exceeding limits
- Possible hidden problems / malfunctioning drainage
- Ad hoc changes in levels to accommodate add-on sports and other facilities.

School 01: St Illtyd's Catholic High School

SITE ANALYSIS

- Localised falls observed on site
- Flooding & puddling observed on site
- Rain garden: Existing
- Existing downpipe observed on site
- Existing channel drain / gully observed on site
- Pedestrian access
- Vehicular access
- Site of existing TfC Project

Figure 7 Site Analysis – Existing Surface Water Movement - St Illtyd's

Site description

All site boundaries have dense mature trees and vegetation, screening the site from external views. Part of the south-eastern boundary has been cleared for new development off the Greenway Road, but dense vegetation is retained. To the south of the site sits an ancient monument Caer Castell, densely covered by trees and vegetation and inaccessible by the school community.

The main vehicular access road runs from the Newport Road entrance through a manmade landform that elevates the playing fields on the south-western corner of the site, creating a small "ravine" that brings the road to a large roundabout and carpark next to the school.

Observed problems

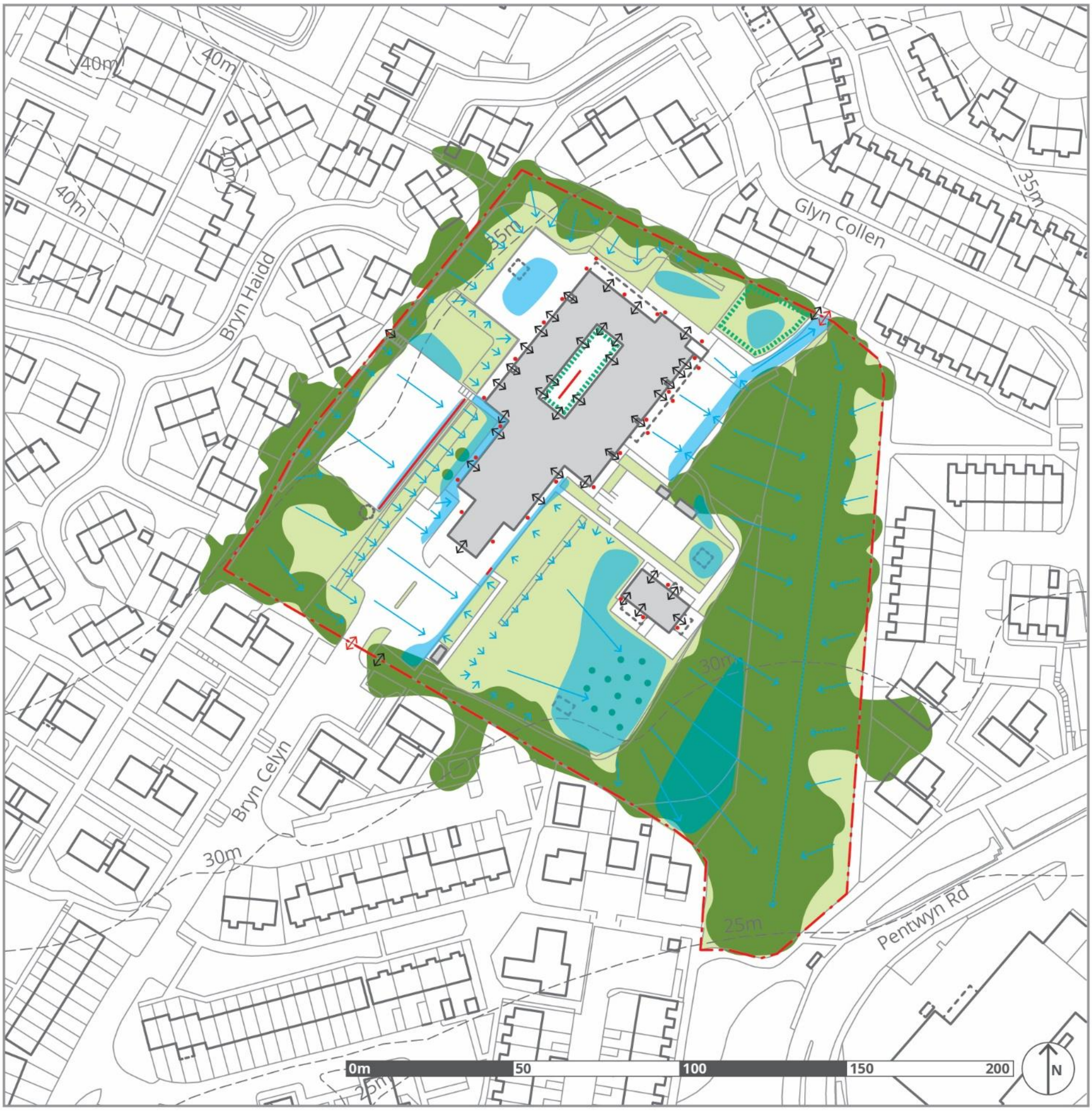
The significant access road, roundabout and car park infrastructure has created a flooding problem when it rains, causing surface water to move from the school playing fields into the impermeable access road and footpath "ravine", towards the impermeable roundabout and car park arrangement. The result is that this area retains significant surface water, described by the school's head teacher as a "lake".

Elsewhere existing drainage infrastructure may not have sufficient capacity to cope with heavy periods of rainfall and in places there is no drainage where it is needed.

Other problems noted on site were:

- Sports pitches were saturated with limited use during winter
- Sports hall had drainage and guttering dripping onto soft area creating erosion
- Current development (planning ref 14/00504/DCO) on the slope to East of boundary – need to ensure any runoff from school site does not affect slope stability
- Areas of soft landscape are used as desire lines and compacting soil
- There is an area of dead space between buildings (litter trap) eastern playground.

School 02: Bryn Celyn & Pen-Y-Groes Primary Schools



SITE ANALYSIS

- Localised falls observed on site
- Flooding & puddling observed on site
- Rain garden: Existing
- Existing downpipe observed on site
- Existing channel drain / gully observed on site
- Pedestrian access
- Vehicular access
- Site of existing TfC Project

Figure 8 Site Analysis – Existing Surface Water Movement - Bryn Celyn & Pen Y Groes

Site description:

All site boundaries have dense mature trees and vegetation, screening the site from external views. There is a large open grassed square used for football that gets very wet impacting the small free standing nursery classroom and preventing it being used for sports.

There are two hard standing areas elevated above the school and its car park to the west of the site and further hard surface play adjacent to the building on the eastern side.

An internal courtyard that appears to be underused, surfaced mainly with concrete paving slabs and a few planting beds. Japanese Knotweed is present along eastern edge. This is to be treated but could impact possible intervention. The adjacent woodland is no longer used due to anti-social behaviour.

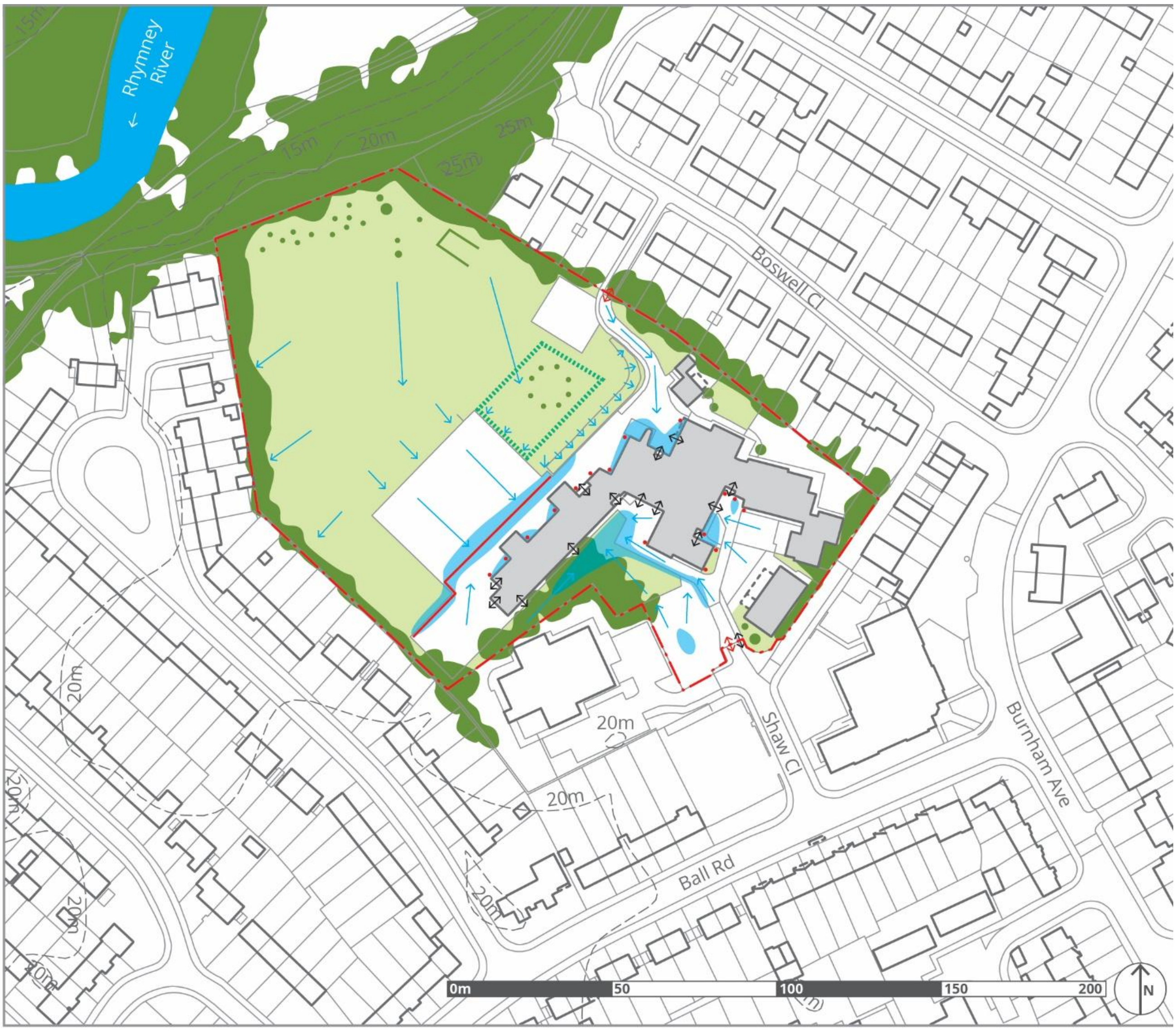
Observed problems:

Surface water generally moves from west to east, collecting along the base of the school's west facing elevation, and other elevated edges to hard surfaced areas. This creates obstacles to footpaths and entrances. Where the water can traverse the site, it collects in areas of soft ground, rendering sports pitches and green spaces inaccessible in winter and causing rising damp damage to the small nursery classroom outbuilding to the south of the site.

Two impermeable hard surfaced play areas to the north-west of the site suffer from flooding and are also possible causes, with the northernmost area at greatest risk.
Existing drainage infrastructure is either blocked, or it does not have sufficient capacity to cope with heavy periods of rainfall.

- Woodland no longer used due to anti-social behaviour
- Main playground East – Ponding adjacent to kerbs positive drainage not working
- Northern Playground – very boggy likely surface water flowing down the slope affecting the nursery.
- Western Playground – Large ponding issue as positive drainage is not in the location needed
- Top playground (west) ponding issues with channel drainage
- West of building (Kitchen) saturated soil and ponding
- South east playground saturated as land slopes from top to bottom.
- Possible ponding on footpath to reception.

School 03: St Cadoc's Primary School



SITE ANALYSIS

- Localised falls observed on site
- Flooding & puddling observed on site
- Rain garden: Existing
- Existing downpipe observed on site
- Existing channel drain / gully observed on site
- Pedestrian access
- Vehicular access
- Site of existing TfC Project

Figure 9 Site Analysis – Existing Surface Water Movement - St Cadoc's

Site description:

The site backs onto the dense vegetation of the River Rhymney valley and associated flood plain to the north. There are few trees along its northern boundary and near the southern entrance. Elsewhere there is little vegetation on the site. The main bulk of the site is composed of grassed playing fields that cover the northern half of the site, with the school buildings car park and play areas to the south.

There are multiple fences preventing free movement and access to the grassed spaces.

Observed problems:

The main surface water problems observed were on hard standing to the north of the school building receiving surface water off the elevated playing fields. There were further areas noted on hard standing adjacent to the building on the southern side of the school.

Excess water from existing down pipes, gullies and gutters was creating damp areas next to the building and surface water drainage infrastructure may not have sufficient capacity to cope with heavy periods of rainfall. The main entrance to the school had few areas of permeable green spaces on carparking both inside the school and outside of its boundaries.

- Cycle storage areas – built on impermeable surface
- Shipping container
- Grass block heavily compacted & malfunctioning as permeable surface
- Field always wet and lots of moles
- Southern playground and grass area falls towards the school.

School 04: Glyncoed Primary School

Figure 10 Site Analysis – Existing Surface Water Movement - Glyncoed

Site description:

This school sits in leafy and verdant location with a dense belt of mature trees and vegetation enclosing the site from the north to the south and a row of mature trees forming the western boundary. The Nant Glandulas (a tributary of the River Rhymney) forms the northern and eastern boundary of the site and the land falls into its steep, tree covered valley from the school playing fields.

Observed problems:

The main surface water problems were noted as being at the immediate southern, western and northern boundaries of the building. Surface water has nowhere to go when it travels west to east as the school building gets in its way, causing significant puddling along the west and southern boundaries

Excess water from existing down pipes, gullies and gutters was creating damp areas next to the building and surface water drainage infrastructure may not have sufficient capacity to cope with heavy periods of rainfall. The large playground has lots of channels and linear drainage, all susceptible to ponding.

Surface water pathway along the Hawthorn's footpath to the south of the school drains towards the site with detritus washing into playground. Outside of the school boundary the surrounding catchment to the footpath is large with steep slopes and fast flows carrying detritus and sediment.

Other observed problems:

- Playing field waterlogged so there is little access during winter
- Watercourse 'out of bounds'
- Use of artificial grass to enable access to certain features on field and to manage muddy area
- Raingarden adjacent to school needs some TLC
- Large car park area is sloping towards the school.

School 05: Pen Y Bryn Primary School

SITE ANALYSIS

- Localised falls observed on site
- Flooding & puddling observed on site
- Rain garden: Existing
- Existing downpipe observed on site
- Existing channel drain / gully observed on site
- Pedestrian access
- Vehicular access
- Site of existing TfC Project

Figure 11 Site Analysis – Existing Surface Water Movement - Pen Y Bryn

Site description:

Of all 5 schools in this study Pen Y Bryn has least available green space and appears to be under pressure from sharing its site with the development of a new early years centre (EYC) to the south. There is limited mature vegetation in the grounds and a large expanse of impermeable hard surfacing.

Observed problems:

The main problem area lies at the northernmost perimeter of the site, where the angle of the school has created a "pinch point" with barely sufficient space for emergency vehicles. This tight space leaves no room for surface water to take a natural course. There are reported issues of surface water from neighbouring properties off this boundary.

Prior to construction of the EYC the school told us that their site was always saturated but this is not such a problem now. Removing areas of green space is detrimental to resolving the surface water issues on this site and having access to a joined-up approach to the design of the school retrofit and the new EYC would benefit both in the longer term.

Excess water from existing down pipes, gullies and gutters was creating damp areas next to the building and surface water drainage infrastructure may not have sufficient capacity to cope with heavy periods of rainfall.

Other observed problems:

- East playground large ponding south-east corner
- Nursery area to the south is always waterlogged again this affects when it can and can't be used
- Lots of ponding north playground (bad patching and levels)
- Downpipe with no drainage affecting access to nursery.

10 Identified Opportunities

Prioritisation

The simplicity of SuDS is that components can be incorporated in different phases over different time frames. Prioritisation of where focus and resources could be best applied were identified through discussions with each school and through site-based observations of inconvenience to users and damage to each school's built infrastructure caused by standing and moving surface water.

In considering prioritisation in schools, it is important to maintain the ethos that SuDS design has the potential to educate and engage with pupils in a playful and interactive way, allowing safe play and movement around the school for longer periods of the year.

Functional Priorities for all school SuDS are to:

- Manage local flood risk
- Improve water quality of storm runoff
- Increase biodiversity
- Improve amenity infrastructure
- Create educational & playful interactive spaces.

It is important to ensure school decision makers understand the following:

- Well designed and incorporated SuDS do not need to hinder opportunities for play and outdoor activity
- SuDS can be purposed to incorporate interactive play whilst leaving sufficient space for formal sports
- SuDS creates greater opportunities for pupils to use all areas (hard and soft) throughout the year.

The proposed hierarchy puts functional spaces first for pedestrian movement and servicing of each school, but we have put children's play spaces as a close second priority as ideally all school projects should be child / student centred. Car parking can be a tricky priority that will need negotiating against the child-centred approach to investment and each school will take a different view on this. Elsewhere we see the perimeter soft ground areas as less obviously in need of investment, but conversely the costs to implement SuDS in soft ground to the playing field edges and larger open spaces can be minimal but with high impact "downstream" on other parts of each site. In certain sites these areas should be given greater priority as quick win, nature-based solutions as is demonstrated in the Volume and Benefits assessment section of this feasibility study.

The following is a suggested hierarchy for prioritising investment and interventions:

- **Hard surfaced functional spaces** – footpaths, service routes, entrances to buildings and site – so the site can be used for normal day-to-day activities after heavy rainfall
- **Play spaces, playgrounds, hard sports areas** – close to the building – to ensure SuDS designs are child-centred for playful activity throughout the year and in all weathers
- **Soft ground** – school playing fields, on periphery of the site – to enable formal team games
- **Car parking** – convenience for staff and commuters.

Integral to the success of all proposals is the need for a maintenance plan that should be implemented to survey and repair blocked or malfunctioning existing drainage. This plan should be updated to incorporate any new SuDS interventions.

Common Problems & Opportunities

Table 1 takes the identified problems common to most or all our five schools and considers opportunities to utilise different SuDS components to resolve the identified problem. This is also included in Appendix A SuDS Component Selection Support.

Table 1 - Opportunities for SuDS to Resolve Common Surface Water Problems

Problem	Opportunity	Applicable SuDS Components	SuDS Benefits & Performance
Large areas of impermeable surfaces	**Break out hard surfaces** that are not essential for play, sports, pedestrian and vehicular use and introduce permeable surfaces, soil and water This is **"De-paving" to create rain gardens / tree trenches** incorporated for permeability across the site without compromising current needs and uses	• **De-paved tree trenches** with **porous structured soils** • Interactive and playful **rain gardens** with integrated hard & soft materials • **Removal of raised edges** to allow better flow of surface water from impermeable to permeable • **Permeable unit paving or porous surfacing** such as: - soft play - gravel - stone aggregate - open-joint brick pavers - open paving patterns - grass-concrete pavers - woodchip and bark, - composite resin etc	**Benefits** - **Water Quantity** - **Water Quality** - **Amenity** - **Biodiversity** - **Shade** - **Education** - **Play /Fun** **Performance** - **Interception** - **Storage** - **Infiltration** - **Conveyance**

Large areas of impermeable roofscapes	Where feasible **retrofit green roofs** to small low risk out buildings such as garages, storage sheds etc; **Disconnect down pipes** and **divert roof water** into **water storage butts, raised planters** and **ground level rain gardens**	**Small green roofs** retrofit to Bike sheds and storage containers, **Disconnected down pipes** attached to: • **Water butts** • **Raised planters** • **Ground level rain gardens**	**Benefits** - **Water Quantity** - **Water Quality** - **Amenity** - **Biodiversity** - Shade - **Education** - **Play /Fun** **Performance** - **Interception** - **Storage** - **Infiltration**
Buildings blocking the natural flow of surface water and creating pinch points	Consider opportunities to retain water on the surface **linking to other parts of the site via rills, swales or surface gullies**, using below ground pipes only where absolutely essential **Break out sections of kerbs and edging** to encourage conveyance of water from hard to soft ground	• **Swales** on soft ground • **Rills and channels** on hard surfaces • **Drop kerbs** • **Gaps in edging** between hard and soft ground	**Benefits** - **Water Quantity** - Water Quality - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Conveyance**
Existing drainage infrastructure – down pipes and gullies exceeding limits	Introduce playful interception components such as **raised planters** or **ground level rain gardens** with **channels**	Disconnected down pipes attached to: • **Water butts** • **Raised planters** • **Ground level rain gardens** **Integrate surface gullies into raingardens** for exceedance management	**Benefits** - **Water Quantity** - **Water Quality** - **Amenity** - Biodiversity - Shade - **Educational** - **Play /Fun** **Performance** - **Interception** - **Storage** - **Infiltration**
Possible hidden problems / malfunctioning drainage	**Survey & repair** extant drainage systems. **Increase capacity** of extant drainage facility where feasible. **Ensure maintenance of SuDS is planned** within capability and resources of School and Council	Design with existing drainage & **plan its maintenance** alongside new SuDS	**Performance** - **Conveyance**

Ad hoc and retrofitted changes in levels to accommodate add-on sports and other facilities	Create **breaks in kerb edges or introduce dropped kerbs** to allow movement of water from hard ground to soft. Anticipate potential problems from future development of changes to landscape.	• **Drop kerbs** • **Gaps in edging** • **Outlets**	**Benefits** - **Water Quantity** - Water Quality - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Conveyance**
Large scale impermeable access roads & car parking	Introduce **permeable surfaces** without reducing pedestrian, car parking & vehicular access provision. **Create space for surface water on soft ground to edges** of parking spaces. Create **breaks in kerb edges or introduce dropped kerbs** to allow movement of water from hard ground to soft. Introduce **rain gardens** at edges of hard surfaces.	• **Permeable unit paving or porous surfacing** • **Swales on soft ground** • **Ground level rain gardens**	**Benefits** - **Water Quantity** - **Water Quality** - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Interception** - **Storage** - **Infiltration** - **Conveyance**
Compacted heavy clay soils	**Aerate the soil** in places where there is heavy footfall as part of normal maintenance Soil can be tilled over on plant beds **Better protection of planted areas** from footfall	• General design and **maintenance** considerations	**Benefits** - **Water Quantity** - **Water Quality** - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Infiltration**

11 Concept Proposals

The following Concept Proposals set out spatial arrangements for each site based on reviewing the identified problems and testing out opportunities for SuDS. Proposals use landscape characteristics of each site and consider how these might influence SuDS options and the rerouting of surface water movement. The main outcome of the Concept Proposals for each of our five schools is to determine viable SuDS components and establish how they might link up in a cohesive, creative and functional way to quantifiably reduce surface water flood risk.

These Concept Proposals have tested the feasibility of retrofitting SuDS on each school site and provide sufficient background to facilitate realistic progress to the next Detailed Design stage by each school, engineers, designers, flood risk managers etc. as and when funding becomes available.

The Concept Proposals are designed to demonstrate the **Art of the Possible**. Each plan identifies an optimal range of solutions using an interrelated set of SuDS components based on the principles and aims set out in previous chapters. Proposals are presented as diagrammatic ideas for each school to consider.

Priorities for sites are suggested as a way to spread costs and test the concept at each school.

Each Concept Proposal can be adapted in different ways to be:

- Delivered in a **phased approach** for when funding becomes available
- Delivered using **different combinations of SuDS**
- Flexible to allow **each school to define and focus on their own priority needs**
- Open to **creative interpretation whilst delivering high performing functionality** as drainage systems.

Example of de-compacted soils and raingarden – Trees for Cities

Example of Check Dam and Swale at Holyoakes School via Robert Bray Associates

Example of Dry River Bed Channel via.© AtkinsRéalis

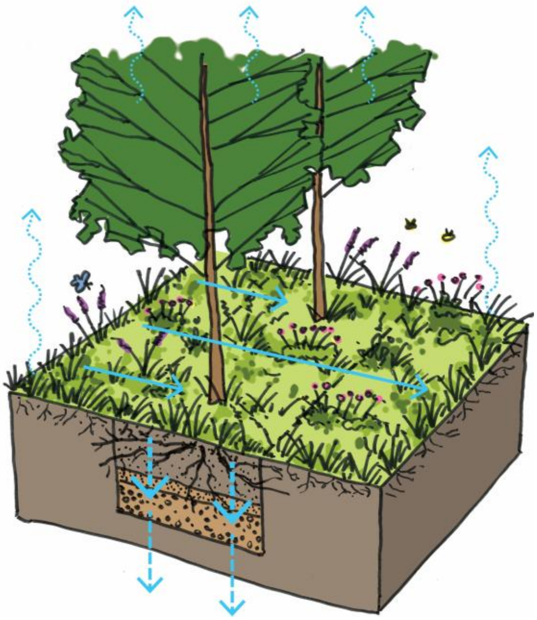
01 St Illtyd's – Concept Proposals

Main sources of surface water:

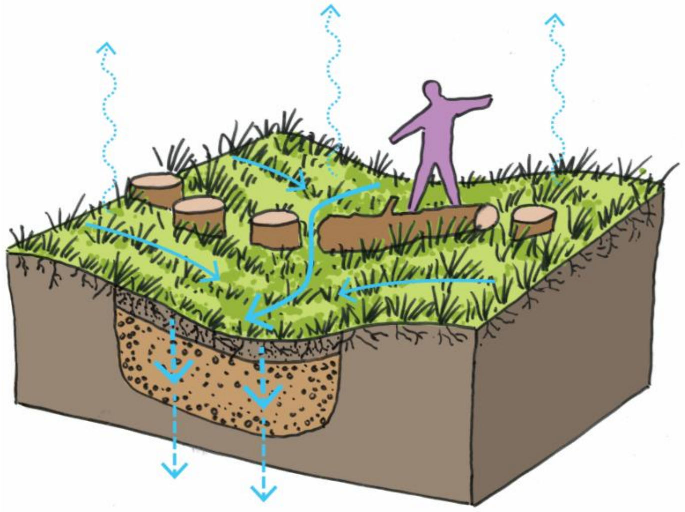
1. Large playing field to east of building
2. Extensive impermeable road, car park and roundabout
3. Building roofs
4. Smaller areas of hard standing around the building

Interconnected High Priority Areas:

- Large playing field to east of building source of SW movement across site towards school
- Access road "ravine", roundabout and lower car park – facilitating surface water movement towards the school
- Building edges / base of building facades – blocking movement of water



Typical Tree Trench in Soft Ground



Typical Playful Swale

Concept Proposals - description

The aim of the concept proposal for St Illtyd's is to capture as much excessive surface water on the main playing field as possible to slow it down before it reaches the main school buildings and surrounding impermeable surfaces. Retaining surface water on this expansive soft ground will prevent some of it from flooding the main access road and so called "ravine" area towards the main car park. By retaining surface water in **Swales and Dry basins** (that get wet only when it rains) these will also support drainage on the main playing field, allowing more opportunity for year-round use.

A **row of trees in a trenched rain garden** will create capacity for additional runoff along the edge of the hard surfaced sports area to the north of the site. This will further support the school's possible future plans for a more formal multi games area on this part of the site. **Groups of trees** are proposed for the top of the embankment slope, between the field and the road, planted to pick up further surface water runoff and create a more natural edge to the open expanse of the playing field. This large site has huge potential to take more trees and this could be a straightforward approach to reinforce surface water resilience.

Meadow grasses are proposed for the unused perimeter areas of the sports field to roughen the surface and provide biodiverse habitat.

By capturing water from the playing field and directing it across the main entrance road, it can be slowed down through dry basins and swales. The upper car park could have its surface replaced with **permeable paving** – e.g. open blocks with aggregate fill to prevent it contributing to flooding downhill.

By capturing water as close to source on the upper levels of the site, it is anticipated that quantity of run off flooding the problem areas in the lower car park could be significantly reduced. To further support this, we have proposed creating a **rain garden** within the roundabout that incorporates permeable paving, whilst also creating a rain garden to the edges of the car park. This approach would not impact vehicle movement and parking.

We propose capturing the runoff from the extensive impermeable roofscape of St Illtyd's via **down pipe disconnection to raised planters, ground level rain gardens and rills**. This approach applies also to the lower priority areas for internal courtyard spaces and to the east, west and southern facades and adjacent areas. Whilst not being the most problematic, down pipe disconnection represents an incremental and very effective quick win for this site to remove roof water from over stretched below ground pipes.

SURFACE WATER MOVEMENT WITH SuDS

- SuDS permeable conveyance channel
- SuDS impermeable conveyance channel
- SuDS feature in existing permeable ground
- SuDS feature in existing impermeable ground
- Disconnected downpipe to rill
- Disconnected downpipe to raised planter / water butt
- Localised falls observed on site

Figure 12 Concept Proposals St Illtyd's - Surface Water Movement with SuDS

- Swale
- Swale with check dam
- Scrape / dry detention basin
- Rain garden: Tanked, connected to other SuDS
- Rain garden: Tanked, connected to SWS
- Rain garden: Infiltration, & connected to SWS
- Pond / wetland
- Permeable / porous paving
- Meadow
- Shrubs
- Trees in pits / trenches
- Wet woodland trees

SITE DESIGN

- Rill
- French drain
- Grated channel
- Underground pipe connecting SuDS features
- Existing downpipe retained
- Disconnected downpipe to rill
- Disconnected downpipe to raised planter / water butt

Figure 13 Concept Proposals St Illtyd's – SuDS Master Plan

02 Bryn Celyn & Pen Y Groes – Concept Proposals

Main sources of surface water:

1. Areas of hard standing around the building including play areas and sports
2. The school's extensive roofscape
3. Significant level changes within the site – multiple changes in levels internally

Interconnected High Priority Areas:

- Play area in north of site – source of surface water movement towards school
- North-west façade of building – nowhere for surface water to move to
- Building edges / base of building facades – blocking movement of water
- Area surrounding the freestanding classroom and playing field to the south of the school – located on boggy waterlogged corner of site

Lower Priority Areas:

- Car park to main entrance area
- Hard standing sports area to east of school building

Typical Raingarden

Typical Downpipe disconnected to Raised Planter

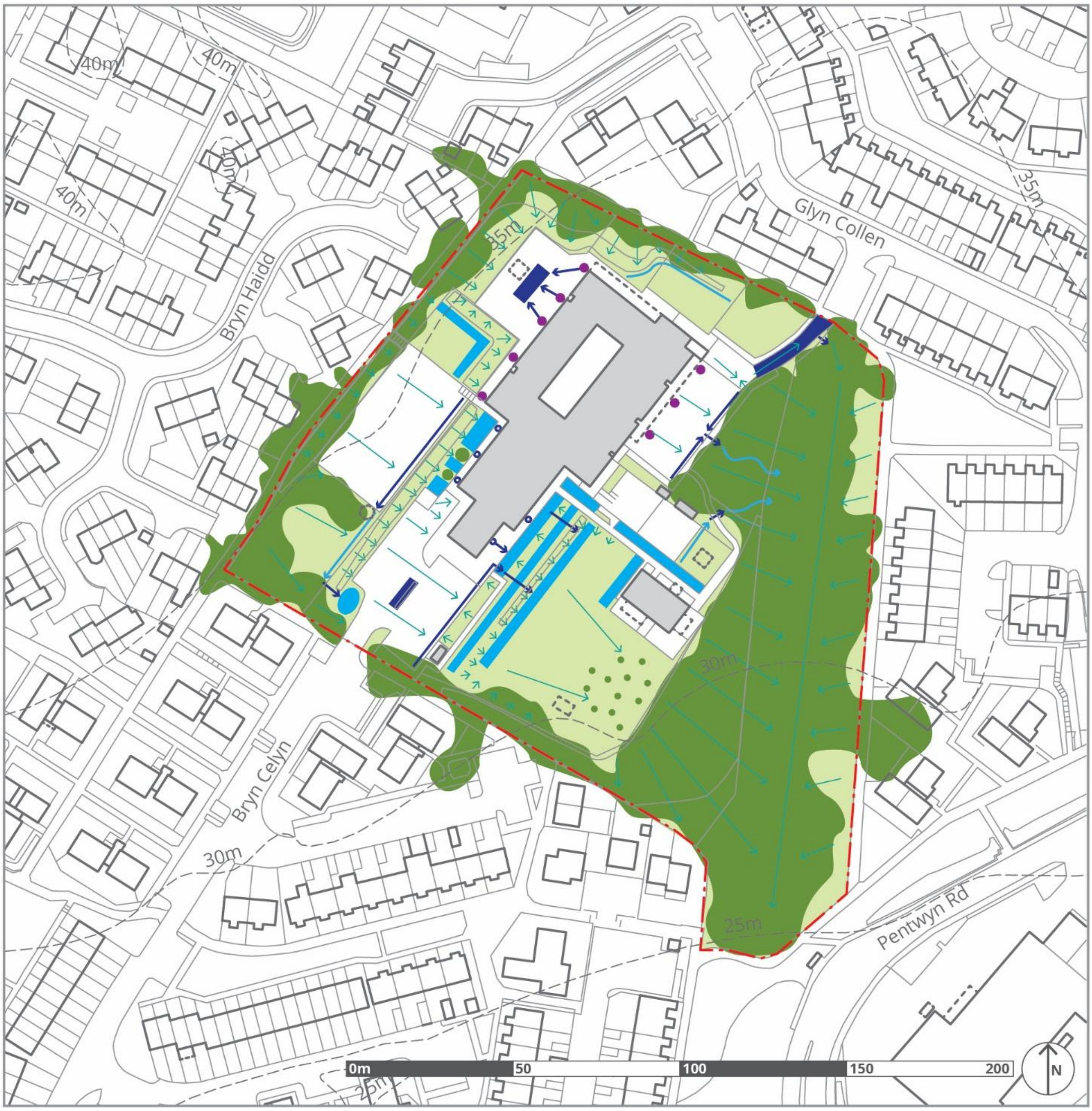
Concept Proposals - description

Concept proposals for Bryn Celyn / Pen Y Groes consider the entire site as a single unit to address the identified problems. Key to this plan is to slow the flow of surface water across the site from west to east by introducing **more shrubs and vegetation** on the west and northern boundaries and using the vegetation to roughen surfaces. Where there are multiple constructed changes in level on hard surfaces, we have proposed an **interconnected sequence of playful rills and channels**, creating space for the water to move across the site. Where hard surfaces are required by the school for formal play, the rills are proposed to the edges of these locations.

To further capture surface water, we propose the use of **interactive and playful rain gardens** that provide controlled volume for during times of heavy rainfall. These rain gardens would act as a temporary storage area for water, ensuring it does not flood areas where it is not wanted. The rain gardens would dry out when it is not raining, slowly draining the surplus water into the existing piped drainage system or allowing it to infiltrate into the ground.

We have proposed **tree trenches** which offer significant volume capacity at the highest part of the site, whilst providing structure, seating and shade to the school grounds. They are positioned to the edges of the play areas again to facilitate business as usual play and sport.

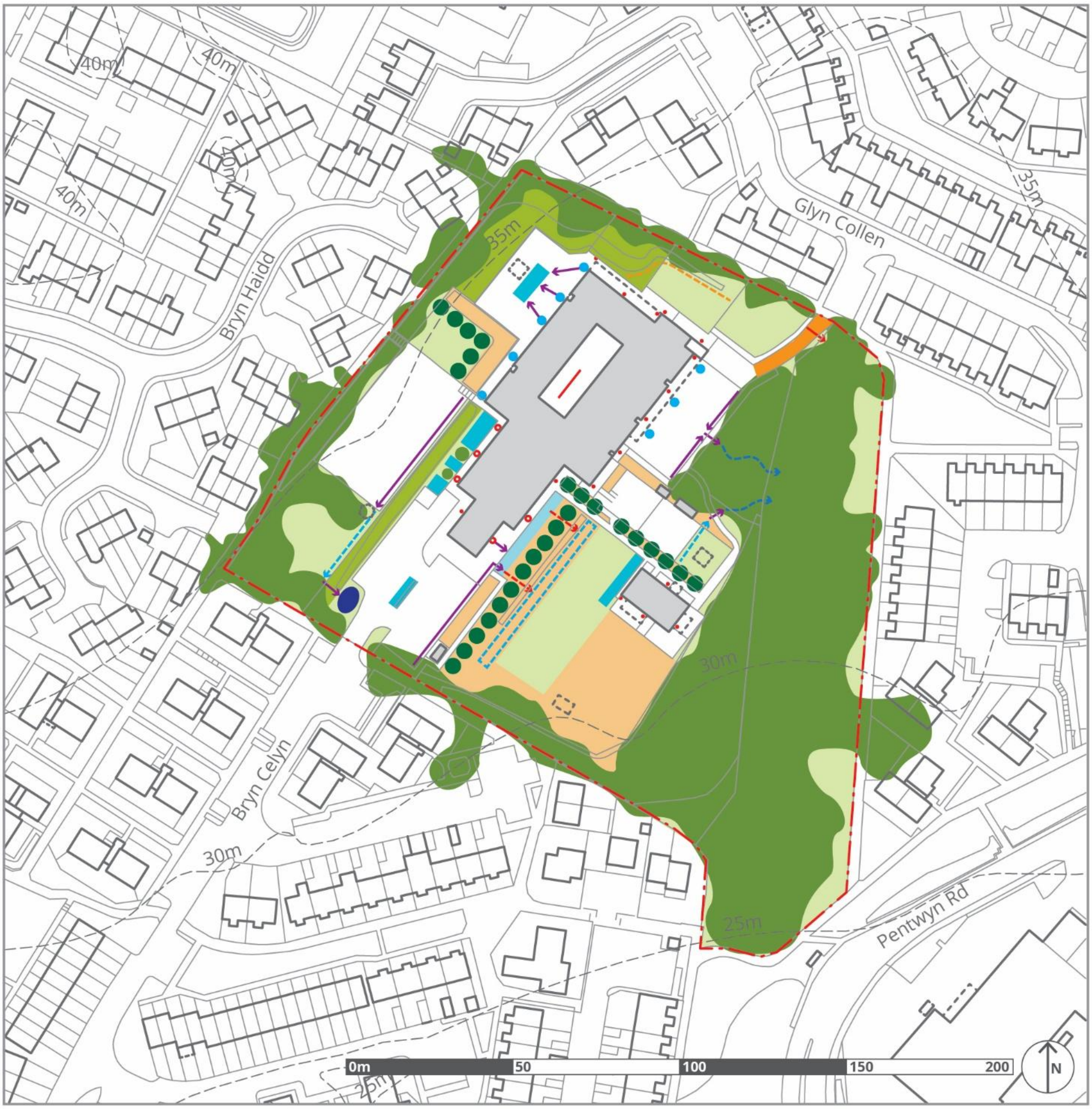
To pick up volume of water discharged from the building roof, we propose several **disconnected down pipes that take water into raised planters** on the northern half of the building, and into **rills and rain gardens** on the southern half of the building. Use of raised planters and disconnected down pipes can be easy to install and offer an efficient, incremental and very effective quick win for this site.



SURFACE WATER MOVEMENT WITH SuDS

- SuDS permeable conveyance channel
- SuDS impermeable conveyance channel
- SuDS feature in existing permeable ground
- SuDS feature in existing impermeable ground
- Disconnected downpipe to rill
- Disconnected downpipe to raised planter / water butt
- Localised falls observed on site

Figure 14 Concept Proposals Bryn Celyn & Pen Y Groes - Surface Water Movement with SuDS



- Swale
- Swale with check dam
- Scrape / dry detention basin
- Rain garden: Tanked, connected to other SuDS
- Rain garden: Tanked, connected to SWS
- Rain garden: Infiltration, & connected to SWS
- Pond / wetland
- Permeable / porous paving
- Meadow
- Shrubs
- Trees in pits / trenches
- Wet woodland trees

SITE DESIGN

- Rill
- French drain
- Grated channel
- Underground pipe connecting SuDS features
- Existing downpipe retained
- Disconnected downpipe to rill
- Disconnected downpipe to raised planter / water butt

Figure 15 Concept Proposals Bryn Celyn & Pen Y Groes – SuDS Master Plan

03 St Cadoc's – Concept Proposals

Main sources of surface water:

1. Large playing field on northern half of site
2. The school's extensive roofscape
3. Hard standing surrounding the building

Concept Proposals – description

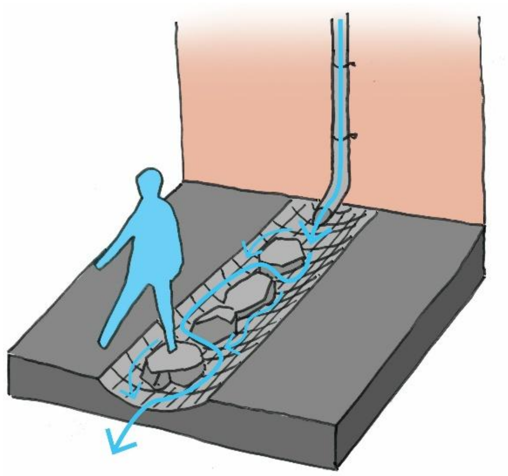
Interconnected High Priority Areas:

- All hard standing areas next to the building where surface water is directed towards the building facades
- Main playing field (preventing water coming off this part of the site will support all other interventions closer to the building
- School entrance to south

Wildflower Scrape in Leicester School

Tree Trench Raingarden, Leicester

Typical Raingarden



Typical Disconnected Downpipe & Channel

Concept Proposals - description

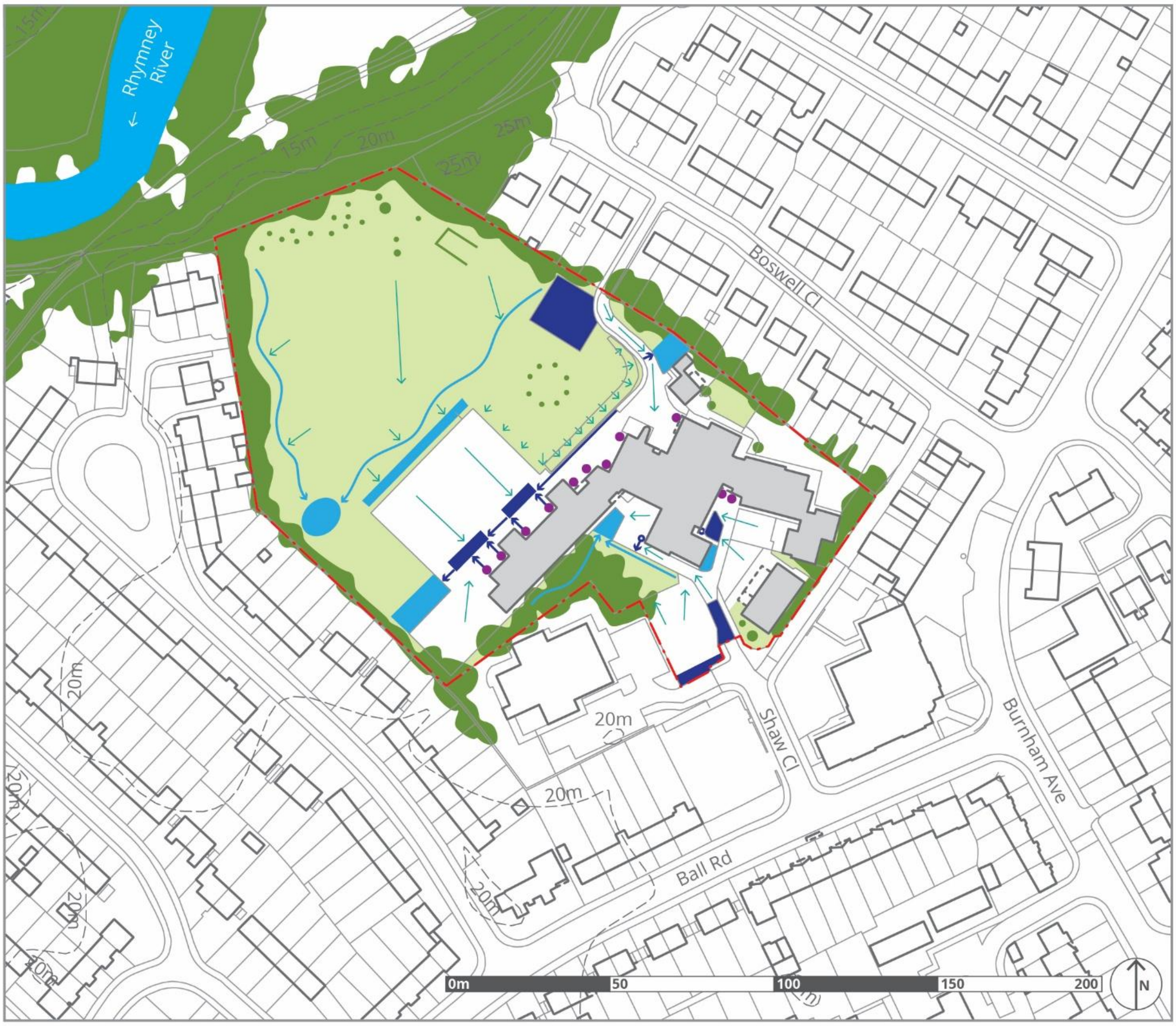
The concept behind this plan is to capture water at source on the main playing field to the north of the school building by introducing **swales and dry basins or scrapes** to hold water back from moving across the site towards the school. We have suggested **managing longer flowering grassland** to the edges of the playing field and to enhance this perimeter space with further trees and vegetation to maximise biodiversity.

To intercept rainwater as it moves towards the school building on all hard surfaces by creating a **tree trench rain garden** between the playing field and the hard surfaced space to the north of the building. **Ground level rain gardens** take surface water off this hard surfaced sports area, linking to a pond on the southern boundary. This redirects the water from the main building and service access road. Rain gardens are temporarily wet, creating volume that fills with water during periods of high rainfall. The **proposed pond** would be designed in agreement with the school, offering a permanently wet wildlife resource whilst functioning to store excess water on site.

To capture large volumes of water that are discharged from the building roof, we have proposed a **series of disconnected down pipes** that take water into **raised planters** on the northern façade of the building, and into **rills and rain gardens** near the southern entrance to the building. Use of raised planters and disconnected down pipes can be easy to install and offer an efficient, incremental and very effective quick win for this site.

Further playful raingardens have been proposed to the southern face of the building utilising surplus spaces and linking into disconnected down pipes.

We have suggested using **permeable paving** in selected areas of the site to reduce surface water runoff from the car park to the north and at the southern entrance threshold.



SURFACE WATER MOVEMENT WITH SuDS

- SuDS permeable conveyance channel
- SuDS impermeable conveyance channel
- SuDS feature in existing permeable ground
- SuDS feature in existing impermeable ground
- Disconnected downpipe to rill
- Disconnected downpipe to raised planter / water butt
- Localised falls observed on site

Figure 16 Concept Proposals St Cadoc's - Surface Water Movement with SuDS

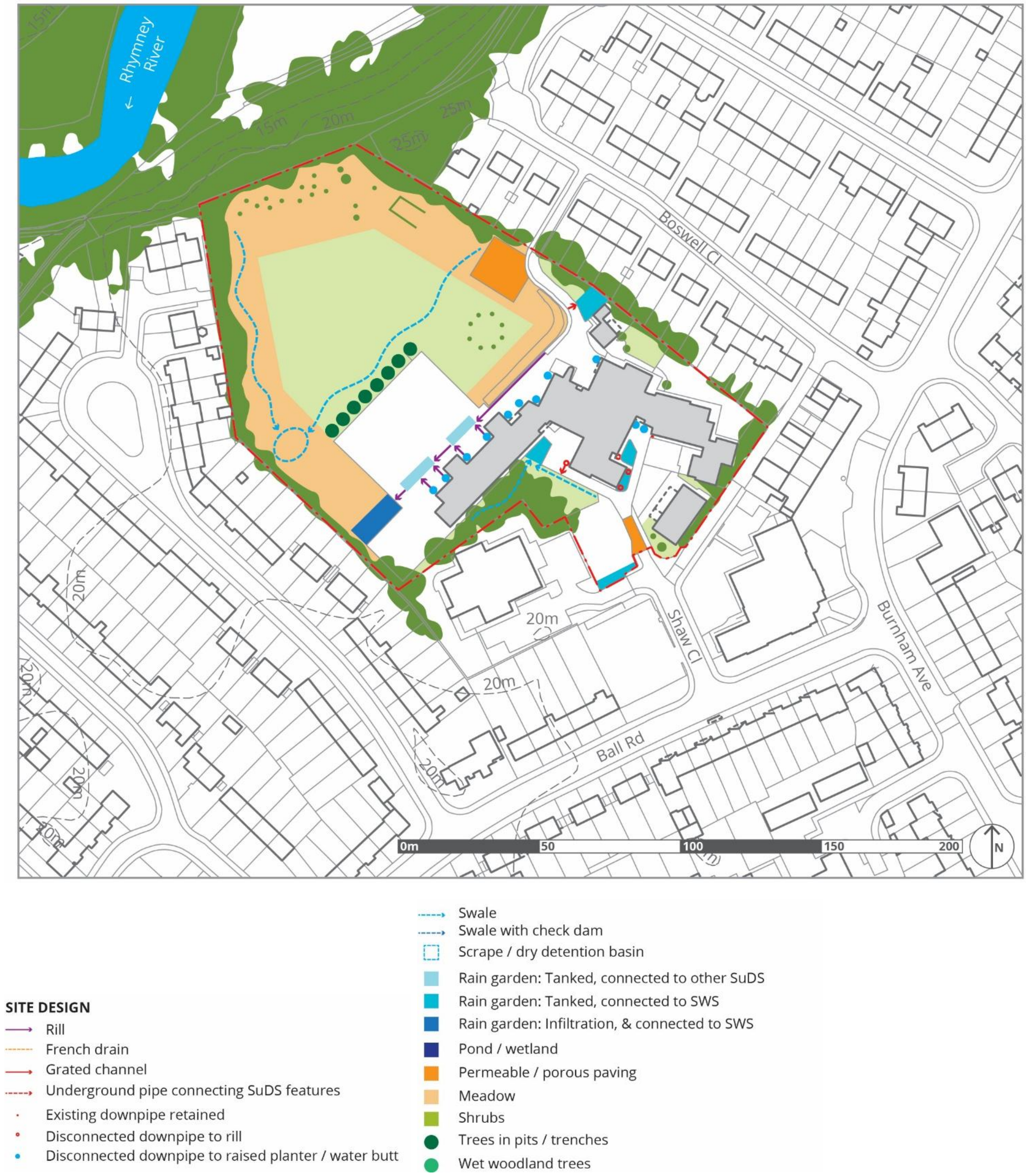


Figure 17 Concept Proposals St Cadoc's – SuDS Master Plan

04 Glyncoed– Concept Proposals

Main sources of surface water:

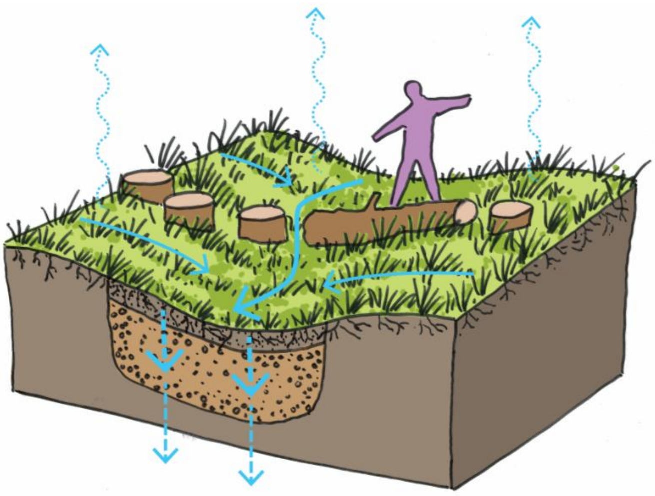
1. Perimeter hard and soft ground boundaries on the west and southern boundaries & surface water and debris ingress from external southern boundary
2. Hard standing play area to the south of the site
3. The school roofs with poorly functioning drainage down pipes and gullies

Interconnected High Priority Areas:

- Perimeter hard and soft ground – narrow, sloping boundaries on the west and southern sides of the site where surface water is directed towards the school building
- All hard standing areas next to the building including building entrances, playground and access pathways
- Car park to north of building

Lower Priority Areas:

- Car park to north of building
- Main playing field (less a priority because the water is moving towards the Nant Glandulas on the north-east boundary)



Typical Playful Swale

Typical Raingarden

Concept Proposals - description

The concept behind this plan is to capture water on the steep and narrow man-made slopes along the western boundary. This is a tricky space as there is little room to implement solutions for the volume of surface water required. Source of water here is from roofs and the adjacent land off site to the west. To capture large volumes of water that are discharged from the building roof into this tight space, we have proposed **a series of disconnected down pipes that take water into rills** at the bottom of the slope. These direct the water around the edge of the playground into a series of **playful swales and rain gardens** where we meet soft ground on the southern entrance. Proposed swales connect a sequence of **dry basins or scrapes** creating volume capacity on site for flood water along the southern boundary to the west of the site.

Additional **vegetation and managed flowering grassland** is proposed to roughen the sloped west and southern boundary surfaces to slow runoff further. Additionally, this is proposed to the perimeter of the playing field where there is capacity to increase biodiverse boundary vegetation, with **trees and managed flowering grasses** as well as a more formal **tree trench and rain garden** for additional drainage capacity, amenity and shade.

Although the focus of this study is within the boundaries of each site, an area of critical influence on surface water flooding within Glyncoed is from the Hawthorn's footpath through the stepped south entrance into the school. A solution on this boundary should ideally be in coordination with a surface water management approach to the footpath and adjacent underpass.

We propose several **interactive and playful rain gardens** to the edges of the main playground south of the building, these would take surface water and roof water from disconnected down pipes via rills. Elsewhere we propose **raised planters and disconnected down pipes** against the building. These can be easy to install and offer an efficient, incremental and very effective quick win for this site.

We propose a **rain garden** for the vehicular entrance north of the school, to pick up on surface water. Simple **drop kerbs** can facilitate water movement into raingardens with minimal changes to hard edging and no loss off parking.

Figure 18 Concept Proposals Glyncoed - Surface Water Movement with SuDS

Figure 19 Concept Proposals Glyncoed – SuDS Master Plan

05 Pen Y Bryn – Concept Proposals

Main sources of surface water:

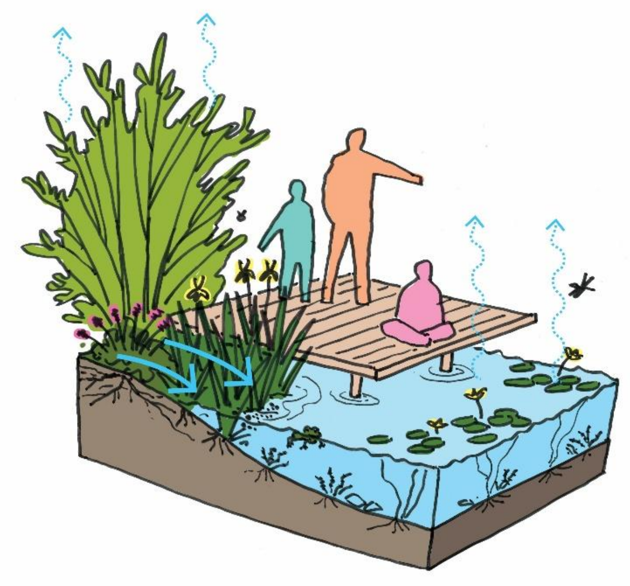
1. Impermeable hard standing to the north of the site
2. Hard standing sports and play areas to the east and south west of the building
3. The school's roofscape

Interconnected High Priority Areas:

- All hard standing areas north of the building including entrances and access pathways
- Areas surrounding the eastern building facade

Lower Priority Areas:

- Hard surfaced sports area to the east of the site
- Car park to north of building
- Main playing field (less a priority because surface water is moving away from the school buildings on the eastern boundary)



Typical Detention Pond/Wetland

Typical Raingarden

Concept Proposals - description

Pen Y Bryn is the smallest of the 5 sites and space for SuDS is precious. Areas in need of drainage solutions are tight and concentrated particularly in the northern corner "pinch point" where the corner of the building meets the boundary fence.

The solution to surface water in this location proposes the use of **series of interactive disconnected down pipes and planters** to collect roof water along the canopy of the northern building façade.

Water on the surface of the northern most corner of the site is directed into a **linear raingarden** that runs along the northern boundary. The water continues its journey from the raingarden into a **narrow rill** taking the water through the tightest part of the site until it reaches soft ground and **a swale** that brings it towards a receiving pond on the north east corner of the site. The **proposed pond** would be designed in agreement with the school, offering a **permanently wet wildlife resource** whilst functioning to store excess water on site. A series of **dry basins or scrapes** are proposed along the eastern boundary along with a proposed **wet woodland set in a managed flowering grassland**. The layout of the naturalised spaces would be in agreement with the school to ensure there is sufficient close mown space for formal sports and play.

On the south and west façade for the building we have proposed a **series of down pipe disconnections, taking roof water into a sequence of rills and channels** leading into **raingardens** next to the school. These would be designed in detail with the school for education, amenity and interactive play. We propose use of **permeable surfacing** to the south east building edge, maintaining this area as hard space for flexible uses.

Dished channels are proposed for the main hard surfaced play area to take water into adjacent **rain gardens** whilst maintaining that space for sports and formal play. On the outer edges of the site to the south, there is scope for further **rain gardens. dry basins and scrapes**.

SURFACE WATER MOVEMENT WITH SuDS

- SuDS permeable conveyance channel
- SuDS impermeable conveyance channel
- SuDS feature in existing permeable ground
- SuDS feature in existing impermeable ground
- Disconnected downpipe to rill
- Disconnected downpipe to raised planter / water butt
- Localised falls observed on site

Figure 19 Concept Proposals Pen Y Bryn - Surface Water Movement with SuDS

SITE DESIGN

- Rill
- French drain
- Grated channel
- Underground pipe connecting SuDS features
- Existing downpipe retained
- Disconnected downpipe to rill
- Disconnected downpipe to raised planter / water butt
- Swale
- Swale with check dam
- Scrape / dry detention basin
- Rain garden: Tanked, connected to other SuDS
- Rain garden: Tanked, connected to SWS
- Rain garden: Infiltration, & connected to SWS
- Pond / wetland
- Permeable / porous paving
- Meadow
- Shrubs
- Trees in pits / trenches
- Wet woodland trees

Figure 20 Concept Proposals Pen Y Bryn – SuDS Master Plan

12 Storage Volume Estimation & Benefits Assessment

Storage Volume Estimation

High level assumptions have been made in calculations for storage volume using the concept plans for each school as the basis. Calculations were created from each site using the HR Wallingford[17] surface water storage estimation tool and are set out below for reference. Concept Proposals have been ambitious in terms of comprehensive considerations for coordinated SuDS systems, however there is scope to be even more ambitious by increasing volume capacity in the large areas of soft ground on each site.

In summary:

- **Concept Proposals for SuDS interventions will reduce runoff from all five sites by around 50%.**
- Whilst these calculations demonstrate a good outcome, **100% reduction is achievable** across all sites due to the land they all have available.

To achieve 100%, the schemes would require greater storage volumes which would mean larger interventions e.g. larger swales at Glyncoed or a less nature-based approach by proposing below ground crate storage at St Illtyd's. Creating additional volume depends on funding and the ambitions of each school.

Our five schools are fortunate in that they have plentiful space to offer up more than token quick wins with planters at the end of downpipes that only manage roof runoff.

These projects demonstrate how problematic flood risk areas such as playgrounds and car parks can be considered as a critical part of the solution, importantly, without compromising current site use.

To achieve successful outcomes, each school needs to be central to a co-design process at detailed design stage so the translation of concept into reality is fully understood and approved by decision makers and the wider school community.

Table 2 – Surface water storage volume L^3 - current land use including new SuDS storage*

	Available storage	Attenuation Storage	% available storage	Long term storage	% difference	total Storage	% difference	Total Storage shortage	% difference
BRYN CELYN/PEN-Y-GROES	664.3	1003	66.23%	301	220.70%	1304	50.94%	639.7	**49.06%**
GLYNCOED	431.7	762	56.65%	206	209.56%	967	44.64%	535.3	**55.36%**
PEN-Y-BRYN	518.86	765	67.82%	185	280.46%	949	54.67%	430.14	**45.33%**
ST CADOC'S	576.94	918	62.85%	273	211.33%	1191	48.44%	614.06	**51.56%**
ST ILLTYD'S	1654.2	2366	69.92%	690	239.74%	3056	54.13%	1401.8	**45.87%**

[17] https://www.uksuds.com/

Refer to Appendix C for further detailed outputs, supporting and comparative calculations

***Storage assumptions**

- Planter – Comparing three products (SuDS Planter, SuDS Pod and East of Eden) used the SuDS Planter 1600x600x950 which is an area of 0.96m^2 and a storage volume of 400 litres (0.4m^3) – this was the best size for storage of all products which meets the 1m^2 assumption, shown in Table 4 Appendix C
- SuDS in existing permeable ground – assumed depth of 600mm and multiplied that by the area giving the volume (the depth has been assumed with underground storage)
- SuDS in existing impermeable ground – assumed depth of 500mm and multiplied that by the area giving the volume
- SuDS conveyance permeable channels –assumed depth of 200mm and a width of 300mm with the length gives a storage volume

SuDS Pollution Matrix Assessment

A SuDS Pollution Matrix Assessment[18] has been carried out as a high level and generic approach.

In summary: The outputs from this assessment demonstrate that the **proposed interventions would be sufficient to manage pollution loadings across all sites.**

Benefits of Proposed SuDS Estimation

ciriabest[19] was tested against on each school individually and collectively with all five schools as essentially a single project to ensure the wider location benefits were captured if applicable.

ciriabest Assessment Process

Refer to Appendix D for all data used against each ciriabest benefit metric gain the results.

The following nine metrics and sub metrics were used in the assessment. Caveats and limitations of the tool for our 5 sites are stated within:

1. Air Quality - **Estimate of the impact of proposals.**
Figures are based on measured area of proposed SuDS in hectares (ha) and proposed number of new trees to be planted.

2. Amenity - Commonly visited local Park or Green Space.
Assumption is based on the pupils attending the school will visit the proposed interventions as a minimum once a year. (*Note - this metric could be considered double counting against Item 6 Education.)*

3.1 Biodiversity - Changes to biodiversity and ecology land use/type (1)
Native Woodland – the size of area (ha) creation of woodland within the project area.

3.2 Changes to biodiversity and ecology land use/type (2)

[18] https://www.uksuds.com/tools/water-quality-assessment-suds-developments-suds-manual

[19] https://www.susdrain.org/resources/best.html

Improved grassland – This is based on area (ha) of pollinator rich species introduced within swales and scrapes.

4. Carbon Sequestration - Assess the Carbon Sequestration from trees planted

Number of trees planted of proposed interventions assumed medium sized deciduous trees.*

*(Note - *Except Glyncoed where 50 of the 60 proposed trees are assumed to be small deciduous.)*

5. Education - Value of Educational Trips visits individual children/year.

Assumed that all pupils attending the school will benefit from the proposed interventions as an educational tool including resources and curriculum activities.*

(Note - **For ciriabest the assumption that all pupils will visit interventions once a year. Cost per visit is assumed at lowest rate due the proposed interventions are within the school grounds.)*

6. Flooding - Retrofit

Due to no known internal flooding from either pluvial or fluvial events at any schools alongside no assessment of the water companies' willingness to pay this metric has not been assessed.

7. Health - Emotional wellbeing (Visits to green space) Adult individuals/year

Assumed there will be two events at the school per year i.e. School Fete/Sports day(s) this allows parents to visit the school and the proposed interventions. The assumption is based on 75%* of pupil's parents/carers will attend each event. e.g. 300 pupils/2/3 = 200 adults X 2 visits = 400 adults visiting the proposed interventions per year.

**The figures used do not account for single parent families or multiple siblings/blended family's attending the same school.*

8.1 Recreation - General Recreational Visits Grassland, Greenbelt, Urban Fringe and Urban Green Space.

Items 1 & 8 combined and divided by 50% (rounded up) as not all will visit grassland throughout the year due to influences such as weather.

8.2 General Recreational Visits to Woodland.

Items 1 & 8 combined and divided by 50% (rounded up) as not all will visit Woodland throughout the year due to influences such as weather.

9. Water Quality - Watercourse or Waterbody Improvement

Although the proposed interventions will provide a benefit this metric has not been measured. At this stage of feasibility the drainage networks and catchments are not understood as to which watercourses or waterbody would be improved.

Results from ciriabest

Results for all five schools are combined in this chapter and each individual school's results are included in Appendix D.

The valuations/assessments are based on the post delivery of the proposed interventions. All figures applied in the tool are new interventions. Two figures shown in the results are based on the confidence values used. "Pre" is before confidence scores are added and "Post" is after the confidence percentages are applied. For example for Bryn Celyn the pre confidence benefits could be £386,046.47 and post confidence benefits could be £119,930.68 so results offer a range between there two figures where actual benefits may sit if SuDS proposals were implemented.

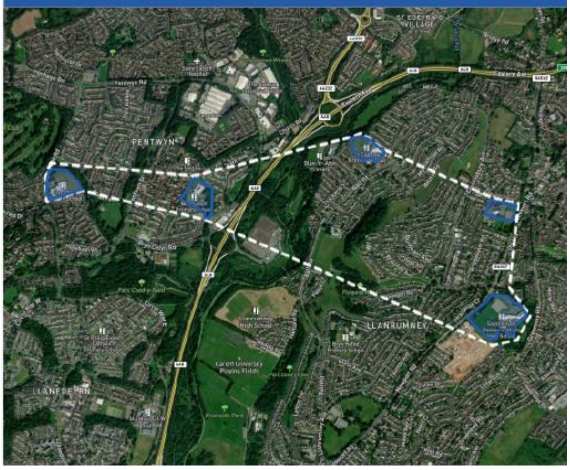
TfC SuDS for Schools - North Cardiff

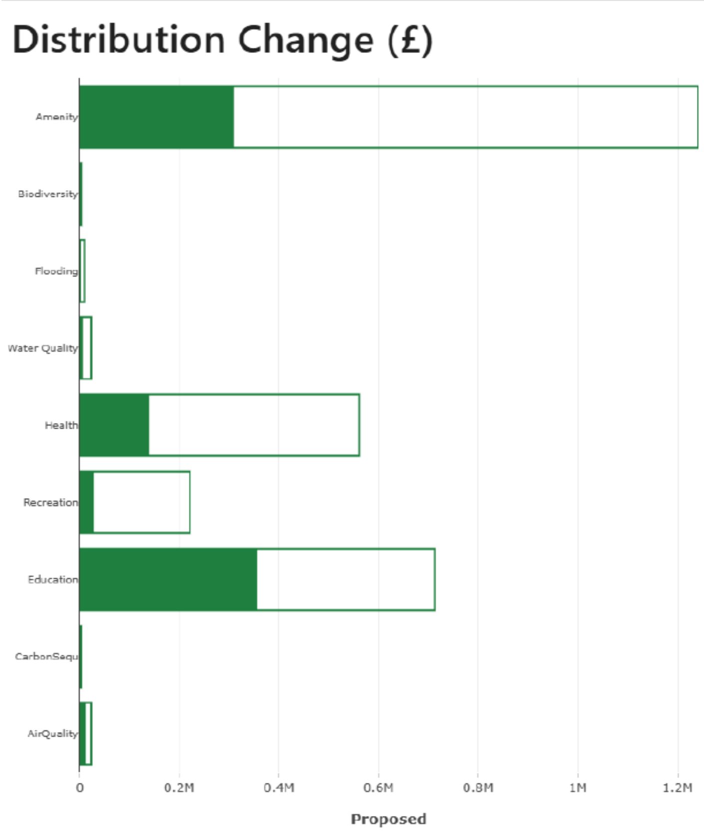
Proposed Benefit Post-Confidence: **£855,878**

Number of Benefits Assessed: **9**

Top 3 in value (proposed post-confidence):

#1	Education	£356,634
#2	Amenity	£310,333
#3	Health	£140,184





Collective outputs of the best performing benefit impact metrics are:

1. **Education** (post confidence range of **£356,634** to pre confidence of **c £0.7million**)
2. **Amenity** (post confidence range of **£310,333** to pre confidence of **over £1.2m**)
3. **Health** (post confidence range of **£140,184** to pre confidence of **c £0.575 million**)

A summary calculated combined financial benefits are estimated to be in the range of the following:

Financial benefits gained for all schools' **top three impacts combined** (based on the conservative post confidence end of the scale) **= £855,878**

Financial benefits gained for all schools, using metrics for **all nine benefits combined** (based on the conservative post confidence end of the scale) **= £856,000**

Total financial benefits gained for all schools, using metrics **for all nine benefits combined** (based on the ***optimistic pre confidence*** end of the scale) **= £2.797 million**

Recreation scored well on the metrics especially if pre confidence scores are applied. However, costs for improvements on other metrics for air quality, carbon sequestration, biodiversity were unsurprisingly small due to the early design stage and small-scale nature of each site, even if collectively measured. When considering each site individually all top three benefit metrics scored most highly and in the same order.

Flooding and water quality demonstrated insignificant improvements through this tool. However, similar benefits have been demonstrated by using other assessment tools' measurements as described earlier for *runoff-retained* and water quality for *pollution loading-as-sufficient* in the proposals.

A breakdown of summary figures for each separate school is included in Appendix D.

Caution and Limitations

The ciriabest tool has clearly demonstrated the proposed interventions will provide added value to the school community and those who visit and access the schools. There are limitations with any estimation tool and it should be understood that ciriabest works better across a wider geographical area measuring multiple interventions. There are other benefits to assess within ciriabest. However, at feasibility stage these metrics and potential outputs are not known.

Should the projects move forward these other metrics, such as water quality, should be measured and those benefits applied at detailed design. Such an approach will significantly refine the ciriabest cost benefit of all proposed projects.

13 Summary & Next Steps

Summary

Testing the feasibility of incorporating SuDS into five school sites that currently suffer from surface water flooding, demonstrates theoretically that SuDS can provide a significant solution to this problem. If the ideas and recommendations in the Concept Proposals are adopted, these can be cost effective, bring additional financial benefits to each school whilst supporting all 4 pillars of SuDS by:

- reducing water quality,
- improving water quality,
- providing amenity for each school and
- increasing habitat creation and biodiversity.

Implementation of SuDS in schools will have positive impact not only for the school, but also for the local area by reducing the runoff from each site and maintaining pollution control. If the Concept design proposals were implemented, the **SuDS interventions would reduce runoff from all five sites by at least 50% with** scope to increase that volume to closer to 100%.

Further assessment of each site for improvements to water quality, suggests that if concept design proposals were installed, **interventions would be sufficient to manage pollution loadings across all five sites.**

Ciriabest has demonstrated strongest positive outcomes collectively on Education, Amenity and Health and on other benefits to a lesser degree. When all benefits are combined the tool demonstrates significant financial gains if SuDS are used on each school.

Financial benefits gained for all schools, using metrics for all benefits combined at a minimum would be **£856,000.**

Total financial benefits gained for all schools, using optimistic end of the output metrics for all combined schools could come close to **£2.797 million.**

In addition to the SuDS pillars this feasibility report demonstrates that if done well, in coordination with the school leaders, pupils and the wider community SuDS can provide significant and wide ranging benefits.

SuDS interventions can:

- Bring educational opportunities that link into the Welsh curriculum
- Create fun and interactive school playgrounds
- Increase year-round opportunities for active play and sporting activities.
- Provide additional benefits of shade through tree cover and thermal comfort if green roofs were adopted
- Be a more cost effective and beneficial intervention than using traditional drainage
- Bring additional cost benefits to each school.

This feasibility Study can serve as a starting point for regular review and assessment of planning and delivery of retrofit SuDS in Welsh schools, in a way that can be replicated and improved over time, through lessons learned by overcoming common challenges.

Next Steps

Capturing the wider benefits of SuDS in our 5 schools beyond the 4 pillars of SuDS, demonstrates significant positive financial benefits to each school and collectively if carried out in a local group.

The case is strong for investment in these schools as pilot projects for other schools to learn from. Detailed design will provide more robust data to support outputs from all tools

It is hoped that Cardiff Council can review the findings of this report and use the learnings and proposals to consider a programme of retrofit to its school estates on the basis that demonstrable benefits can be gained.

Next Steps to achieve this are:

- Produce early **cost estimates**
- Agree **budget**
- Source **funding**
- Appoint correct **team of experienced professionals** including SuDS drainage engineers and landscape architects
- Set up **consultant and steering team** for planning and delivery of detailed design proposals
- Host **School Community engagement and co design** workshops
- Progress the Concept Proposals to **detailed and technical design**
- **Update ciriabest and other benefits analysis** to refine those done at concept stage
- Provide outline **cost estimates**
- **Engage continually** with school leadership, pupils and wider communities
- Appoint **Contractors**
- **Implement**
- **Use**
- **Monitor and Evaluate**
- **Maintain**
- **Share findings** as case studies that set out **the processes, challenges and lessons learned** for iterative implementation of continual improvement to delivering future SuDS in Welsh schools.

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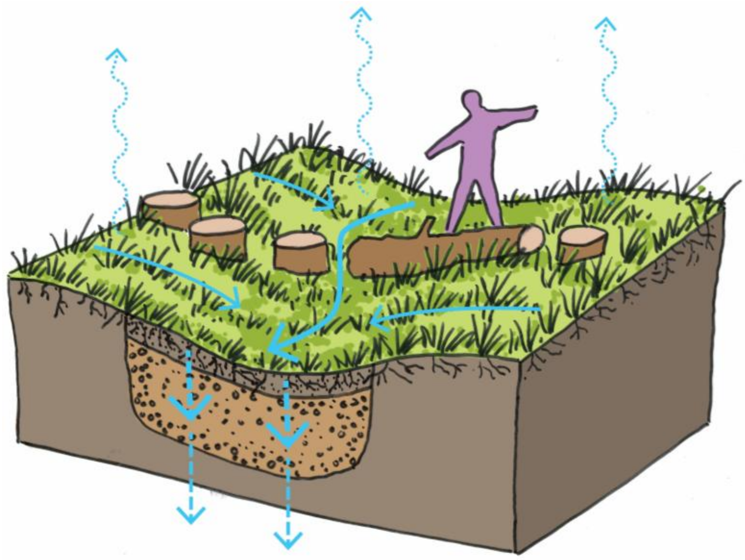
SuDS in Cardiff Schools

Feasibility Study

Appendices



APPENDICES

Appendix A	**SuDS Component Selection Support**
Appendix B	**Permeable and Impermeable Areas for Each Site**
Appendix C	**Surface Water Storage Calculations**
Appendix D	**ciriabest Outputs**
Appendix E	**Cardiff Schools SuDS Engagement – Activity Summary**

Appendix A – SuDS Component Selection Support

The following three tables support the different stages of identifying surface water flooding problems and causes, through to identifying the SuDS component options to help define the best resolution of the identified problem.

- Table 01 SuDS Selection Process - Early Considerations helps to identify if there is a problem, what might be the cause and whether SuDS might be a solution to the problem.
- Table 02 Identifies common and specific problems as found on our 5 schools; considers opportunities to overcome those problems and suggests specific SuDS that could be used to resolve the issue with associated benefits for each SuDS component suggested.
- Table 03 Selected SuDS Components and Application in Schools identifies and illustrates through images a selection of commonly used SuDS interventions with a description of their application and how they might be used in school.

01 SuDS Selection Process - Considerations for SuDS in Schools

The following table 01 sets out early questions to consider if a school is at high risk of surface water flooding. Responses to these questions steer towards most common responses and considerations needed to identify the right SuDS Solution for your school. For the specific problem.

Question	Response	Considerations	Potential SuDS Solutions
Where is the Surface Water coming from?	Roofs Hard surfaces Soft ground Off site	Use this information as a starting point for your SuDS plan; Use this to decide what sort of SuDS interventions might be suitable; Response may be all four	
Can you address Surface Water Flooding at source?	Yes? No?	If "Yes" - then SuDS can be the solution; If "No" - remember there are usually always options for SuDS even if you think there are not - speak to a SuDS advisor e.g. your Local Authority SAB	Taking advice early at Concept Plan design stage will result in the most efficient and comprehensive solution
What is causing the Surface Water Flooding problem?	Existing drainage exceeding capacity	Increase Stormwater Drainage Capacity - SuDS can do this	Consider SuDS over traditional piped drainage

	Poor ground levels; Standing Water - not moving on the surface; Water collecting at or moving towards buildings and infrastructure	Create conveyance or movement routes for flood water away from problem locations; Create capacity to retain surface water and slow the flow	Consider Swales / Rills and channels to move the water from problem areas; Create raingardens, scrapes, basins for volume and to hold the water back
	Existing drainage damaged / malfunctioning	Survey Maintain Repair	Incorporate existing drainage into SuDS to act as overflow for exceedance
Impact of Surface Water flooding - is it preventing the main use of your facilities?	Preventing main use of site; Damaging buildings & infrastructure; Causing school to close or having to close off parts of the school	High Priority	Prioritising your needs will support allocation of funding and the design of a phased implementation of the SuDS Concept Plan
	Inconvenient but school is still functioning; Standing water but able to access site and buildings; not able to use the site for activities	Medium Priority	Plan high priority interventions with future plans in mind to accommodate additional features later when funding becomes available
	Seasonal surface water flooding	Lower Priority	
Does your school have space to retain the water on site?	Yes	If "Yes": Consider SuDS and establish your Concept plan; Retain surface water on site & release slowly	Use this information to plan the locations, routes and scale of your SuDS interventions
	No	If "No": Remember SuDS can be used even in very small sites	Consider disconnected down pipes and planters
How much space is available for SuDS?	Consider parameters of the site for interventions and places that cannot be altered; Measure the area of land to plan where SuDS may be planned and incorporated	Work closely with your advisers to plan locations, flow of surface water and quantity of surface water that could potentially be treated using SuDS	Use this information to plan the scale and scope of your SuDS interventions

How much of the site is permeable?	Measure areas of permeable land	Permeable land is easier to work with when creating SuDS; Soft ground is usually cheaper to work with than digging into hard	Use edges of soft ground to create Swales, Scrapes and Dry Basins; Use soft ground to plant up with trees and shrubs; Create biodiverse wildflower meadows or change the mowing regime to a 2 times per year to allow flowering grasses and rougher surfaces; Make sure soft ground is maintained - tilled & aerated where compacted
What areas of the site are impermeable (including roofs)?	This will inform options for concept design and the scale of the problem	Are there sheds or out buildings that might take small green roofs? Are there down pipes that can be disconnected & fed into raised planters?; Where can you break out hard surfaces that won't disturb existing functions of the school?	Consider the best place to accommodate SuDS in hard such as: Rain gardens Raised Planters Small green roofs
How does the Surface Water move across the site	Use Contour maps for concept plan and Topographical Survey for detailed levels at detailed design stage	Try to plan connected SuDS to follow the natural falls of the site	Join up SuDS with: Swales Rills Channels
Where will the Surface Water be discharged	Check existing discharge points	Retain water on site where feasible: Use existing drainage to take excess water from SuDS	Keep outlets discrete; Integrate Outlets & Inlets into SuDS design to be functional whilst being attractive and fun

02 Opportunities for SuDS to Resolve Common Surface Water Problems

(Taken from Main feasibility Study)

Problem	Opportunity	Applicable SuDS Components	SuDS Benefits & Performance
Large areas of impermeable surfaces	**Break out hard surfaces** that are not essential for play, sports, pedestrian and vehicular use and introduce permeable surfaces, soil and water This is "**De-paving" to create rain gardens / tree trenches** incorporated for permeability across the site without compromising current needs and uses	• **De-paved tree trenches** with **porous structured soils** • Interactive and playful **rain gardens** with integrated hard & soft materials • **Removal of raised edges** to allow better flow of surface water from impermeable to permeable • **Permeable unit paving or porous surfacing** such as: - soft play - gravel - stone aggregate - open-joint brick pavers - open paving patterns - grass-concrete pavers - woodchip and bark, - composite resin etc	**Benefits** - **Water Quantity** - **Water Quality** - **Amenity** - **Biodiversity** - **Shade** - **Education** - **Play /Fun** **Performance** - **Interception** - **Storage** - **Infiltration** - **Conveyance**
Large areas of impermeable roofscapes	Where feasible **retrofit green roofs** to small low risk out buildings such as garages, storage sheds etc; **Disconnect down pipes** and **divert roof water** into **water storage butts, raised planters** and **ground level rain gardens**	**Small green roofs** retrofit to Bike sheds and storage containers, **Disconnected down pipes** attached to: • **Water butts** • **Raised planters** • **Ground level rain gardens**	**Benefits** - **Water Quantity** - **Water Quality** - **Amenity** - **Biodiversity** - Shade - **Education** - **Play /Fun** **Performance** - **Interception** - **Storage** - **Infiltration**
Buildings blocking the natural flow of surface water and creating pinch points	Consider opportunities to retain water on the surface **linking to other parts of the site via rills, swales or surface gullies**, using below ground pipes only where absolutely essential **Break out sections of kerbs and edging** to encourage conveyance of	• **Swales** on soft ground • **Rills and channels** on hard surfaces • **Drop kerbs** • **Gaps in edging** between hard and soft ground	**Benefits** - **Water Quantity** - Water Quality - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Conveyance**

	water from hard to soft ground		
Existing drainage infrastructure – down pipes and gullies exceeding limits	Introduce playful interception components such as **raised planters** or **ground level rain gardens** with **channels**	Disconnected down pipes attached to: • **Water butts** • **Raised planters** • **Ground level rain gardens** **Integrate surface gullies into raingardens** for exceedance management	**Benefits** - **Water Quantity** - **Water Quality** - **Amenity** - Biodiversity - Shade - **Educational** - **Play /Fun** **Performance** - **Interception** - **Storage** - **Infiltration**
Possible hidden problems / malfunctioning drainage	**Survey & repair** extant drainage systems. **Increase capacity** of extant drainage facility where feasible. **Ensure maintenance of SuDS is planned** within capability and resources of School and Council	Design with existing drainage & **plan its maintenance** alongside new SuDS	**Performance** - **Conveyance**
Ad hoc and retrofitted changes in levels to accommodate add-on sports and other facilities	Create **breaks in kerb edges or introduce dropped kerbs** to allow movement of water from hard ground to soft. Anticipate potential problems from future development of changes to landscape.	• **Drop kerbs** • **Gaps in edging** • **Outlets**	**Benefits** - **Water Quantity** - Water Quality - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Conveyance**
Large scale impermeable access roads & car parking	Introduce **permeable surfaces** without reducing pedestrian, car parking & vehicular access provision. **Create space for surface water on soft ground to edges** of parking spaces. Create **breaks in kerb edges or introduce dropped kerbs** to allow movement of water from hard ground to soft. Introduce **rain gardens** at edges of hard surfaces.	• **Permeable unit paving or porous surfacing** • **Swales on soft ground** • **Ground level rain gardens**	**Benefits** - **Water Quantity** - **Water Quality** - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Interception** - **Storage** - **Infiltration** - **Conveyance**

Compacted heavy clay soils	**Aerate the soil** in places where there is heavy footfall as part of normal maintenance Soil can be tilled over on plant beds **Better protection of planted areas** from footfall	• General design and **maintenance** considerations	**Benefits** - **Water Quantity** - **Water Quality** - Amenity - Biodiversity - Shade - Educational - Play /Fun **Performance** - **Infiltration**

03 Selected SuDS Components and Application in Schools

The following SuDS components and details have been identified as some of those most suited for use in different combinations across all 5 schools. It is recommended that these SuDS are used in a connected combination that links each component across the site wherever possible. This can be used to identify options for schools at detail design stage.

SuDS Component	Component Description	Purpose for Schools
Disconnected Down Pipes 	Disconnected down pipes are a quick win intervention that takes up little space with minimal expense and disruption. Disconnecting down pipes significantly manages surface water discharge from large areas of impermeable roof. IMAGES – Wendy Allen design; Robert Bray Associates; Owen Davies	Disconnecting down pipes takes roof water into a playful system that feeds water into raised beds or ground level rain gardens. Rerouting water on its journey creates educational, playful and interactive functionality.
Raised Planters 	Raised planters are normally attached to disconnected down pipes and can be used in areas for water volume where space is tight. They are an efficient way of capturing roof water and can come in a variety of sizes. Often used where digging into the surface is not feasible.	Raised bed are a very accessible SuDS intervention in schools - children can be directly involved in planting and maintaining them. With fun down pipes and information boards, these interventions are an excellent way of educating children about the SuDS in their schools.

Rain Gardens 	Simple shallow depressions at ground level that allow surface water run off to pond temporarily and infiltrate through vegetation and soils; Called rain gardens in this application or known also as bioretention systems. IMAGES – Trees for Cities; Meristem Design via David MacColl	Proposed widely to capture water in areas that demonstrate significant areas of ponding on hard surfaces. Aim to ensure education & playfulness is integrated into design and they are located in careful positions so other formal play and activity is not hindered.
Water Butts  IMAGE – Get Composting	A simple intervention that can be attached to a disconnected down pipe to pick up roof water for irrigation	

Tree Pits & Tree Trenches

Incorporated into a range of SuDS components, trees can support high performance of bioretention systems, ponds, wetlands infiltration systems through evapotranspiration, soil stability, offering biodiversity, shade and thermal comfort benefits.

IMAGES – Arup; Trees for Cities

Trees are proposed across all school sites forming parts of wet woodlands, in trenches as bioretention systems and large rain gardens. Tree pits
In schools can be protected by using seating and low picket fences to edges without preventing water from moving over flush kerbs into their soil.

Cardiff City Centre has engineered tree pits and trenches as large scale raingardens, using engineered specialised soils. These principles can be adapted for small scale school interventions too.

Scrapes / Dry Retention Basins

A generally dry depression in a landscape linked to a swale, pipe or channel; They normally only are wet when it rains;

Overflow is incorporated and can form part of set of adjustable weirs along a swale as an example. Sometimes called a Scrape.

IMAGES –Groundwork London/susdrain; Arup; Urban design Group

These can be used in the soft ground around the edges of playing fields and boundaries on our schools to support movement of water away from playing fields and hard surfaces next to school buildings.

They can be a playful dry rivers mimicking a river bed with vegetation, stepping stones and rocks to scramble over

Swales

Swales are vegetated channels used to convey water from one part of a SuDS component to another, while the water is being infiltrated enroute.

Swales can be grassed and vegetated with rough edges or close mown to increase flow.

Swales are connective SuDS that link different components and features together – playful stepping blocks and a check dams (or weirs) can been installed to make the site accessible and to slow the flow of water

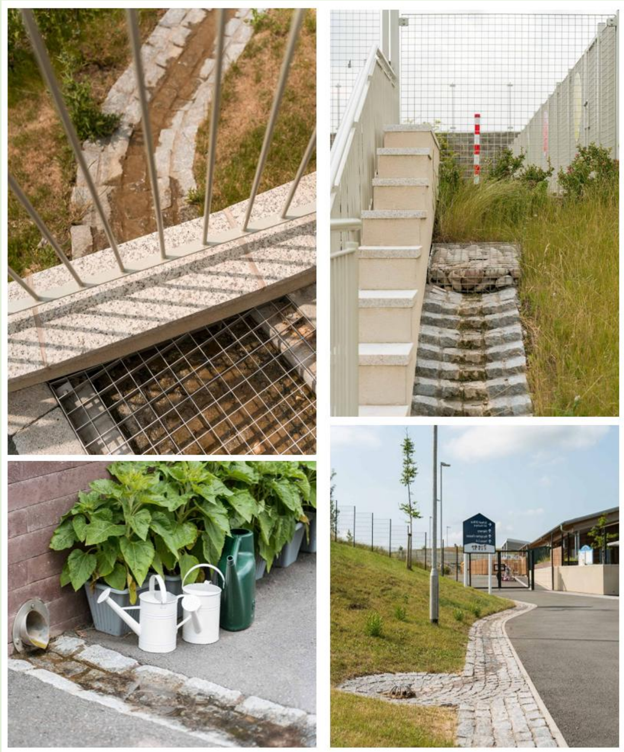
IMAGES - https://slowtheflow.net/; Groundwork London; susdrain

In our schools we want to slow the flow and this can be supported by having rough grassed edges with vegetation to their edges.

The swales can be used to capture and hold back water via stepped adjustable check dams or weirs.

Swales provide opportunities for education and fun whilst serving a significant surface water management function at the same time.

Channels & Rills



Narrow hard-edged, shallow channels that are used to convey surface water where space is limited.

IMAGES – Robert Bray Associates

They connect SuDS across footpaths and play areas or at edges of car parking. They can be shallow without the need for a grate or deeper requiring a grated cover to avoid trip hazards.

Permeable or Porous Paving

IMAGES – SmartPave; UniLock; Grasspark

Permeable and porous paving materials are used in places where hard surfaces are required to take vehicles and other heavy loads. Permeable paving is designed to allow water to infiltrate between the joints into a porous foundation. Concrete blocks, aggregates and concrete / plastic blocks with voids for soil and gravel can be used to reduce run off and retain surface water between the paving and in the porous foundation layers.

In more naturalistic spaces bark and wood chippings can be effective with regular top ups.

Permeable paving is a useful intervention in schools for formal play areas with porous rubber crumb surfacing; or for use in places where surface water causes problems; where there is heavy footfall and/ or vehicular movement.

This is a more expensive option that other suggestions and should be used only where needed to keep costs within budgets.

Small Scale Green Roofs

Green roofs can capture rain water at source, whilst offering a biodiverse alternative to impermeable roofing materials. They can offer further thermal comfort keeping buildings cool in summer and insulating in winter.

IMAGES – The Grass Roof Company; Groundwork London/susdrain

In schools where SuDS is being retrofitted the most simple and least risky areas for green roofs are on the tops of small structures like bin stores, bike stands and containers used for storage.
Green roofs can retain significant volume and quantity of surplus roof water whilst offering biodiverse, educational opportunities.

Kerbs - Raised with Gaps and Flush

Kerb details and flush levels offer opportunities for water to flow into adjacent porous ground, trenches, raingardens or filter drains.

IMAGES – Meristem Design via David MacColl; Arup via Greenblue Urban

Drop kerbs can be retrofitted into a site to avoid expensive adjustments by resetting them flush with ground level

Rain gardens can be defined by kerbs with breaks, rocks and stepping stones, timber logs and edging

Appendix B Permeable and Impermeable Areas for Each Site

Existing Surface Measurements Without SuDS

	EXISTING								
	TOTAL SITE AREA (m2)	A: PERMEABLE GROUND (m2)	A: PERMEABLE GROUND (%)	B: IMPERMEABLE GROUND (m2)	B: IMPERMEABLE GROUND (%)	C: IMPERMEABLE BUILDING (m2)	C: IMPERMEABLE BUILDING (%)	TOTAL IMPERMEABLE AREA (B + C) (m2)	TOTAL IMPERMEABLE AREA (B + C) (%)
BRYN CELYN/PEN-Y-GROES	26,694	17,997	67.4	5,996	22.5	2,701	10.1	8697	32.6
GLYNCOED	25,922	18,707	72.2	4,734	18.3	2,481	9.6	7215	27.8
PEN-Y-BRYN	16,278	9,191	56.5	5,285	32.5	1,802	11.1	7087	43.5
ST CADOC'S	19,186	11,412	59.5	5,666	29.5	2,108	11.0	7774	40.5
ST ILLTYD'S	57,095	37,385	65.5	14,703	25.8	5,007	8.8	19710	34.5

St Illtyd's

Bryn Celyn/Pen Y Groes

St Cadoc's

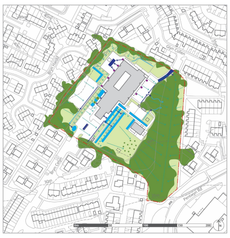
Glencoed

Pen Y Bryn

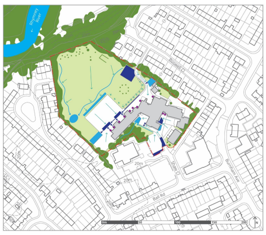
Proposed Surface Measurements with SuDS

	PROPOSED								
	D: SuDS IN EXISTING PERMEABLE GROUND (m2)	E: SuDS IN EXISTING IMPERMEABLE GROUND (m2)	F: SuDS DOWNPIPE PLANTER/WATER BUTT (m2)	TOTAL SuDS AREA (D + E + F) (m2)	G: SuDS CONVEYANCE PERMEBALE CHANNEL (m)	H: SuDS CONVEYANCE IMPERMEBALE CHANNEL (m)	TOTAL SuDS CONVEYANCE CHANNEL LENGTH (G + H)	EXISTING PERMEABLE GROUND + SuDS IN EXISTING IMPERMEABLE GROUND (A + E) (m2)	EXISTING PERMEABLE GROUND + SuDS IN EXISTING IMPERMEABLE GROUND (A + E) (%)
BRYN CELYN/PEN-Y-GROES	930	197	8	1135	90	188	278	18,194	68.2
GLYNCOED	602	115	4	721	190	205	395	18,822	72.6
PEN-Y-BRYN	490	437	6	933	66	244	310	9,628	59.1
ST CADOC'S	513	502	11	1026	229	93	322	11,914	62.1
ST ILLTYD'S	1,879	996	9	2,884	420	462	882	38,381	67.2

St Illtyd's



Bryn Celyn/Pen Y Groes



St Cadoc's

Glencoed

Pen Y Bryn

Appendix C – Surface Water Storage Calculations

Table 1 – Surface water storage volume - current land use including new SuDS storage* *(Used in Main Feasibility Study)*

	Surface Water Storage Volume (current land including new SuDS storage)								
	Available storage	Attenuation Storage	% available storage	Long term storage	% difference	total Storage	% difference	Total Storage shortage	% difference
BRYN CELYN/PEN-Y-GROES	664.3	1003	66.23%	301	220.70%	1304	50.94%	639.7	49.06%
GLYNCOED	431.7	762	56.65%	206	209.56%	967	44.64%	535.3	55.36%
PEN-Y-BRYN	518.86	765	67.82%	185	280.46%	949	54.67%	430.14	45.33%
ST CADOC'S	576.94	918	62.85%	273	211.33%	1191	48.44%	614.06	51.56%
ST ILLTYD'S	1654.2	2366	69.92%	690	239.74%	3056	54.13%	1401.8	45.87%

Table 2 – Surface water storage volume – Using increased permeable area. This table just shows that if we include the SuDS being introduced in the hard areas it increases the permeable area so requires slightly less storage volume

	Surface Water Storage Volumes (Using increased permeable area)								
BRYN CELYN/PEN-Y-GROES	664.3	990	67.10%	297	223.67%	1287	51.62%	622.70	48.38%
GLYNCOED	431.7	751	57.48%	199	216.93%	949	45.49%	517.30	54.51%
PEN-Y-BRYN	518.86	720	72.06%	156	332.60%	877	59.16%	358.14	40.84%
ST CADOC'S	576.94	780	73.97%	206	280.07%	986	58.51%	409.06	41.49%
ST ILLTYD'S	1654.2	2246	73.65%	655	252.55%	2900	57.04%	1245.80	42.96%

Table 3 – Surface water storage volume – difference between table 1 & 2

	Difference								
BRYN CELYN/PEN-Y-GROES	0	13	-0.87%	4	2.97%	17	-0.67%	17.00	0.67%
GLYNCOED	0	11	-0.83%	7	7.37%	18	-0.85%	18.00	0.85%
PEN-Y-BRYN	0	45	-4.24%	29	52.14%	72	-4.49%	72.00	4.49%
ST CADOC'S	0.00	138	-11.12%	67	68.73%	205	-10.07%	205.00	10.07%
ST ILLTYD'S	0.00	120	-3.74%	35	12.81%	156	-2.91%	156.00	2.91%

*Storage assumptions

- Planter – Comparing three products (SuDS Planter, SuDS Pod and East of Eden) selected the SuDS Planter 1600x600x950 which is an area of 0.96m^2 and a storage volume of 400 litres (0.4m^3) – this was the best size to storage of all products which meets the 1m^2 assumption, shown in Table 4 below
- SuDS in existing permeable ground –assumed a depth of 600mm and multiplied that by the area giving the volume (the depth has been assumed with underground storage)
- SuDS in existing impermeable ground – assumed a depth of 500mm and multiplied that by the area giving the volume
- SuDS conveyance permeable channels – I assumed a depth of 200mm and a width of 300mm with the length gives a storage volume

Based on concept proposals these calculations are assumptions and a broadbrush approach. These are likely to change after detailed design and it is likely that the storage volume would increase.

Table 4 – Downpipe planters comparison

	SuDS Planter					SuDS Pod		East of Eden - Rain Garden Planter				
Size	Extra Small (l)	Small (l)	Medium (l)	Large (l)	Extra Large (l)	Total Capacity (l)	Stored volume (l)					
mm	800x600x950	1200x600x950	1600x600x950	2000x600x950	2000x1000x950	1262x623x1025		1000x650x900	1200x650x900	1500x650x900	1800x650x900	2000x650x900
area (m^2)	0.48	0.72	0.96	2	2	0.79		0.65	0.78	0.975	1.17	1.3
litres	150	300	400	500	900	445	81	208.08	257.04	330.48	403.92	452.88
M^3	0.15	0.3	0.4	0.5	0.9	0.445	0.81	0.208	0.257	0.33	0.4039	0.4528

Outputs for each school from HR Wallingford's Surface water Storage Estimation Tool

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	Owen Davies
Site name:	St Illytd's High School
Site location:	Cardiff

This is an estimation of the storage volume requirements that are needed to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	51.51771° N
Longitude:	3.11519° W
Reference:	198579725
Date:	Feb 20 2025 13:01

Site characteristics

Total site area (ha):	5.71
Significant public open space (ha):	3.74
Area positively drained (ha):	1.9699999999999998
Impermeable area (ha):	1.9699999999999998
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	1.97
Net impermable area for storage volume design (ha):	1.97
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
SPR:	0.3	0.3

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	70
Rainfall 100 yrs 12 hrs:	--	97.44
FEH / FSR conversion factor:	1.16	1.16
SAAR (mm):	1019	1019
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.3	0.3
Hydological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 10 year:	1.42	1.42
Growth curve factor 30 year:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Q_{BAR} for total site area (l/s):	16.15	16.15
Q_{BAR} for net site area (l/s):	5.57	5.57

Design criteria

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	4.9	4.9
1 in 30 years (l/s):	9.9	9.9
1 in 100 year (l/s):	12.1	12.1

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	2366	2366
Long term storage 1/100 years (m^3):	690	690
Total storage 1/100 years (m^3):	3056	3056

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	Owen Davies
Site name:	St Cadoc's Primary School
Site location:	Cardiff

This is an estimation of the storage volume requirements that are needed to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	51.52665° N
Longitude:	3.12654° W
Reference:	3423952849
Date:	Feb 20 2025 13:15

Site characteristics

Total site area (ha):	1.92
Significant public open space (ha):	1.14
Area positively drained (ha):	0.78
Impermeable area (ha):	0.78
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.78
Net impermable area for storage volume design (ha):	0.78
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
SPR:	0.3	0.3

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	70
Rainfall 100 yrs 12 hrs:	--	97.44
FEH / FSR conversion factor:	1.16	1.16
SAAR (mm):	1062	1062
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.3	0.3
Hydological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 10 year:	1.42	1.42
Growth curve factor 30 year:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Q_{BAR} for total site area (l/s):	5.7	5.7
Q_{BAR} for net site area (l/s):	2.31	2.31

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	4.1	4.1
1 in 100 year (l/s):	5	5

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	918	918
Long term storage 1/100 years (m^3):	273	273
Total storage 1/100 years (m^3):	1191	1191

TREES FOR CITIES

hrwallingford

Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	Owen Davies
Site name:	Glyncoed Primary School
Site location:	Cardiff

This is an estimation of the storage volume requirements that are needed to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	51.52461° N
Longitude:	3.15368° W
Reference:	689522190
Date:	Feb 20 2025 13:13

Site characteristics

Total site area (ha):	2.59
Significant public open space (ha):	1.87
Area positively drained (ha):	0.7199999999999998
Impermeable area (ha):	0.7199999999999998
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.72
Net impermable area for storage volume design (ha):	0.72
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
SPR:	0.3	0.3

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	70
Rainfall 100 yrs 12 hrs:	--	97.44
FEH / FSR conversion factor:	1.16	1.16
SAAR (mm):	1083	1083
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.3	0.3
Hydological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 10 year:	1.42	1.42
Growth curve factor 30 year:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Q_{BAR} for total site area (l/s):	7.87	7.87
Q_{BAR} for net site area (l/s):	2.19	2.19

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	3.9	3.9
1 in 100 year (l/s):	4.8	4.8

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m³):	762	762
Long term storage 1/100 years (m³):	206	206
Total storage 1/100 years (m³):	967	967

This report was produced using the storage estimation tool developed by HRWallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at http://uksuds.com/terms-and-conditions.htm. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.

hrwallingford

Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	Owen Davies
Site name:	Bryn Celyn Primary School
Site location:	Cardiff

This is an estimation of the storage volume requirements that are needed to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	51.52446° N
Longitude:	3.14178° W
Reference:	2498558631
Date:	Feb 20 2025 13:10

Site characteristics

Total site area (ha):	2.67
Significant public open space (ha):	1.81
Area positively drained (ha):	0.8599999999999999
Impermeable area (ha):	0.8599999999999999
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.86
Net impermable area for storage volume design (ha):	0.86
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
SPR:	0.3	0.3

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	70
Rainfall 100 yrs 12 hrs:	--	97.44
FEH / FSR conversion factor:	1.16	1.16
SAAR (mm):	1083	1083
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.3	0.3
Hydological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 10 year:	1.42	1.42
Growth curve factor 30 year:	1.78	1.78

Design criteria

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Growth curve factor 100 years:	2.18	2.18
Q_{BAR} for total site area (l/s):	8.11	8.11
Q_{BAR} for net site area (l/s):	2.61	2.61

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2.3	2.3
1 in 30 years (l/s):	4.6	4.6
1 in 100 year (l/s):	5.7	5.7

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	1003	1003
Long term storage 1/100 years (m^3):	301	301
Total storage 1/100 years (m^3):	1304	1304

This report was produced using the storage estimation tool developed by HRWallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at http://uksuds.com/terms-and-conditions.htm. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.

TREES FOR CITIES

hrwallingford

Surface water storage requirements for sites

www.uksuds.com | Storage estimation t

Calculated by:	Owen Davies
Site name:	Pen-Y-Bryn Primary School
Site location:	Cardiff

This is an estimation of the storage volume requirements that are needed to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	51.52354° N
Longitude:	3.11615° W
Reference:	2269104260
Date:	Feb 25 2025 18:30

Site characteristics

Total site area (ha):	1.63
Significant public open space (ha):	0.92
Area positively drained (ha):	0.7099999999999999
Impermeable area (ha):	0.7099999999999999
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.71
Net impermable area for storage volume design (ha):	0.71
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
SPR:	0.3	0.3

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	70
Rainfall 100 yrs 12 hrs:	--	97.44
FEH / FSR conversion factor:	1.16	1.16
SAAR (mm):	1041	1041
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.3	0.3
Hydological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 10 year:	1.42	1.42
Growth curve factor 30 year:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Q_{BAR} for total site area (l/s):	4.73	4.73
Q_{BAR} for net site area (l/s):	2.06	2.06

Design criteria

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	3.7	3.7
1 in 100 year (l/s):	4.5	4.5

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m³):	765	765
Long term storage 1/100 years (m³):	185	185
Total storage 1/100 years (m³):	949	949

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Appendix D – ciriabest Outputs

Appendix D spreadsheet sets out all the numbers used for the 9 ciriabest / B£ST metrics measured (of which 7 were viable), with justifications, assumptions and confidence values used.

Item	1	2			3
Metric		Air Quality			Amenity
Title	Number of pupils	SuDS Area m²	SuDS Area ha	Trees	Visited Green Space
Bryn Celyn	314	1133	0.113	26	314
Glyncoed	348	721	0.072	10	348
Pen-Y-Bryn	249	933	0.093	20	249
St Cadoc's	335	1026	0.103	8	335
St Illtyd's	926	2884	0.288	87	926
Comment	Number of pupils at each school	Conversion of m² to ha and number of trees introduced			Commonly Visited park or green space People visiting/year
Justification/Assumptions Approach	N/A	Direct figures from feasibility outputs			Assumed people visiting will be pupils from the school at one visit per year* *This could be regarded as double counting in relation to Item 6 Hence low confidence scoringon quantity and valuation.
Quantity confidence %	N/A	N/A	N/A	N/A	50
Valuation confidence %	N/A	N/A	N/A	N/A	50
Other variables	N/A	N/A	SO2 Central NO2 Central O3 Central PM-2.5 Central	SO2 Central NO2 Central PM-2.5 Central	N/A
Evaluation period	2025-2055				

Item	4		5	6
Metric	Biodiversity		Carbon	Education
Title	BE2 Type 1	BE2 Type 2	CS2	EDu2
Bryn Celyn	0.025	0.025	26	314
Glyncoed	0.185	0.025	10	348
Pen-Y-Bryn	0.025	0.041	20	249
St Cadoc's	0.01	0.025	8	335
St Illtyd's	0.169	0.232	87	926
Comment	Area of intervention (ha)		Carbon Sequestration from trees planted Co2	Number of educational trip visits Individual children/year
Justification/Assumptions Approach	Type 1 - Native woodland - the size of area (ha) creation of woodland within the project area. Type 2 - Improved Grassland - based on area of pollinator species introduced within swales and scrapes.		Assumed medium	Assumed that all pupils will benefit from the interventions as an educational tool including resources and ciriculum activities. For B£ST the assumption that all pupils will visit the interventions once a year, cost is based on lowest price per visit @ £16.93
Quantity confidence %	75	75	100	100
Valuation confidence %	50	50	75	50
Other variables	N/A	N/A	arbon Value - Cent	N/A
Evaluation period	2025-2055			

Item	7	8	9		10
Metric	Flooding	Health	Recreation		Water Quality
Title	F2 Retrofit	H3 Visit to Green Space	R2 - Visits to Grassland	R2 - Visit to woodland	Watercourse or Waterbody improved
Bryn Celyn	0	416	365	365	0
Glyncoed	0	464	406	406	0
Pen-Y-Bryn	0	332	291	291	0
St Cadoc's	0	447	391	391	0
St Illtyd's	0	1619	1273	1273	0
Comment	Iternal flooding of schools	Emotional Well Being Adult individuals/year	Number of visits to grassland and woodland Adult and children individuals/year		WFD improvement to watercourse (km)
Justification/Assumptions Approach	No assessment of the Water company willlingness to pay undertaken at feasibility	Assumed that there will be two events at the school per year i.e. School fete/Sports day(s) allowing parents to visit the school and proposed interventions. It has been assumed 75%* of pupils parents/carers will attend each event e.g. 300 pupils / 2/3 = 200 adults/carers X 2 visits = 400 adults/carers visiting the interventions per year. *this figure does not account for single parent families, or multiple siblings attending the same school.	Item 1 & 8 combined and then divided by 50% rounded up. Not all will visit woodland throughout the year due to influences such as weather. Assumed low confidence in Quantity using 25%		As the drainage networks and catchment are not known which watercourse or body will be improved at feasibility this metric has not been measured
Quantity confidence %	N/A	50	25	25	N/A
Valuation confidence %	N/A	50	50	50	N/A
Other variables	N/A	N/A	N/A	N/A	N/A
Evaluation period	2025-2055				

The following summarises the cost benefits quantified after using cirabest / B£ST tool:

	11	12
	£	£
	B£ST Valuation	B£ST Valuation combined
Bryn Celyn	£119,931.00	£855,462
Glyncoed	£132,830.00	
Pen-Y-Bryn	£93,603.00	
St Cadoc's	£127,315.00	
St Illtyd's	£371,901.00	

Individual Outputs from ciriabest for each School

School 01: St Illtyd's Catholic High School, Rumney

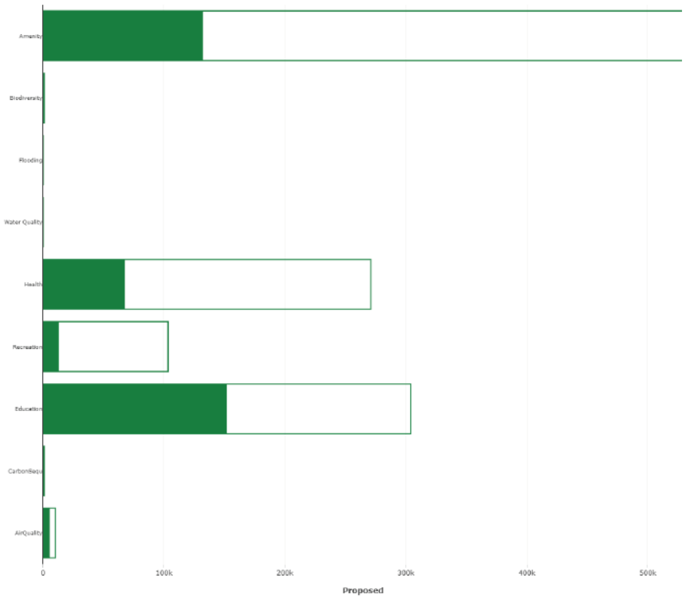
St Illytds High School

Proposed Benefit Post-Confidence:	£371,901
Number of Benefits Assessed:	9

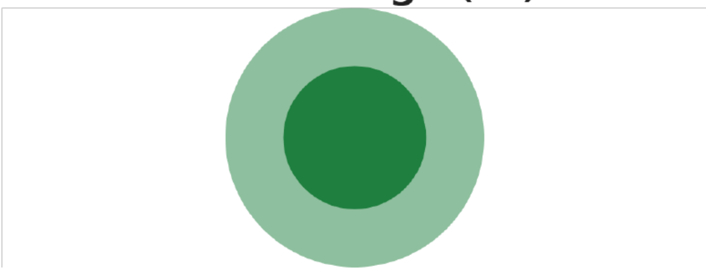
Top 3 in value (proposed post-confidence):

#1	Education	£152,045
#2	Amenity	£132,306
#3	Health	£67,749

Distribution Change (£)



Total Benefit Change (£k)



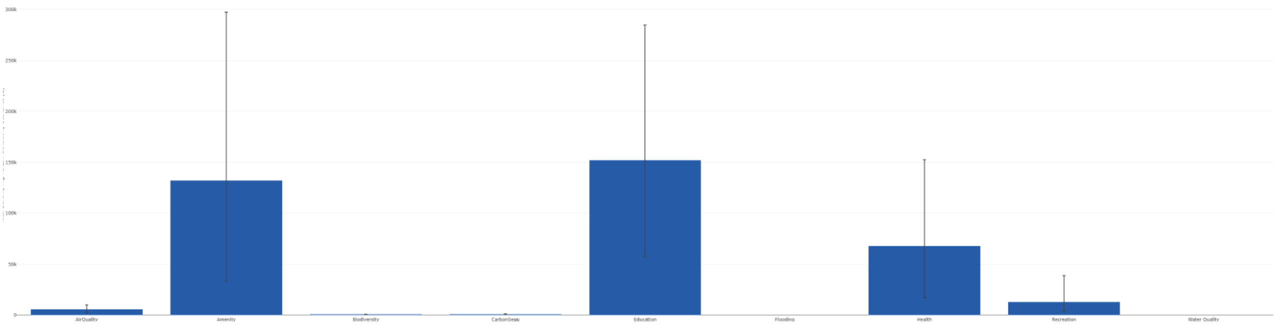
Benefit=Pre:£1,220, Post:£372

Capitals Breakdown Change

Asset group	Capital Value Pre-conf (£k)	Capital Value Post-conf (£k)
Natural	58.87	10.5
Social	828.34	240.22
Financial	90.33	22.58
Manufactured	0.0	0.0
Human / Intellectual	242.38	98.61
Gross asset value	1,219.91	371.9
Liabilities (costs)	0.0	0.0
Net asset value	1,219.91	371.9

Sensitivity Analysis

Low Threshold Total=£113,317, High Threshold Total=£786,204



School 02: Bryn Celyn & Pen-y-Groes, Pentwyn

Bryn Celyn - SuDS for Schools

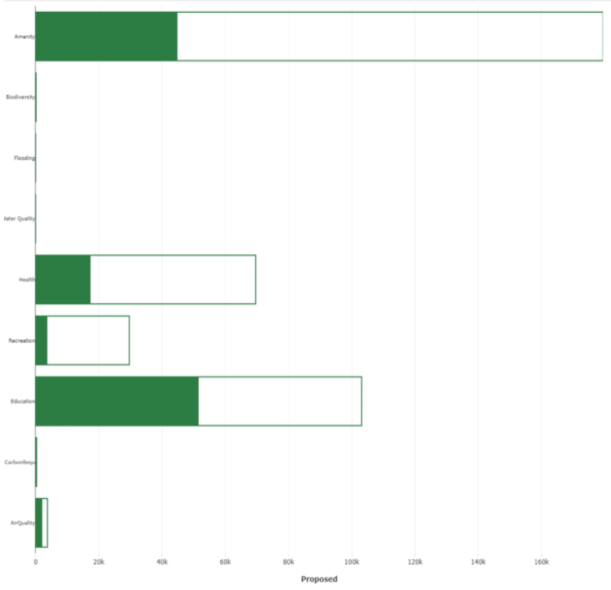
Proposed Benefit Post-Confidence: **£119,931**

Number of Benefits Assessed: **9**

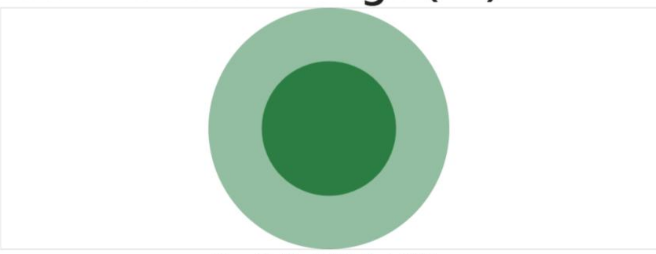
Top 3 in value (proposed post-confidence):

#1	Education	£51,558
#2	Amenity	£44,864
#3	Health	£17,408

Distribution Change (£)



Total Benefit Change (£k)



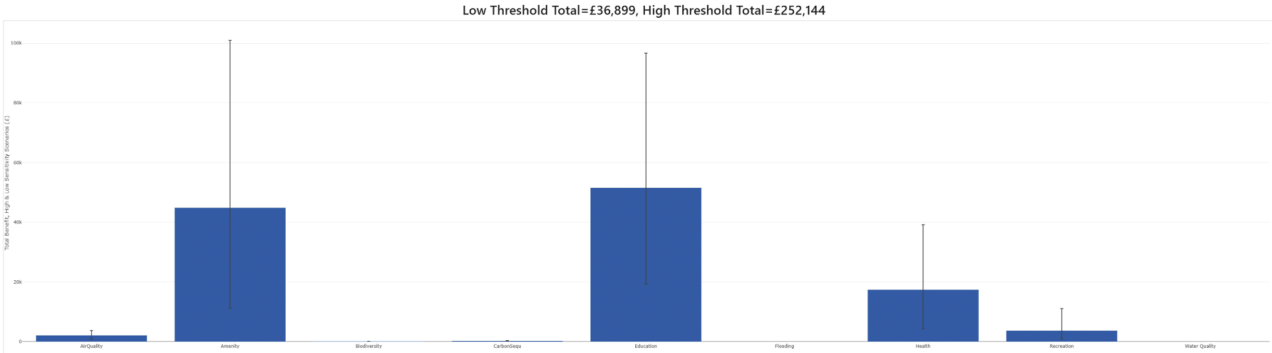
Benefit=Pre:£386, Post:£120

Capitals Breakdown Change

Asset group	Capital Value Pre-conf (£k)	Capital Value Post-conf (£k)
Natural	17.16	3.2
Social	270.91	79.35
Financial	23.21	5.8
Manufactured	0.0	0.0
Human / Intellectual	74.77	31.58
Gross asset value	386.05	119.93
Liabilities (costs)	0.0	0.0
Net asset value	386.05	119.93

Sensitivity Analysis

Low Threshold Total=£36,899, High Threshold Total=£252,144



School 03: St Cadoc's Primary School, Llanrumney

St Cadocs Primary School

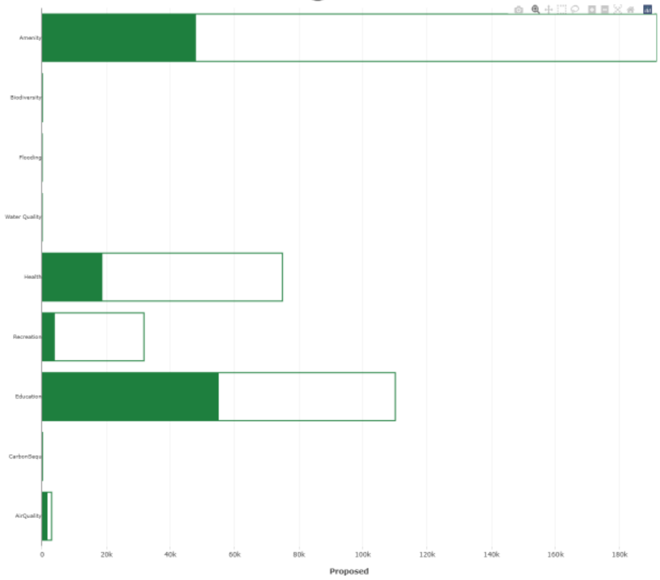
Proposed Benefit Post-Confidence: **£127,315**

Number of Benefits Assessed: **9**

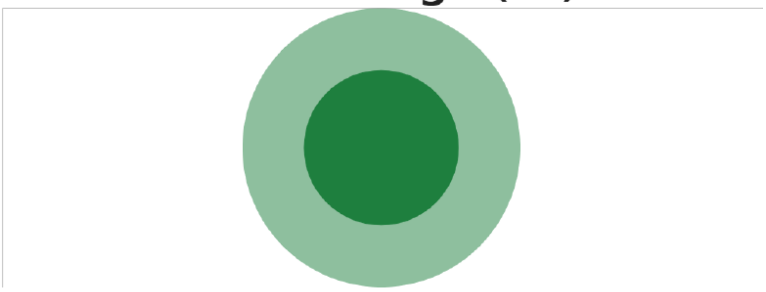
Top 3 in value (proposed post-confidence):

#1	Education	£55,006
#2	Amenity	£47,864
#3	Health	£18,705

Distribution Change (£)



Total Benefit Change (£k)



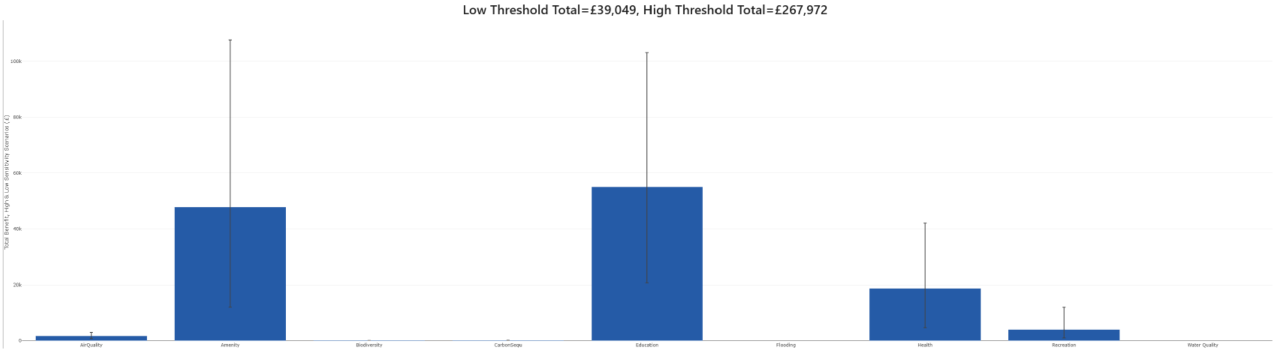
Benefit=Pre:£411, Post:£127

Capitals Breakdown Change

Asset group	Capital Value Pre-conf (£k)	Capital Value Post-conf (£k)
Natural	17.53	2.92
Social	288.76	84.42
Financial	24.94	6.24
Manufactured	0.0	0.0
Human / Intellectual	79.95	33.74
Gross asset value	411.18	127.32
Liabilities (costs)	0.0	0.0
Net asset value	411.18	127.32

Sensitivity Analysis

Low Threshold Total=£39,049, High Threshold Total=£267,972

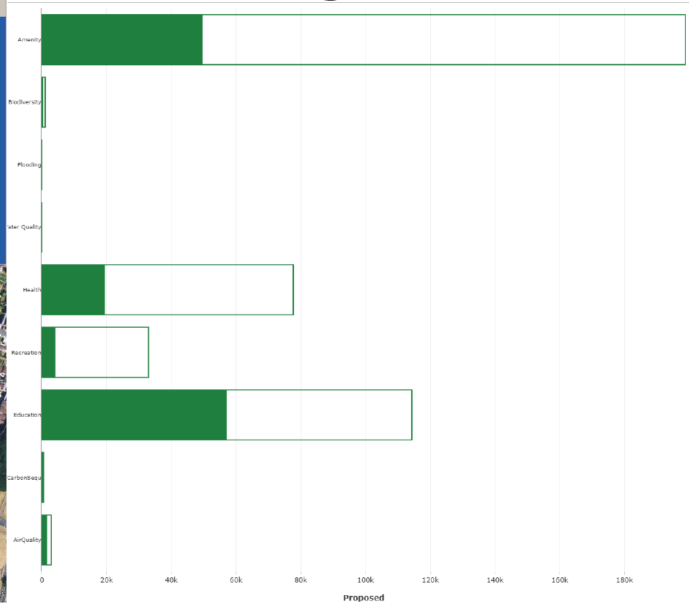


School 04: Glyncoed Primary School, Pentwyn

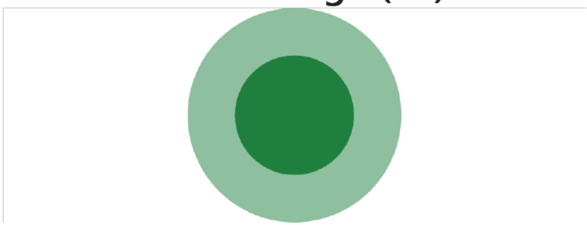
Glyncoed Primary School

Proposed Benefit Post-Confidence:		£132,830	
Number of Benefits Assessed:		9	
Top 3 in value (proposed post-confidence):			
#1	Education	£57,140	
#2	Amenity	£49,722	
#3	Health	£19,416	

Distribution Change (£)



Total Benefit Change (£k)

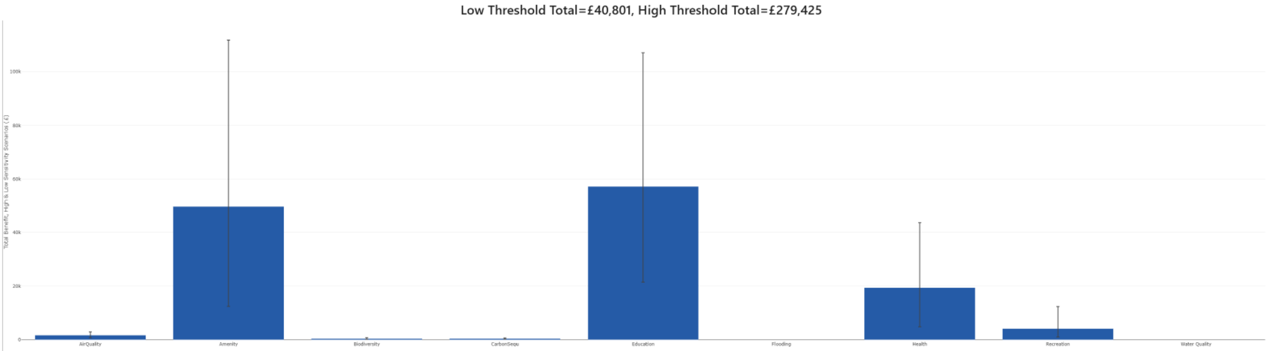


Capitals Breakdown Change

Asset group	Capital Value Pre-conf (£k)	Capital Value Post-conf (£k)
Natural	19.5	3.66
Social	299.87	87.65
Financial	25.89	6.47
Manufactured	0.0	0.0
Human / Intellectual	83.03	35.04
Gross asset value	428.29	132.83
Liabilities (costs)	0.0	0.0
Net asset value	428.29	132.83

Sensitivity Analysis

Low Threshold Total=£40,801, High Threshold Total=£279,425



School 05: Pen Y Bryn Primary School, Llanrumney

Pen-Y-Bryn Primary School

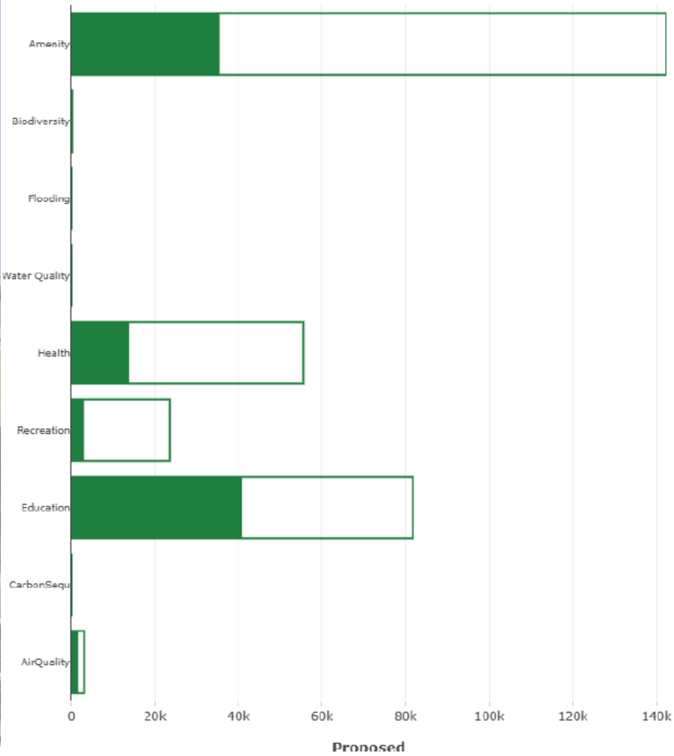
Proposed Benefit Post-Confidence: **£95,080**

Number of Benefits Assessed: **9**

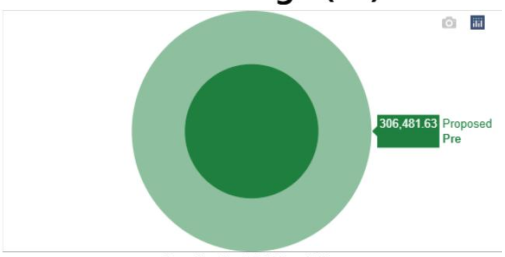
Top 3 in value (proposed post-confidence):

#1	Education	£40,885
#2	Amenity	£35,577
#3	Health	£13,893

Distribution Change (£)



Total Benefit Change (£k)



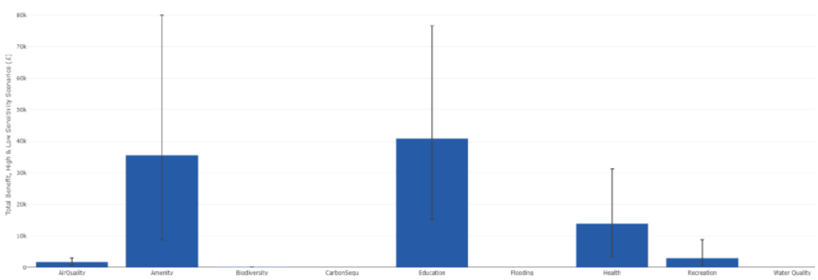
Benefit=Pre:£306, Post:£95

Capitals Breakdown Change

Asset group	Capital Value Pre-conf (£k)	Capital Value Post-conf (£k)
Natural	13.5	2.39
Social	215.05	62.98
Financial	18.52	4.63
Manufactured	0.0	0.0
Human / Intellectual	59.41	25.07
Gross asset value	306.48	95.08
Liabilities (costs)	0.0	0.0
Net asset value	306.48	95.08

Sensitivity Analysis

Low Threshold Total=£29,218, High Threshold Total=£199,991



Appendix E - Cardiff Schools SuDS Engagement – Activity Summary

Cardiff SuDS Engagement Summary.

Objectives of project - to increase pupil and teacher awareness of:

1. Water management and water conservation
2. Changes in weather patterns (including high rainfall resulting in surface water flooding) linked to climate change
3. Demonstrating the role of plants & trees in mitigating surface water flooding

Schools involved:

1. Glyncoed Primary, 7 Pentwyn Rd, Cardiff CF23 7BW
2. St Cadoc's Primary, Shaw Cl, Llanrumney, Cardiff CF3 5NX
3. Pen-Y-Bryn Primary, Dunster Rd, Llanrumney, Cardiff CF3 5TP
4. St Illtyd's Catholic High School, Newport Rd, Rumney, CF3 1XQ

5&6 shared site - Bryn Celyn & Pen-y-Groes, Bryn Celyn, Pentwyn, Cardiff, CF23 7E

Key Stats:

St Cadocs x 6 workshops x 90 pupils x3 teachers
Glyncoed x4 workshops x 60 pupils x 3 teachers
St Illtyd's x3 workshops with High school STEM club x23 pupils x1 staff
Bryn Celyn x4 workshops x60 pupils x2 staff
Pen-y-Groes x5 workshops x 60 pupils x 2 staff
Pen-Y-Bryn x2 workshops x 30 pupils x 2 staff

Summary of delivery:

Each school group took part in two workshops to map and understand the impacts that surface water flooding has on their school and learn what nature-based solutions could mitigate the impacts of surface water flooding and design their own SuDs playground. Students surveyed the school grounds and mapped permeable and impermeable surfaces in the playground and took note where the large puddles, overflowing drains etc occurred during heavy rain. Students Identified what species of trees they have in their playground and learn understood which additional species could be planted to support flood mitigation. Students then created their own designs in their existing playgrounds.

Day 1

Project Assembly & Staff briefing.

Topic 1 - Why does it rain? Why is the rain getting worse?
Presentation: Understanding rain, climate change, flooding impacts.
LO: Recap water cycle, explain greenhouse effect and why it causes more heavy rain

Topic 2 – Grass vs Paving + Playground analysis
Presentation: Why does it flood?
LO: Explain why urban areas are more prone to flooding than natural areas, analyse the school grounds for flood vulnerability/likelihood

Activities:

- **Flood mapping.** Students have a map of the school building and playground, from lived experience student map effects of previous floods and discuss past observations of the playground after heavy rain.

- **How green is the playground?** Estimate total size of playground. Measure/estimate size of green spaces. Calculate a fraction or percentage of green coverage. Count how many trees – Calculate trees/m2.
- **Infiltration practical.** Hypothesis: Water will drain most quickly underneath a tree. IV: How quickly for a fixed amount of water to infiltrate. Dependant Variable: Location/surface. Test: On grass, on bare earth, on concrete/gravel

Day 2

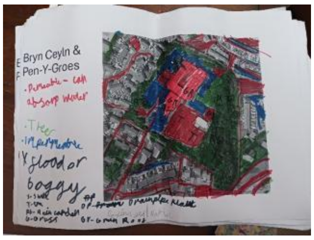
Topic 3 – The Solutions
Presentation: What can we do about it?
LO: Understand some SuDS methods, name and identify some trees that are better suited for flood prone areas.

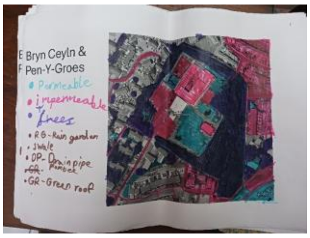
Activity- Designing a SuDS garden. Guide students through SuDS examples and methods. Review tree species for suds projects. Students designed their own SuDs playground with interventions based on natural solutions.

01 St Illtyd's

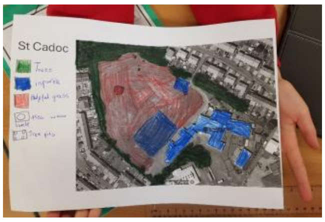


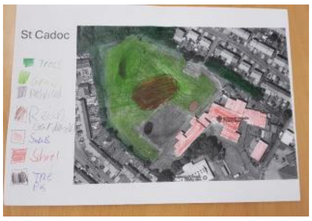
02 Bryn Celyn/Pen Y Groes

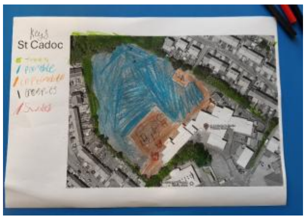





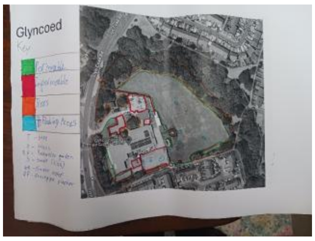
03 St Cadoc's

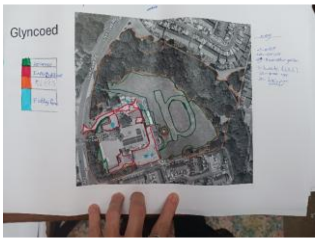


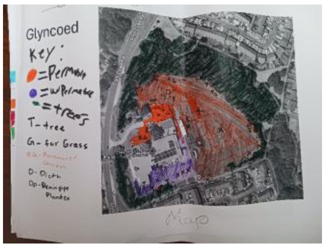




04 Glencoed







05 Pen Y Bryn (No photos)