Enabling
ZERO WASTE

Glynn Vivian Art Gallery

Noddir gan Lywodraeth Cymru
Sponsored by Welsh Government

ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

Enabling Zero Waste: Glynn Vivian Art Gallery

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Glynn Vivian Art Gallery

1 Executive Summary

Enabling Zero Waste (EZW) is a Constructing Excellence in Wales (CEW) initiative which aims to establish if, and how, the construction industry can achieve the zero waste targets established in the Welsh Government's waste strategy document, Towards Zero Waste.

CEW is working in collaboration with the industry to provide a detailed insight into the achievability of zero waste at present, and disseminating best practice, solutions and opportunities. Along with identifying any associated barriers to achieving the targets.

The Glynn Vivian Art Gallery is a public art gallery in Swansea, South Wales. Regeneration and development of the gallery was part of the Sustainable Regeneration Framework for Swansea Bay. Several changes during construction, and additional works, meant the original contract value rose from £5.3million to £6.3million.

The original contractors, Opco Construction, went into administration in 2013 having undertaken some of the demolition works including the removal of asbestos. The EZW project became involved when John Weaver began their package of works in March 2014, which was due to be completed by March 2015. However, due to issues on site, the project timescale was extended with building opening in October 2016.

There were three companies contracted to manage the waste produced by the Glynn Vivian project during EZW involvement, these were;

- Derwen Plant Ltd. (Derwen) – A Green Compass company
- Stenor Environmental Services Ltd. (Stenor)
- Peter Davies Agricon Ltd. (Agricon)

Stenor and Agricon dealt with the inert waste produced by a soil slip at the back of the site. They removed the waste in 97 containers. Derwen dealt with the construction waste which was sorted for recycling, recovery and landfilling. The work of these three waste management companies allowed the project to report;

- Total percentage of waste prevented or reused = 1.8%
- Total percentage of waste recycled = 82.9%
- Total percentage of waste to energy recovery = 12.1%
- Total percentage of waste to landfill = 3.4%

By reaching a reuse, recycling or other material recovery rate of 96.6%, by volume, the Glynn Vivian project shows how achievable the present Welsh Government target of 70%, by weight, is. It also highlights the achievability of the 2019-20 90%, by weight, target. The Welsh Government aims for 100% diversion of construction and demolition waste from landfill by 2050. The 3.4% of waste calculated to have been landfilled is based on annual landfill rates reported for the Derwen waste management facility.

Whilst the above targets have been achieved, further focus is considered to be required on waste prevention and reuse, rather than relying on the effectiveness of waste management infrastructure. A 1.4% reduction of waste needs to be achieved year upon year by the construction sector in order to meet the Towards Zero Waste target.

Cost savings on this project attributed to consideration of the waste hierarchy and effective waste management were over £400,000. This would have equated to 6.3% of the project value. Actual waste management costs reached 0.9% of the project value, highlighting how important the consideration of waste can be to project finances and profitability.

Other successes on the project include:

- Site managers were trained to input waste data onto SMARTWaste
- Site managers took waste seriously and regularly looked in the skips removing waste that wasn't segregated properly or could be re-used
- John Weaver found solutions for their waste through good relationships with local waste companies
- The John Weaver team visited Derwen to gain an appreciation of how waste is managed

Recommendations for contractors include:

- It being a priority for contractors to have a member of the site team who takes ownership for waste management. In addition, it is crucial that the person responsible for producing waste forecasts makes regular contact with the site team to ensure that forecasts are achievable, reasonable and based on previous performance
- The importance of segregation of waste at source is clear to all members of the site team
- Focusing on, and discussing, waste at all stages of a project, with all involved on site

Recommendations for clients include:

- Ongoing communication with design consultants and contractors is important
- Think through potential additional needs ideally long before construction, but if not, in time to allow for appropriate management of design and waste
- Be aware how decisions can have knock on impacts on management of waste
- Consider how you will use your asset? What demands will you place on it and how will that affect longevity?

Recommendations for designers include:

- BIM offers a viable option for the elimination of design waste. Easy visualisation of each discipline's inputs allows for easy identification of errors or clashes between the designs of different disciplines
- Consider asset management and how the asset will be used. How will use change over time – for example in this case there is potential for different exhibits to be hung on different walls
- Engagement with contractors to improve material understanding
- Consideration to the standard sizes of materials during design

2 About

2.1 Enabling Zero Waste

Enabling Zero Waste is a Constructing Excellence in Wales (CEW) initiative which provides practical, positive and proactive assistance to construction, demolition and civil engineering projects in Wales. The aim is to establish if, and how, the construction industry can achieve the zero waste targets established in the Welsh Government's waste strategy, Towards Zero Waste (1).

CEW provides EZW project participants with technical advice, expertise and guidance on waste management and Building Information Modelling (BIM) to help overcome barriers to waste minimisation and design for deconstruction. Each project is provided with a bespoke and tailored package to best suit its needs.

CEW is working in collaboration with the construction industry to provide a detailed insight into the achievability of zero waste. The goal being to share best practice solutions and opportunities, along with identifying any barriers associated with achieving the Welsh Government's waste targets. CEW offers practical assistance to construction project design and site teams to explore viable solutions to achieving zero waste and EZW project objectives to;

- Understand and evidence when and how wastes occur during the construction process
- Understand current strategies, methodologies and opportunities for the diversion from landfill of site wastes
- Analyse the feasibility/viability of achieving zero waste to landfill in the current environment
- Work to develop solutions to prevent and minimise the generation of on-site waste, leading to a reduction in waste management, disposal and landfill costs
- Support changes to behaviour and processes that encourage prevention and minimisation of waste
- Achieve site efficiencies from waste management opportunities/solutions
- Minimise site traffic through reduction in supplies, materials and waste transport allowing for cost savings
- Disseminate solutions and opportunities from the development of effective waste management strategies
- Provide learning and education opportunities regarding alternative waste management techniques which can be disseminated for future projects ensuring continual benefits

2.2 Contractor

John Weaver (Contractors) is an established family firm with over 100 years construction expertise, combining the strong traditional values of skilled craftsmanship with modern materials, building techniques, and sound business management.

John Weaver (Contractors) is a client led organisation whose management approach to servicing commissions is to provide a first rate service based on a tradition of quality at competitive cost. The company is committed to the Egan objectives (2) and over many years a successful team has been built up around these objectives (3).

3 Project Background

The Glynn Vivian Art Gallery is a public art gallery in Swansea, South Wales. Regeneration and development of the gallery is a part of the Sustainable Regeneration Framework for Swansea Bay.

Built over two years from 1909 to 1911, the original gallery is in the Edwardian baroque style and is a Grade-II* Listed building (4). The listed status of the building meant the internal fabric could not be altered from its original state. An extension to the gallery, built in 1974, was connected to the original building by a link structure (5).

In 2011 the gallery shut to begin the development and refurbishment project which included;

- Demolition of a previous link between the 1911 and 1970s buildings
- A new entrance and shop at street level
- Re-design of the 1974 gallery extension and a new glazed link structure
- A new passenger lift to allow full physical access to all exhibitions and collection galleries, as well as all education and study facilities
- More space for the display of collections and exhibitions
- A new storage and conservation area to enable the future development of the collections
- New technical areas and administrative offices
- Renewal of the existing education studio and improved facilities for working with schools, colleges and the participants
- A new lecture space and community room
- A dedicated library and archive devoted to visitor research
- A new social space with refreshments and wi-fi access

The original contractors, Opco Construction, went into administration in 2013 (6) having undertaken some of the demolition works, including asbestos removal. In March 2014 John Weaver began their package of works which was due to be completed by March 2015. However, due to issues on site, the project timescale was extended with the opening of the building in October 2016.

EZW involvement began with John Weaver and so works undertaken under the previous contract have been mentioned within this report but not included within overall waste figures

3.1 Cost

Original contract value was £5.3million which rose to £6.3million due to several changes during construction, and additional works

4 Methodology

EZW support for the site was carried out through:

- Site visits and guidance
- Review of waste data
- Review of waste management companies
- Visit to the waste management company Derwen with John Weaver staff
- Search for alternative disposal options

Waste management support site visits were undertaken as part of Enabling Zero Waste, which included discussions with the site team regarding current site and waste issues, progress, potential solutions and improvements. Support was also provided to the site team with waste management recommendations including:

- Site housekeeping
- Toolbox talk development
- Review of surplus materials and how the company deals with surplus
- Review of waste data and reporting of waste
- Alternative source for roofing materials

It was found that little contact was required with this project as it became obvious that the company and staff involved were aware of the requirement to minimise waste, reuse material and were in the habit of reusing resources from other sites. There were three main reasons why site practices were geared to be waste aware:

1. John Weaver had a site manager who worked throughout the project with all employees to raise awareness of waste and how to record accurate data onto SMARTWaste
2. The site manager received significant support from the John Weaver environmental representative
3. John Weaver has been involved in many conservation projects and it is normal company practice to store materials for reuse, using materials from other sites and managing surplus materials (3)
4. Only a small amount of work is sub-contracted. John Weaver have a resource of direct employees. The message to reduce waste had been taken on board by site staff, and led to good practice on site and minimised waste

Arup demonstrated on this project how BIM could be used effectively by the client and exhibitors to easily identify hidden electrical fixtures within the main gallery spaces. The aim was to allow exhibitors to place exhibits and wall fixings with the confidence that they wouldn't damage electrical services in the process or produce unnecessary waste.

This use of technology through augmented reality allows users to visualise model information and assets that would not be possible otherwise. The end user can interrogate the model and identify the location of fixtures in situ with relative ease. This will aid exhibition design, as well as facilities management and maintenance.

A site visit to Derwen Group was carried out by John Weaver to review how their waste was dealt with and how it was segregated to reduce any waste going to landfill.

Communications work involved regular updates via twitter, update events, webinars and presentations.

5 Waste Management Analysis

There were three companies contracted to manage the waste produced by the Glynn Vivian project during EZW involvement, these were;

- Derwen Plant Ltd. (Derwen) – A Green Compass company
- Stenor Environmental Services Ltd. (Stenor)
- Peter Davies Agricon Ltd. (Agricon)

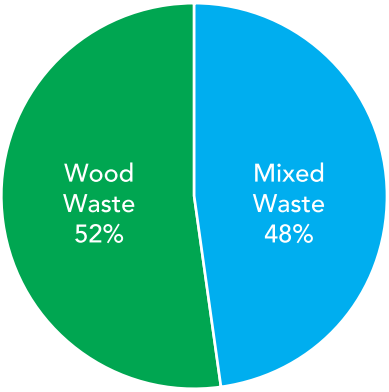
The Green Compass scheme provides verified waste performance data against PAS402:2013 Waste resource management – specification for performance reporting.

5.1 Analysis by project phase

5.1.1 Demolition Phase

Demolition work undertaken by Cardiff Demolition produced 55.5 tonnes of waste. Cardiff Demolition demolished the existing link structure and stripped out the 1970s building. The work was carried out as part of the original Opco contract in February 2013, prior to the involvement of the EZW project. Because this waste was produced prior to the EZW project's involvement under a separate contract for the works it hasn't been included in overall figures.

All the waste was either disposed of as mixed wood waste or general waste. Mixed waste accounted for 28.6 tonnes 52% and general waste was 26.8 tonnes 48%.



Some of the original parquet flooring was retained on site and placed on pallets in order to be cleaned and re-used within the new building. No details of recycling rates were contained in the demolition waste report.

John Weaver produced eight skips of demolition waste when they took over from Opco in 2014, totaling 67.2m^3 2.9% of waste arsings. Seven of the eight skips were segregated; six inert skips and bituminous mixtures skip. The non-segregated skip contained a 50/50 mix of inert materials and bituminous materials.

Demolition Phase – John Weaver	
Total Waste m^3	67.2
Diverted from landfill m^3	52.6
Diverted from landfill %	78.3%*

* Based on Derwen 2014 figures

Disposal of the six inert waste skips was charged at a flat rate by Derwen. The other two skips were charged a lift fee and per tonne fee. Had the skips all been classed as mixed waste with no segregation, the cost for removing the waste would have been almost twice as expensive, saving more than £2400.

5.1.2 Excavation Phase

Excavation Phase	
Total m^3	1,279.0
Diverted from landfill m^3	1,279.0
Diverted from landfill %	100.0

The bank at the back of the site collapsed during 2014. This led to the removal of significant quantities of soil and inert waste, 1279.0m^3. This equates to 54.6% of total waste arisings.

Two of the chosen waste management companies were used during this phase, Stenor and Agricon. Between them they removed 97 containers of excavation waste. The size of container varied, with the predominant container size used being 20 tonne wagons.

Each container was visually inspected with records kept via the SMARTWaste tool. All waste was classified by the European Waste Classification (EWC) codes, as can be seen in the table.

More than half of the containers leaving site were classified as soil and stone (17 05 04). Alternatives exist to paying for the disposal of waste classified as soil and stone. The Contaminated Land Applications in

	No. of Containers		
Material Type	Agricon	Stenor	Total
Concrete (17 01 01)		3	3
Bricks (17 01 02)		2	2
Inert (17 01 07)	4	38	42
Soils and Stone (17 05 04)	35	15	50
Total	39	58	97

Real Environments (CL;AIRE) definition of waste code of practice provides a clear, consistent and efficient process which enables the reuse of excavated materials on-site or their movement between sites for reuse.

Agreements can be struck between donor and receiver sites to cover costs of movement and transport of soil. This offers a cost-effective source of material for the receiver site and an equally cost-effective method of disposal for the donor site. Testing is required to prove the soil isn't contaminated.

Given that this was not an anticipated waste stream all of the £19,012.50 costs were unexpected.

5.1.3 Construction Phase

Construction Phase	
Total m^3	998.0
Diverted from landfill m^3	927.9
Diverted from landfill %	93.0

998.0m^3 of waste was produced under works classified as the construction phase, 42.6% of total waste arisings. 2015 saw the majority of construction phase waste production 72.9% of the construction phase total.

92.3%, 927.9m^3, of construction waste was diverted from landfill with 66.1%, 659.2m^3, of waste being recycled and 26.9%, 268.6m^3, sent for energy recovery. 7.0% 70.1m^3 went to landfill.

61.9m^3 of inert waste, 6.2% of construction waste, was removed by Stenor. Most of the construction waste was processed by Derwen 936.1m^3, 93.8% of construction waste. Table below shows how the construction waste was processed over the course of the project by Derwen.

	Recycling	Recovery	Landfill	Total
2014	48.3%	29.9%	21.9%	
	80.4	49.8	36.5	166.7
2015	67.2%	28.1%	4.7%	
	459.4	192.1	32.1	683.7
2016	67.1%	31.2%	1.7%	
	57.5	26.7	1.5	85.7
Total	63.8%	28.7%	7.5%	
	597.3	268.6	70.1	936.1

All figures are based on Derwen's rates for 2014-2016 and are not project specific. Units in m^3

These figures are based on project waste data provided by John Weaver via SMARTWaste and the annual recycling, recovery and landfill rates provided by Derwen. They are not project specific recycling, recovery and landfill rates.

Wood waste was the most significant waste stream at 31.9% of construction waste, by volume. A timber skip was held on site where segregation was good and the timber waste was tightly packed. The waste was the result of;

- Extensive works on the roof of the Grade-II* listed structure – stripping of the concrete tiles, timber battens, and replacing rotten timber joists
- Building false walls to hide electrical systems – as per Grade-II* planning conditions
- Pallets – these were stored on site and used to store materials around the site. Pallets were only waste when they were broken and placed in the timber skip
- The use of timber for protection of works
- Wet rot was found in October 2015 - Parquet flooring within the ground floor gallery area had to be removed along with some timber joists. The site ensured that the contaminated timber was separated and placed into flexible tonne bags. The waste management company was informed of the contamination and the bag was removed with the timber skip.

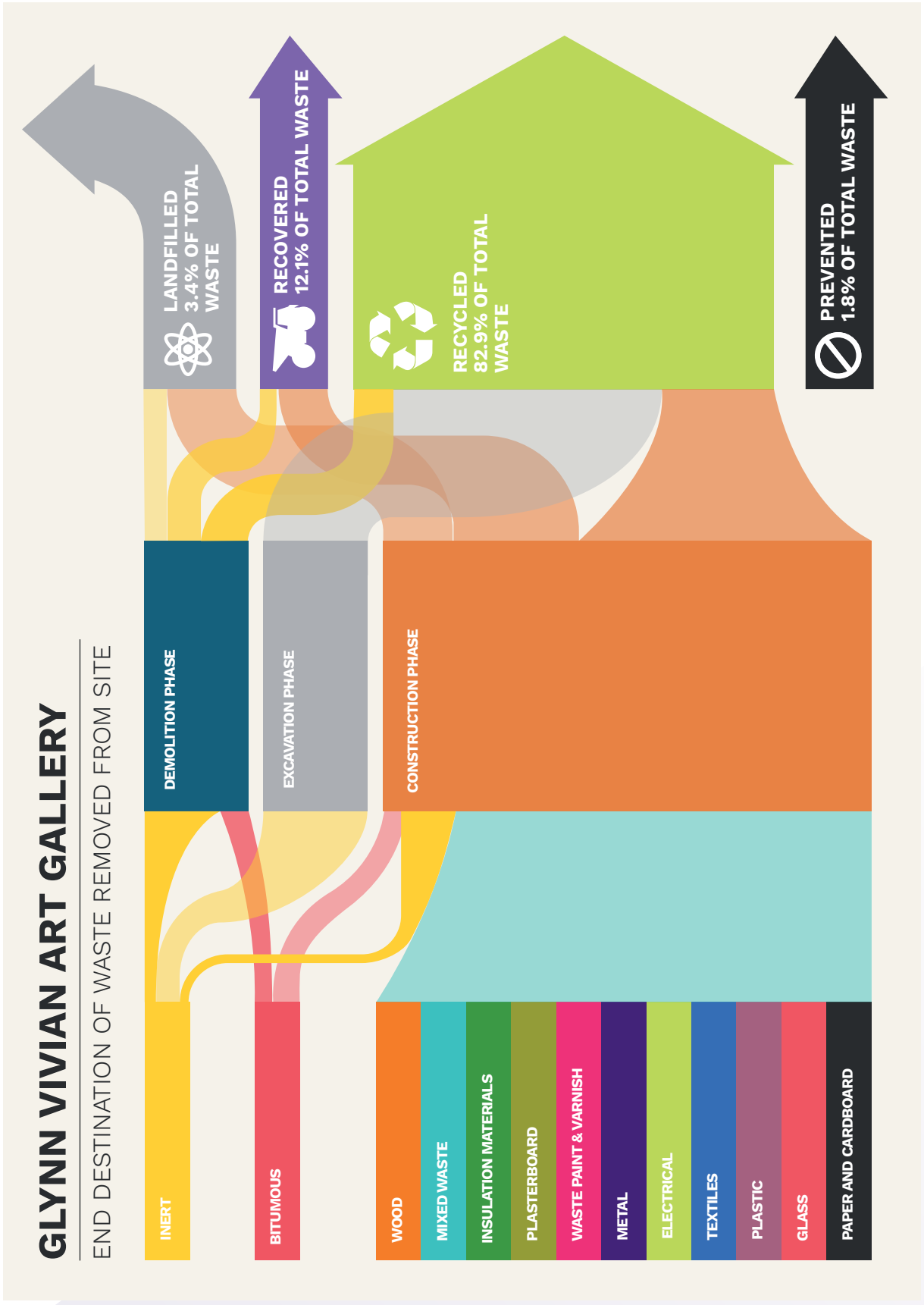
Other significant construction phase waste streams include inert 15.5%, mixed 18.2%, insulation 11.7% and plasterboard 9%. This can be seen in the table below.

Before leaving the site the contents of mixed waste skips were recorded on SMARTWaste detailing the contents within the skip. Site staff regularly checked the skip contents as they were aware of the extra costs of mixed waste on site and they would remove items such as cardboard boxes to ensure good segregation. This reduced contamination within the skips.

Due to room sizes, plasterboard offcuts were inevitable. Plasterboard waste was minimised and awareness raised with staff on site. Plasterboard offcuts were found to be stored on site to minimise wastage.

	2014				2015				2016				
Material	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Total	% of Total
Electrical	0.0	0.0	0.0	0.6	0.6	4.6	2.1	13.2	4.9	0.0	0.0	26.0	2.6%
Glass	0.0	0.0	0.0	9.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	15.1	1.5%
Inert	6.1	0.0	22.6	5.8	18.4	21.1	62.3	7.0	6.1	5.5	0.0	155.1	15.5%
Insulation materials	0.0	0.0	8.5	0.6	5.2	33.7	48.7	14.7	4.6	1.2	0.0	117.1	11.7%
Metal	0.0	0.0	0.8	0.0	2.8	5.8	6.7	8.3	1.8	0.9	0.0	27.1	2.7%
Mixed	24.5	0.0	7.9	8.9	15.0	21.7	30.6	41.0	22.3	3.4	6.1	181.4	18.2%
Other bitumous	0.0	0.0	0.0	0.0	4.3	0.6	1.2	0.0	0.0	0.0	0.0	6.1	0.6%
Paper & Cardboard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.9	0.0	2.1	0.2%
Plasterboard	0.0	0.0	0.0	0.0	0.0	22.0	42.9	25.1	0.0	0.0	0.0	90.0	9.0%
Plastic	0.0	0.0	4.1	2.4	2.1	1.5	0.9	1.2	1.5	1.5	0.0	15.4	1.5%
Textiles	0.0	0.0	0.3	0.0	0.0	0.0	0.0	12.2	4.6	0.0	0.0	17.1	1.7%
Waste paint & varnish (non-hazardous)	0.0	0.0	0.0	0.0	0.6	2.8	7.3	12.2	4.3	0.0	0.0	27.2	2.7%
Wood	0.0	45.9	18.4	18.4	24.5	36.7	85.7	73.7	9.8	4.9	0.0	317.9	31.9%
Total	30.6	45.9	62.5	45.7	79.6	150.5	288.5	208.7	61.2	18.4	6.1	997.7	
% of Total	3.1%	4.6%	6.3%	4.6%	8.0%	15.1%	28.9%	20.9%	6.1%	1.8%	0.6%		

Construction phase waste by type. Units in m^3


GLYNN VIVIAN ART GALLERY
END DESTINATION OF WASTE REMOVED FROM SITE
INERT
BITUMOUS
WOOD
MIXED WASTE
INSULATION MATERIALS
PLASTERBOARD
WASTE PAINT & VARNISH
METAL
ELECTRICAL
TEXTILES
PLASTIC
GLASS
PAPER AND CARDBOARD
DEMOLITION PHASE
EXCAVATION PHASE
CONSTRUCTION PHASE
LANDFILLED 3.4% OF TOTAL WASTE
RECOVERED 12.1% OF TOTAL WASTE
RECYCLED 82.9% OF TOTAL WASTE
PREVENTED 1.8% OF TOTAL WASTE

5.2 Analysis by Programme

5.2.1 2014

	Waste volume m^3	Diverted from landfill m^3	Diverted from landfill %
Construction	184.7	144.4	78.2
Demolition	67.2	52.6	78.2
Excavation	1279.0	1279.0	100
Total	1530.9	1476.0	96.4

In 2014 1530.9m^3 of waste was produced. This was 65.3% by volume of the total waste arisings for the project.

The most significant component of waste in 2014 was from the excavation phase. The 1279.0m^3 of waste produced was 83.5% of 2014 waste and 54.6% of total waste arisings. All this waste was unexpected, resulting from the collapse of the bank at the rear of the site. The cost attributed to removal was £19,012.50, a third of the total waste management cost.

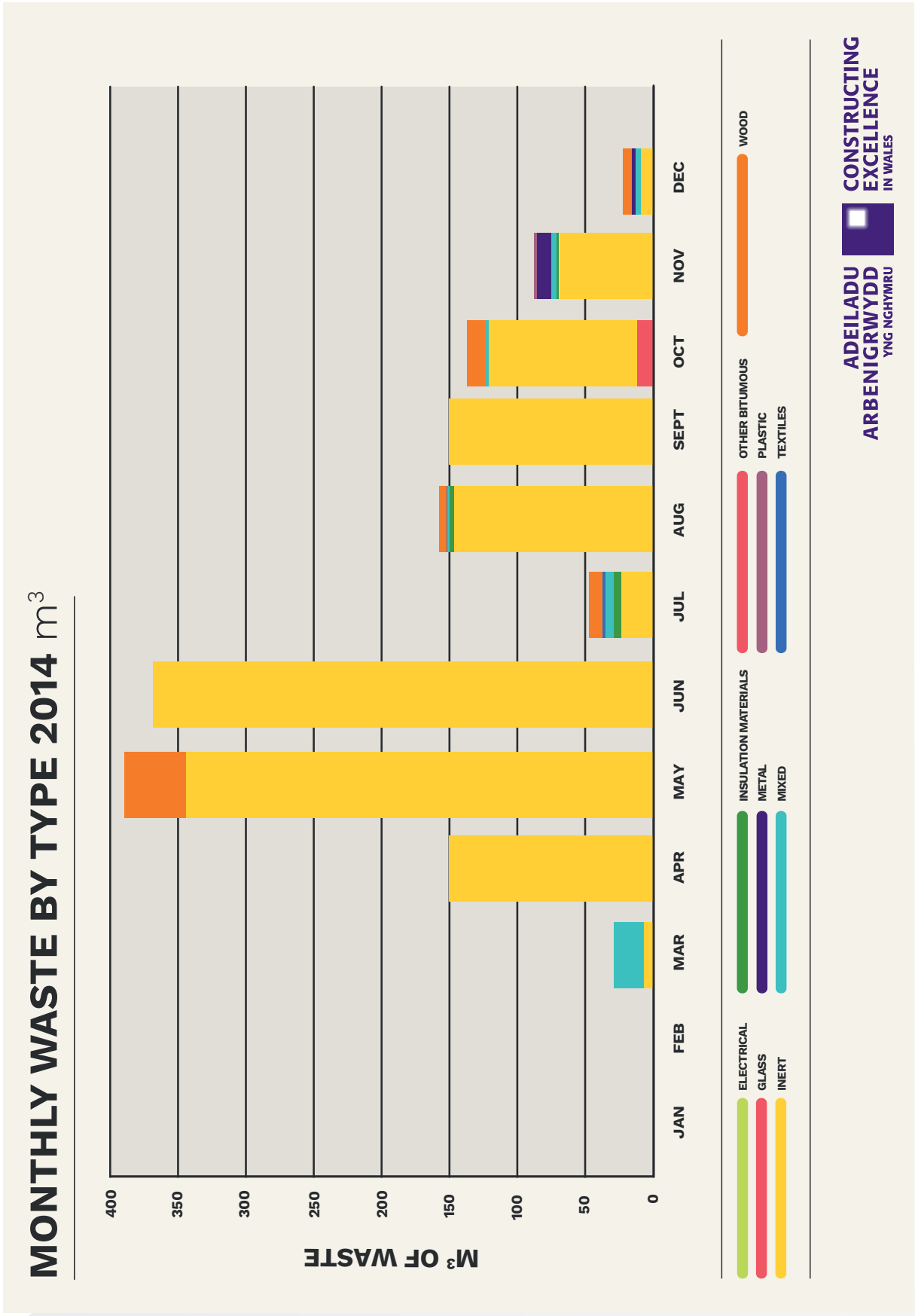
Much of the excavation waste was classed as soil and stone, which could have been removed from site without classification as waste. The CL;AIRE definition of waste code of practice provides an alternative which enables the reuse of excavated materials on-site or their movement between sites for reuse. Costs for transport could have been reduced and shared between the Glynn Vivian site and a receiver site, with the receiver site benefiting from an alternative to virgin imported material.

Segregation of waste in 2014 was high with 117 of the 121 containers, 96.7%, leaving site being segregated. This helped to achieve a diversion from landfill rate of 96.4%, 1476.0m^3 for the year. 107 containers were inert waste, the other 10 segregated skips were; one glass skip, one bitumous skip and eight wood skips.

The remaining waste was of a mixed nature and removed in four mixed waste skips.

Quarter	Electrical	Glass	Inert	Insulation materials	Metal	Mixed	Other bitumous	Plastic	Textiles	Wood	Grand Total
Qtr1	0	0	6.1	0	0	24.5	0	0	0	0	30.6
Qtr2	0	0	859.7	0	0	0	0	0	0	45.9	905.6
Qtr3	0	0	317.5	8.5	0.8	7.9	0	4.1	0.3	18.4	357.5
Qtr4	0.6	9	188.3	0.6	0	8.9	9.2	2.4	0	18.4	237.4
Grand Total	0.6	9	1371.6	9.1	0.8	41.3	9.2	6.5	0.3	82.7	1531.1

Table of all waste in 2014. Units in m^3


MONTHLY WASTE BY TYPE 2014 m3
M3 OF WASTE
400
350
300
250
200
150
100
50
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
ELECTRICAL
GLASS
INERT
INSULATION MATERIALS
METAL
MIXED
OTHER BITUMOUS
PLASTIC
TEXTILES
WOOD
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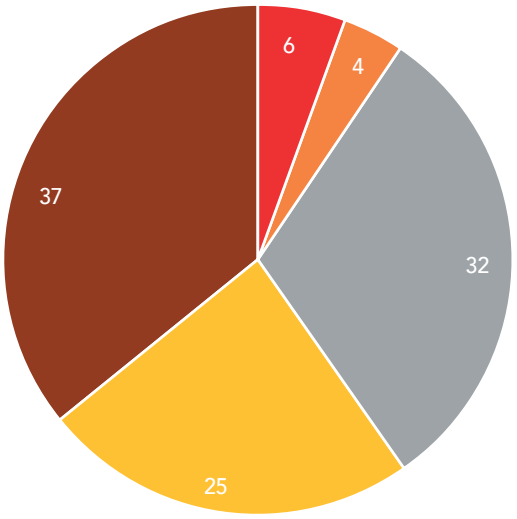
5.2.2 2015

	Waste volume m^3	Diverted from landfill m^3	Diverted from landfill %
Derwen	683.7	651.6	95.3
Stenor	43.7	43.7	100
Total Waste	727.4	695.3	95.6

The majority of the project's construction phase was undertaken during 2015. 727.4m^3 of waste was produced, 31.0% of total waste arisings.

Derwen removed 94.0% of waste, by volume, in 2015. This totalled 175.2 tonnes, 683.7m^3 and removal required 112 of the total 147 Derwen skips used on this project. Segregation was good with 55 of the 112 skips (49%) being segregated.

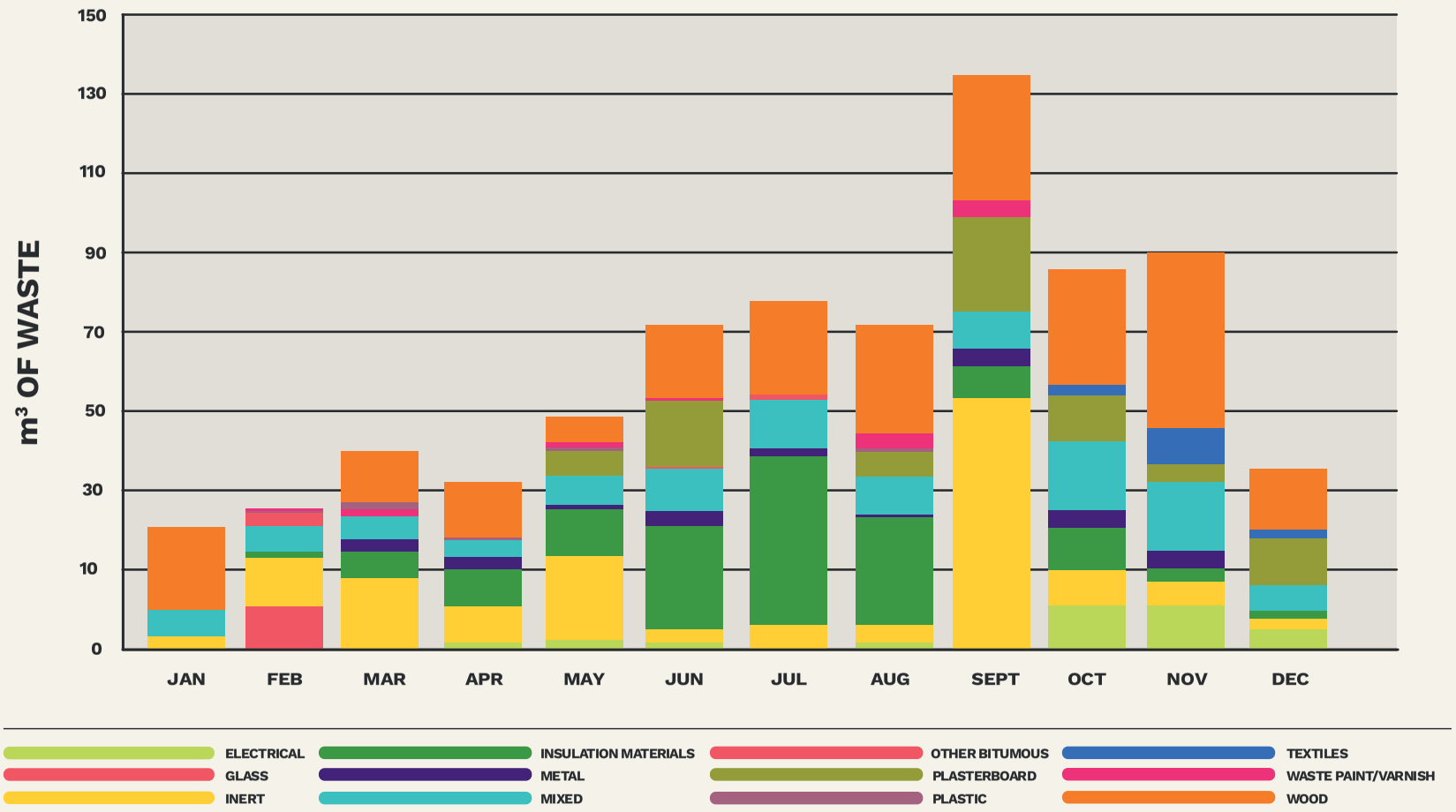
In September 2015 43.7m^3, 6% of 2015 waste, was removed by Stenor. Peaks in waste were seen in inert waste (13.1 tonnes) during May and gypsum waste (8.5 tonnes) in September. These can be attributed to excavation for the lift shaft and plasterboard works respectively.



	Electrical	Glass	Inert	Insulation materials	Metal	Mixed	Other bitumous	Plasterboard	Plastic	Textiles	Waste paint & varnish (non-hazardous)	Wood	Grand Total
Qtr1	0.6	6.1	18.4	5.2	2.8	15.0	4.3	0.0	2.1	0.0	0.6	24.5	79.6
Qtr2	4.6	0.0	21.1	33.7	5.8	21.7	0.6	22.0	1.5	0.0	2.8	36.7	150.5
Qtr3	2.1	0.0	62.3	48.7	6.7	30.6	1.2	42.9	0.9	0.0	7.3	85.7	288.5
Qtr4	13.2	0.0	7.0	14.7	8.3	41.0	0.0	25.1	1.2	12.2	12.2	73.7	208.7
Grand Total	20.5	6.1	108.8	102.3	23.6	108.3	6.1	90.0	5.7	12.2	22.9	220.6	727.3

Table of all waste in 2015. Units in m^3

MONTHLY WASTE BY TYPE 2015 m^3



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5.2.3 2016

Waste volume m^3	Diverted from landfill m^3	Diverted from landfill %
85.7	84.2	98.2

During 2016 all waste was construction phase waste and removed by Derwen in mixed construction waste skips totalling 25.2 tonnes, 85.7m^3. There was no segregation of waste. Reporting on SMARTWaste, includes visual estimates of the waste in the eighteen skips used;

Material	Volume m^3	Percentage
Inert	11.6	13.5%
Wood	14.7	17.2%
Metal	2.8	3.3%
Insulation materials	5.8	6.8%
Plastic	3.1	3.6%
Paper & Cardboard	2.1	2.5%
Mixed	31.8	37.1%
Textiles	4.6	5.4%
Waste paint & varnish (non-hazardous)	4.3	5.0%
Electrical	4.9	5.7%

Table of waste streams 2016

The work conducted in 2016 was mainly finishing works and additional works requested by the client. Additional works, and unplanned activities, create issues for the forward planning of waste management. Contractors cannot predict upcoming waste streams, and often leads to ad hoc solutions reliant on mixed waste skips. In this case space was also an issue, allowing for only one skip on site.

EWC Code Definition	% of Waste
Packaging	23.6%
Other Municipal Waste	23.2%
Wood, glass and plastic	14.6%
Concrete, bricks, tiles, and ceramics	13.2%
Insulation and abestos-containing construction materials	6.8%
Electrical equipment	5.7%
Textiles	5.4%
Waste Paint	5.0%
Metals	2.1%
Soil	0.4%

Table of waste by EWC code 2016

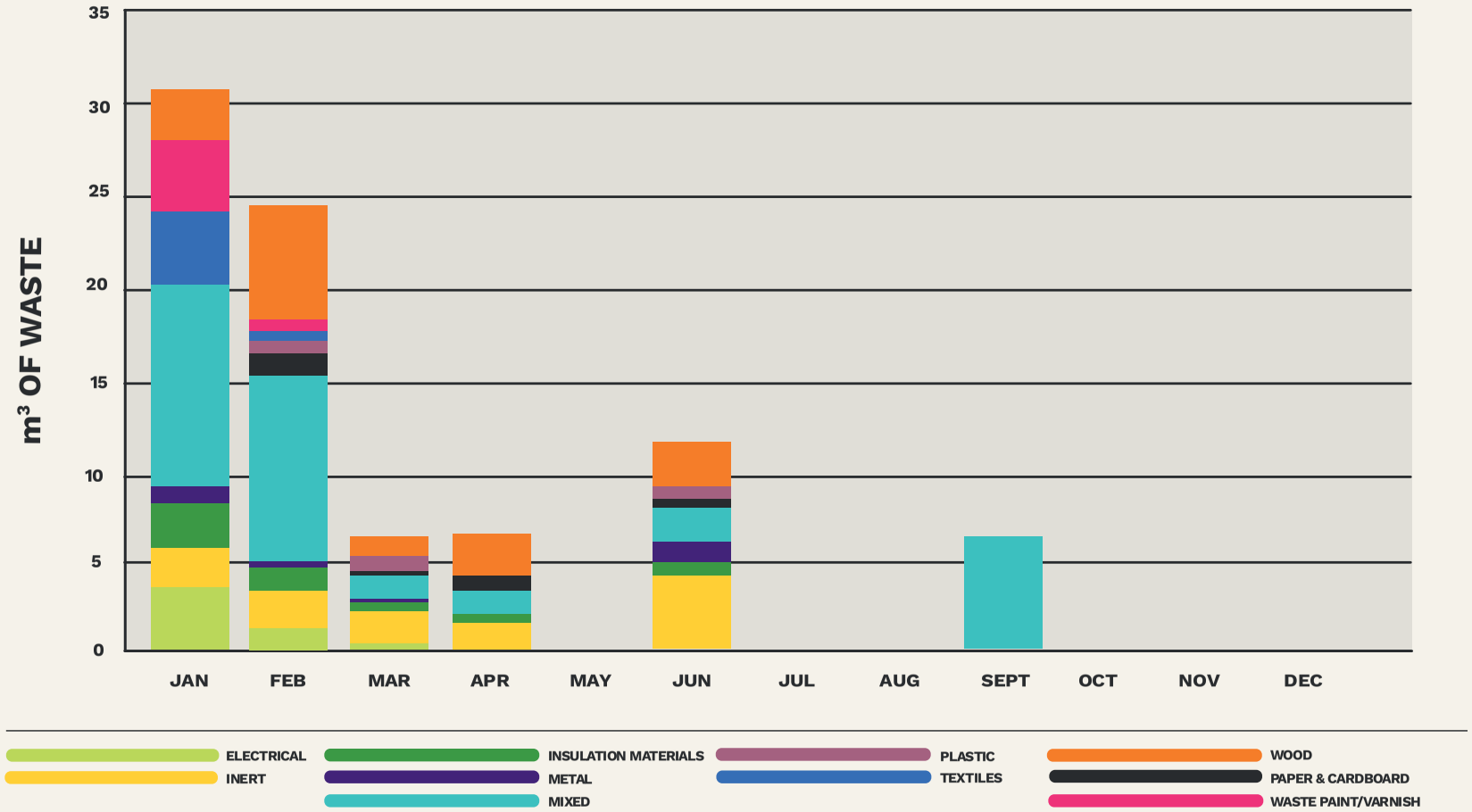
What can be seen in the above table is that packaging and municipal waste made up the majority of the waste volume in 2016, 46.8%. Excessive packaging has been repeatedly highlighted to EZW as an issue on construction sites and suppliers are encouraged to reduce packaging where possible.

Municipal waste (site canteen and office waste) has also been highlighted and there have been trials of site canteen waste collections in Torfaen and Ceredigion as part of other EZW projects. These trials have involved segregation of food waste and recyclates within the site office and canteen. Collections were then made as part of local municipal collections made by the councils.

The lack of on site segregation of waste, leading to co-mingling and likely contamination of recyclates, shifted the responsibility for recycling on to the waste management company. Landfill diversion rates reported by the Derwen waste management facility in 2016 were high with only 1.74% of waste processed going to landfill. This success translates well when it is applied to this project with only 1.5m^3 of waste going to landfill. However, this is not due to site efforts or practices but instead an achievement of Derwen's practices.

57.5m^3 67.1% of the waste was recycled and 26.7m^3 31.2% sent for energy recovery.

MONTHLY WASTE BY TYPE 2016 m^3



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CONSTRUCTING EXCELLENCE IN WALES

5.3 Analysis by Waste Management Option

5.3.1 Prevention

Total cost savings due to prevention equate to £25,270

The project involved conservation of the original Grade-II* building which was carried out with the intent to retain as much of the original features as possible. This involved:

Window Frames – 20 window frames were restored on site and 5 windows were sent off site for restoration. It is estimated that this would have been 2 tonnes of timber waste and would have cost £267 to dispose of. New windows would have cost in excess of £25,000 based on £1,000 per new window matching the original Edwardian baroque style.

Total = c.£25,270

Roofing timber and joists – Repairs were carried out on the roof joists. Joists in good condition were repaired and any sections that could be reused, were reused, where practicable.

5.3.2 Reuse

Quantifiable savings due to reuse were £57,194.

The project involved a large amount of conservation work. Because of this it was found that John Weaver were in the habit of conserving materials and not disposing of items that could be reused. It was found that the site team were regularly reusing materials to reduce waste as well as being part of the brief to conserve as much as was possible of the original building.

Examples of reuse included

1. Bricks – Brick waste produced through creating new openings within the building was stored on pallets and kept on site in order to be reused or replace broken bricks. Estimated to be 2.5 tonnes of prevented brick waste. Disposing of 2.5 tonnes of inert (brick) waste would have cost £144
2. Parquet Flooring – 14 pallets of oak parquet flooring were stored to be cleaned and reused. This has been estimated to be 12 tonnes of timber waste prevented. Disposal of this timber would have cost £1,542 based on the fee per tonne of wood and a skip lift fee. This assumes 1.15 tonne per skip based on project average for a wood skip. New oak parquet flooring at £60 per m^2 would have incurred an extra cost of approximately £55,500. Total = c.£57,050.
3. The site hoarding was erected by a sub-contractor, who also removed it with the intention of reusing it on another site
4. Wooden boards were used to protect some architecture within the old building. This was later reused as patressing, noggins and external shuttering.
5. Roofing timber and joists – Repairs were carried out on the roof joists. Joists in good condition were repaired and any pieces that could be reused were reused, where practicable.

5.3.3 Recycling

Total recycling rate for this project was 82.9% and recycling practices saved £310,244.

Provision for recycling was made on site with segregation encouraged for timber, plasterboard, glass, cardboard and mixed waste. 181 of the 258 containers (70.2%) which left site were segregated, easing recycling for the waste management companies and helping to maintain the value of the recyclate material.

Some material types were kept separately on site and taken to John Weaver's yard where recycling material is bulked for cost effective recycling. 11 transfers were made for bulking up 12.1 tonnes of waste, with Derwen being the final destination for all the waste.

- 9 Plasterboard skips – 11.4 tonnes
- 1 Mixed skip – 0.7 tonnes (10% Inert, 75% Insulation, 15% Canteen/office)

Plate glass was carefully removed during the roof construction. As a waste it was kept separately and transported direct to GlassTech Recycling as arranged by Derwen. At the time GlassTech would have exported this waste to Portugal for further treatment or downcycling it into insulation. Recent improvements in GlassTech's systems mean it would now go for re-melt.

- 1 Glass skip – 2.07 tonnes

Recycling of the inert waste via segregated loads removed by Stenor and Agricon diverted 1279m^3 of inert waste from landfill. This cost £19,012.50 to be removed in ninety-eight 20 tonne wagons, but could have cost c.£240,000+VAT for disposal in mixed waste skips. Saving £271,000 based on £115 per tonne and 325 skip lifts at £50 each.

Assuming no segregation for recycling, and applying mixed waste skip fees to all waste, the cost of disposing of this waste to Derwen could have been c.£47,000. The actual cost, was £37,774.44. The saving was therefore more than £9225 20.0% due to on site segregation for recycling.

5.3.3.1 Derwen

Derwen has reported recycling rates of 48.3% in 2014, rising to 67.2% in 2015 and 67.1% in 2016. These rates suggest 171 tonnes, 62.0%, of the 275.8 tonnes of waste processed by Derwen was recycled. Broken down by year;

Year	Recycling Rate	Tonnes Recycled
2014	48.3%	36
2015	67.2%	118
2016	67.1%	17

5.3.3.2 Stenor Environmental Services

Stenor Environmental Services (Stenor), based in Swansea, removed groundworks and excavation waste in 2014. This waste resulted from the collapse of the bank at the rear of the site. Stenor screened and separated the waste allowing for 100% of the waste to be recovered.

Sixty loads in 20 tonne wagons were removed, with the contents reported on SMARTWaste as;

- Concrete 3 wagons
- Brick 2 wagons
- Stone 1 wagon
- Inert 40 wagons
- Soil 14 wagons

In September 2015, during the construction phase, three 16 tonne wagons of inert waste were removed from site by Stenor.

5.3.3.3 Peter Davis Agricon Ltd.

In 2014 Peter Davis Agricon Ltd. (Agricon), based in Swansea, removed 39 containers of inert and soil waste which resulted from the collapse of the bank at the rear of the site. Agricon screened the waste allowing for 100% of the waste to be recovered.

5.3.4 Energy Recovery

Derwen converts residual wastes into refuse derived fuel. The rates for the period of this project were;

Year	Energy Recovery Rate	Tonnes Recovered
2014	29.9%	64.4
2015	28.1%	192.1
2016	31.2%	26.7

Applying these rates to the 984.8m^3 of waste removed by Derwen for this project suggests 283.3m^3, 30.3% was sent for energy recovery.

Total percentage of waste arisings going to energy recovery therefore = 12.1%

5.3.5 Landfill

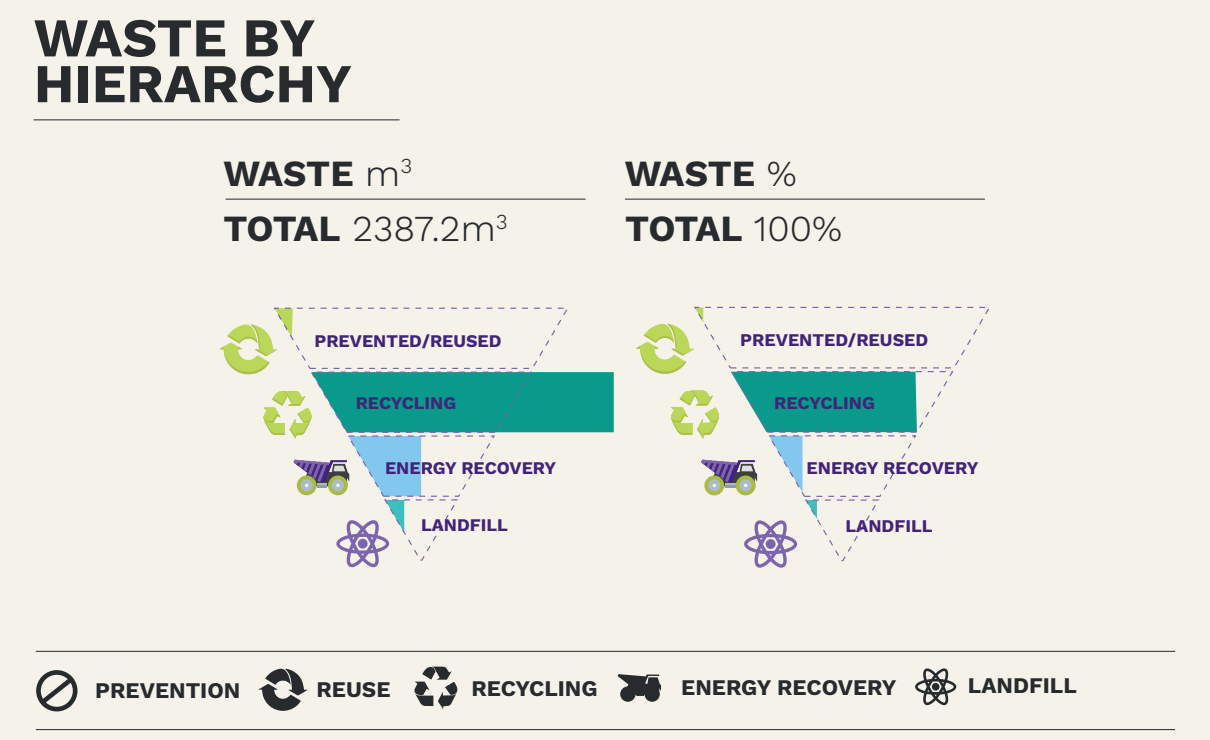
Landfill rates for Derwen were;

Year	Landfill Rate	Tonnes Landfilled
2014	21.9%	215.5
2015	4.7%	683.7
2016	1.74%	85.7

Applying these rates to the 984.8m^3 of waste removed by Derwen for this project suggests 80.8m^3 8.2% was sent to landfill.

No other waste is reported as going to landfill.

Total percentage to landfill therefore = 3.4%



5.4 Analysis by Material Type

This section is based on waste volumes for each material type, as reported on SMARTWaste by the site team.

5.4.1 Inert

Removal of inert waste from the Glynn Vivian site involved a total of 114 segregated containers, removed by three waste contractors Derwen, Stenor and Agricon. The size of containers varied from 20 tonne wagons to 8 yard skips. The classification of inert waste included;

• Concrete	66.3m^3	4.4%
• Bricks	50.8m^3	3.4%
• Tiles & Ceramics	13.2m^3	0.9%
• Soil and stone	470.0m^3	31.5%
• Mixture	891.8m^3	59.8%

Inert waste was produced throughout the project with significant peaks in May / June 2014, October 2014 and then again in September 2015. The total was 1492.0m^3, 63.7% of total project waste.

The May / June peak was due to excavation phase waste. A slip of made ground at the back of the site resulted in an unplanned waste stream comprised of concrete, soil and stone, brick and inert waste. Most of the waste was classified as either soil and stone or inert waste. This was removed by Stenor and Agricon, mainly in 20 tonne wagons. The cost of this unexpected waste and haulage costs was £19,012.50.

Costs for removal by Derwen were for 50.9 tonnes of inert waste across 11 containers. These eleven containers were charged at a flat rate per skip. If the mixed waste lift rate and per tonne charge were applied disposal would have cost five times the actual cost.

Much of the inert waste was classed as soil and stone, which could have been removed from site without classification as waste. The CL;AIRE definition of waste code of practice provides an alternative which enables the reuse of excavated materials on-site or their movement between sites for reuse. Costs for transport could have been reduced and shared between the Glynn Vivian site and a receiver site, with the receiver site benefiting from an alternative to virgin imported material.

5.4.2 Wood

Total wood waste for the project was 317.9m^3, 13.6% of total waste produced on this project. There were two peaks in wood waste during the course of the project in May 2014 and November 2015.

Timber waste was created during roofing works carried out by John Weaver joiners. Concrete tiles and timber battens were stripped and rotten timber joists were replaced. Repairs were carried out on the roof joists in repairable condition and any pieces that could be reused were reused, where practicable. A timber skip was part of the site waste compound, where segregation was good and the skip was tightly packed.

Pallets were kept on site and used to store materials around the site. They were also taken to other sites to be used in a similar way. Pallets were only considered waste when they were broken, they were then disposed of in the timber skip.

Parquet flooring within the ground floor gallery area had to be removed along with some timber joists due to the discovery of wet rot in October 2015. The site team ensured that the contaminated timber was separated and placed into a flexible tonne bag (FIBC). The waste management company was contacted to inform them of the contamination and the bag was removed at the same time as the timber skip.

14 pallets worth of parquet flooring was reclaimed, stored, cleaned and reused on site. Preventing an estimated 12 tonnes of timber waste. Similarly 20 window frames were restored on site and 5 windows were sent off site for restoration. It is estimated that this would have been 2 tonnes of timber waste. Other examples of avoiding disposal through reuse include;

- The site hoarding - erected by a sub-contractor who also removed it with the intention of reusing it on another site
- Wooden boards - used to protect some architecture within the old building. This was later reused as patressing, noggins and external shuttering.

Estimated 20 tonnes of waste avoided through reuse, this saved approximately 17 skips worth of waste (based on an average of 1.15 tonnes of wood waste per wood skip). This saved £3780 of cost if disposed of as mixed waste or £2500 as wood waste. An additional 38.0% - 57.5% on top of actual wood disposal costs respectively. Cost for the removal of wood waste by Derwen was based on a rate per tonne and a lift charge. The per tonne rate was 53.6% of the mixed waste rate, achieving a saving of 21.1% on top of the costs avoided through reuse. Wood disposal would have been 110% more expensive without the examples of reuse and segregation of waste highlighted here.

5.4.3 Plasterboard

90.0m^3 of plasterboard waste, 13.2 tonnes, was produced. It was then removed by Derwen. This represents 9.0% of construction waste and 3.8% of total waste arisings. The waste resulted from works from May to December of 2015, peaking at 24.5m^3 in September.

Due to room dimensions in the existing structure, some plasterboard offcut waste was inevitable. Awareness of plasterboard waste was raised with staff on site and it was minimized as best as possible. For example, plasterboard offcuts were found to be stored on site for use where practicable, minimising wastage.

The restricted nature of the site meant there wasn't space for a dedicated plasterboard skip during the plasterboard works. Plasterboard waste was stored around the site in tonne bags which were removed by John Weaver and taken to their yard, where plasterboard waste was bulked up.

Nine plasterboard containers of varying size were transported to John Weaver's yard. They contained a total 11.4 tonnes of plasterboard waste which was bulked up, allowing for more cost-effective disposal.

Cost of gypsum disposal by Derwen was 26.1% cheaper per tonne than disposal as mixed waste.

5.4.4 Insulation

The project generated 117.1m^3 of insulation waste, 11.7% of construction waste and 5.0% of total waste arisings. It was produced between June 2014 to June 2016 in a bell curve peaking in July 2015.

Some insulation waste, 0.53 tonnes, was taken to John Weaver's yard for bulking up for most cost-effective disposal. Derwen was the final destination for this waste. Insulation waste was disposed of in mixed waste skips at the highest cost charged by Derwen.

5.4.5 Mixed

Mixed waste was produced throughout the project.

Production rose to a peak in November of 2015 before falling away in 2016. 181.4m^3 of mixed waste was recorded, 18.2% of construction waste, 7.7% of total waste.

Site staff regularly checked the contents of the mixed waste skip, as they were aware of the cost of waste on site. They would remove items such as cardboard boxes to ensure good segregation and reduce contamination within any of the skips on site.

Mixed waste skips were on site throughout the project and were removed by Derwen. Before leaving site the contents of each mixed waste skip was estimated and noted on SMARTWaste. Some of the recorded contents was office waste, which was minimal on site but was not collected separately.

5.4.6 Canteen & Office Waste

There was a steady rise in the volume of canteen and office waste to November 2015 then a fall as the number of staff on site reduced. The fall in volume coincided with canteen waste becoming a significant percentage of monthly waste. For example, 18% of waste in June 2016 was classified as canteen / office waste.

Often site canteen and office waste is co-mingled with food waste contaminating recyclates, making disposal to landfill the most viable option. Trials undertaken by EZW in Torfaen and Ceredigion demonstrated an alternative disposal option. Collections of canteen and office waste were made as part of the regular council municipal waste collection, for a nominal fee. These have included food waste and recyclate collections.

Using council municipal collection services in Torfaen and Ceredigion encouraged segregation of recyclates and food waste. This maintained the value of recyclates, by reducing contamination, and allows for disposal of food waste via anaerobic digestion instead of landfill.

Benefits include:

- Increased diversion from landfill for recyclates and food waste
- Fewer collections of mixed waste skips from construction sites; reducing the number of lorries associated with construction sites
- Lower mixed skip weights reducing waste disposal costs
- Increased recycling rates
- Increased throughput for digestion facilities

It is hoped that these trials will spread across Wales.

5.4.7 Roofing Materials

Conservation requirements for the roof of the original building meant the existing roof was to be stripped of the concrete tiles and repairs were then carried out to the roof structure. Roofing batten timbers were removed as they required replacing, and the roofing joists were repaired as much as possible, replacing any rotten wood. The concrete tiles were then replaced with slate.

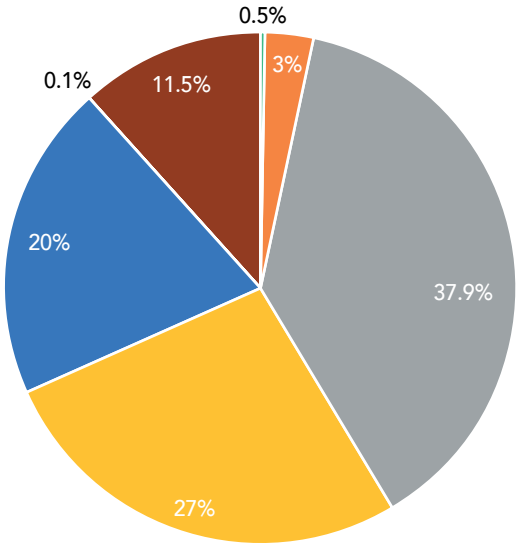
The concrete tiles were carefully removed and stored on pallets as some were in good repair. Broken tiles were disposed of in the inert skip. Enquiries were made with local reuse facilities and architectural salvage companies. Unfortunately, as they were not good quality tiles, they were not in demand. Roofing tiles were distributed to anyone who would make use of the tiles and tended to be members of the public who wanted a few tiles to carry repairs on their homes.

Part of the roofing was glass allowing natural light to flood into the building. It needed stripping out and replacing with new glass. The glass was carefully removed and kept separate to other waste. It was taken direct to a glass recycler GlassTech who would have exported this waste to Portugal for further treatment or downcycling it into insulation. Recent improvements in GlassTech's systems mean it would now go for re-melt.

5.5 Analysis by Cost

5.5.1 Actual Waste Management Costs

For the project as a whole John Weaver had 258 containers of waste removed from site. 151 (58.5%) were from the construction phase, 9 (3.5%) from demolition phase and 98 (38.0%) from the excavation phase.



Total Derwen Cost =	£37,774.44
Total Stenor & Agricon Cost =	£19,012.50
Total Waste Management Cost was =	£56,786.94

Mixed waste skips accounted for 47.0% of the waste management cost but were only a third of the total skips. Meaning mixed waste collections contributed an extra 14% to the costs, compared to other containers.

5.5.2 Potential Waste Management Costs

Without consideration of the waste hierarchy, waste management costs had the potential to be in excess of £400,464. This potential cost is based on no segregation of waste and the disposal of all waste at the mixed waste skip rate. It also accounts for extra costs which would have been incurred without prevention or reuse of waste. Details can be found in section 5.3.

Total cost savings due to prevention =	£ 25,270
Quantifiable savings due to reuse were =	£ 57,194
Segregation of waste for recycling saved =	£318,000
Total =	**£400,464**

There was potential to spend nearly seven times the actual waste management cost on this project. Over £400,000 was saved.

5.6 Analysis Against Benchmarks

Waste data is available in the SMARTWaste system for hundreds of projects completed in Wales. Projects can report in waste volumes or waste tonnages for a wide variety of project types. The data has been analysed to produce performance indicators for waste arisings per £100k and per 100m2 for volume and/or tonnage of waste produced.

Here the performance of the construction phase is compared with the SMARTWaste benchmark for a public building.

BREEAM (BRE Environmental Assessment Method) is a widely used environmental assessment method for buildings and communities. It addresses environmental and sustainability issues and credits are used as part of the assessment criteria.

5.6.1 SMARTWaste

	Construction Phase Data	SMARTWaste Benchmark*	Comparison
$m^3/100m^2$	21.2	21.7***	-3.3%
$m^3/£100k$	15.8	21.1**	-25.1%

*for a public building
**based on 10 projects
***based on 8 projects

New public building projects on SMARTWaste average $21.7m^3/100m^2$ and $21.1m^3/£100k$. The construction phase of the Glynn Vivian project achieved $21.2m^3/100m^2$ and $15.8m^3/£100k$. These results mean the project was 3.3% and 25.1% less wasteful than the established benchmarks.

5.6.2 BREEAM

	Construction Phase Data	1 credit	2 credits	3 credits	Exemplary
$m^3/100m^2$	21.2	<13.3	<7.5	<3.4	<1.6

The Glynn Vivian project achieved $21.2m^3/100m^2$ of waste for the construction phase of the project. This was 1.6 times the volume needed to achieve a BREEAM credit.

6 Modelling

6.1 Building Information Modelling (BIM)

It is widely recognised in the built environment sector that the translation of drawings into the actual structures frequently gives rise to unforeseen clashes, particularly in respect of complex junctions and mechanical and electrical services. It is common practice that clashes encountered are resolved reactively on site, often wasting materials and time. Through the use of software BIM's goal is to eliminate this waste.

BIM is, however, as much about people and process as it is about software, offering the opportunity to achieve greater efficiencies, as well as better working methods. The collaborative approach required to produce an effective design through BIM ensures a constant flow of information between disciplines. BIM then allows operatives to visualise each other's inputs, encouraging mutual understanding and good working relationships.

6.2 Using BIM at Glynn Vivian

The Grade-II* listing of the original Edwardian gallery restricts development of the building. The internal fabric couldn't be altered from its original state. False walls were used to hide electrical systems, whilst providing a pristine, unobstructed wall space for exhibitors.
Arup demonstrated how BIM could be used by the client and exhibitors to easily identify all the hidden electrical fixtures within the main gallery spaces. The aim was to allow exhibitors to place exhibits and wall fixings with the knowledge that they won't hit electrical services in the process.

6.2.1 Preparing the Model

For this project Arup (7) used "Matterport" a maneuverable scanner comprised of a 3D camera and sensors which spins 360 degrees on top of a five-foot tripod. The camera and array of 2D and 3D sensors rotates, to quickly capture the appearance and dimensions of a space.

LiDAR was the sensing technology used. It measures distance by illuminating a target with a laser and analyzing the reflected light. The information the scanning equipment collects generates point cloud data that can store the size and colour of the scanned objects.

By repeating every five to six feet, the technology can stitch together the scan data to build an accurate picture of the environment. The scanner also captures photographic data, which can be grouped together in an environment that is very similar to Google Street View.

The resulting point cloud data was processed and converted into a useable point cloud format for use within a data rich and parametric BIM package. This point cloud was used as a reference within the BIM environment, for building up an accurate representation. This was done by placing parametric elements such as walls, floors and roofs to match the point cloud.

6.2.2 Utilising the Model

To provide a way in which the gallery staff and exhibitors could access the data, and use it functionally within the gallery, Arup turned to augmented reality. New technologies are assisting design and construction teams in the visualisation of ideas and designs.
Virtual Reality (VR) through headsets and immersive environments and Augmented Reality (AR) allow designers, developers and users to visualize finished designs without them having to be built.

Present AR technologies require key markers (or locators), to allow data within the virtual environment to accurately overlay the real environment. Markers such as barcode and RFID tags were not seen as viable options for use within the gallery environment. The actual features of the building are utilised by applying Simultaneous Localisation And Mapping (SLAM).
Through SLAM, the Project Tango device uses points on surfaces to link actual surfaces to virtual, digital surfaces.

Project Tango is a technology platform from Google that allows developers to create experiences that incorporate 3D mapping, and augmented reality.

6.3 BIM Outcomes

This use of technology through AR allows users to visualise model information and assets that would not be possible otherwise. The end user can interrogate the model and identify the location of fixtures with relative ease. This will aid exhibition design as well as facilities management and maintenance.

Utilisation of BIM technologies provides an ideal opportunity for the construction industry to record buildings in an intelligent way. Through the careful combination of scanning and model creation, smart data can be generated and reused for multiple purposes. It provides an efficient way to reveal model information behind physical barriers.

7 Future Proofing - Application of Environment Bill

The project has highlighted future potential issues for the industry. Specifically, with regard to the upcoming incineration and landfill bans for wood, paper, cardboard, glass, plastic, metal and food waste as part of the Environment (Wales) Bill.

If the Bill were applied to this project around 50.0m3 of material may require an alternate disposal solution. As such, research will need to be carried out to understand what alternate disposal options, along with the appropriate infrastructure, are necessary to enable the necessary changes required by legislation.

8 Key challenges

8.1 Waste

The project forecasted particular waste management challenges resulting from:

- A compact working site with very limited storage space - the site is in a heavily congested area immediately adjacent to a busy arterial route taking traffic out of the city. There is ongoing renovation in this area of Swansea with the conversion of the old library (immediately opposite the site) into the new Swansea Metropolitan University - School of Art
- The site is on a steep hill resulting in a sloping site - deliveries and removals were limited to smaller vehicles and were only able to be partially filled resulting in additional loads to and from site
- The Grade-II* listed status - due to sensitive restoration and refurbishment, the potential for additional waste to be generated was identified. There was the potential for hazardous waste due to the original materials that may have been used
- Predicted waste streams - included plastic, timber, packaging, bricks (although many of these were removed, cleaned and prepared for reuse), concrete waste and plasterboard

Segregation of waste was managed well despite the space limitations. Tonne bags were used around the site which were then either removed by the company vehicle for recycling back at the skips they had at their yard or through bringing in skips for specific jobs when space allowed it.
Using the company vehicle to remove any surplus materials also demonstrated that having a site vehicle can be invaluable in preventing wastage and reduced the need to purchase more materials, at a company level.

8.2 Behavioural/Cultural

Site behaviours and culture can often lead to significant wastage or a laissez-faire attitude to waste and waste segregation.

Employees directly employed by John Weaver were found to be very aware of waste issues and how their wastage impacts on the project feasibility and costs. This was found to be following 2 years of staff training, raising awareness of staff at all levels of the company. Site Managers were trained on how to input waste data onto SMARTwaste themselves. They were found to regularly check the contents of skips, take out waste that wasn't segregated properly or could be re-used. If a skip couldn't be made available on site due to space restriction, John Weaver would put temporary storage on site, then transport the waste back to their yard to bulk the waste up for recycling.

With site management and all staff having a waste awareness on site it became embedded in site culture. When sub-contractors were employed to carry out work on site, waste awareness was raised with these sub-contractors along with minimising waste and using their materials effectively.

8.3 How has EZW Influenced Waste Management for the Project Team?

The Glynn Vivian Art Gallery was an extremely challenging project, with site constraints, programme and complex design. The existing building and in turn the site was on a steep hill with little room for set down or site compound areas, making logistics for the site material delivery, storage and waste segregation/removal very difficult. This resulted in the need to prioritise waste management to its up most effectiveness.

With the help of CEW's Enabling Zero Waste scheme we managed to identify opportunities which helped to reduce the waste impact. Due to the nature of a refurbishment project and the fact that a previous contractor had already carried out the demolition works, it was decided that we would focus our efforts on the area we could make a difference, for example reuse of existing materials within the refurbishment and new build extensions.

A consultant was provided by EZW who during their site visits worked with the site team to come up with new and alternative ways of reducing the waste on site.

The knowledge provided was extremely helpful and the good rapport that was built up with the site team went a long way to ensuring the best outcomes from the project.

CEW also provided the use of BIM for the project to see if this would help in the reduction of waste, however due to the already complexed design being in place it was unrealistic to try to use the model for the entire project. Therefore, it was decided to focus this more for the end user, to help reduce waste produced in the future by the constant redesign of the gallery spaces. It is felt that if BIM had been used as part of the design stage it would have helped in the coordination of many complexed details and in turn helped towards the reduction of waste for the project.

John Weaver Contractors and the project team certainly benefited from the knowledge and experience of working with CEW and the EZW scheme, and would welcome any opportunity to work with them in the future.

9 Successes

9.1 Welsh Government Targets

Towards Zero Waste (TZW), the Welsh Government's overarching strategy document on dealing with waste in Wales, aims to produce benefits for the environment, economy and for society. TZW sets a target for the construction and demolition industry in Wales to prepare for reuse, recycling or other material recovery at least 70% of waste, by weight, by 2015-16. The target for 2019-20 is 90%.

By reaching a reuse, recycling or other material recovery rate of 96.6%, by volume, the Glynn Vivian project shows how achievable the present target of 70%, by weight, is. It also highlights the achievability of the 2019-20 90%, by weight, target.

The Welsh Government aims for 100% diversion of construction and demolition waste from landfill by 2050. The 3.4% of waste calculated to have been landfilled on this project was due to the practices of the waste management company. Derwen could not supply project specific rates for recycling, recovery and landfill, only whole operations performance. This makes it impossible to prove 100% diversion from landfill until waste management companies either achieve 100% diversion, or have project specific recording of waste end destination.

Further focus is considered to be required on waste prevention and reuse rather than relying on the efficiencies of waste management infrastructure. A 1.4% reduction of waste still needs to be achieved year upon year in order for the Towards Zero Waste targets for the sector to be achieved.

9.2 Waste Awareness

Waste was high on the agenda of John Weaver and site employees, which was evident to the members of the EZW team who visited the site. Site team members employed directly by John Weaver were found to be aware of waste issues and how they impact on the project and costs of the project.

Site managers were trained to input waste data onto SMARTWaste themselves. They were found to regularly look in the skips and take out waste that wasn't segregated properly or could be re-used.

If a skip couldn't be made available on site due to space restriction, John Weaver would use temporary storage on site, then transport the waste back to their yard to be bulked up before disposal.

The work that has been carried out over the past 2 years by the environmental representative on site was impressive. Despite the project producing more waste than was anticipated, due to ground excavation and additional works, John Weaver found the best solutions for their waste through good relationships with local waste companies.

Waste awareness could be raised during pre-let meetings when bringing in contractors and thus ensuring the awareness is raised at the start and before coming onto site.

9.3 BIM

The innovative use of BIM and augmented reality (AR) on this project should provide significant benefits in the future. Asset and facilities management at the Glynn Vivian Art Gallery will be improved through the ability to see hidden services without exploratory works. This will save significant time, money and materials through the life of the gallery.

Similar use of BIM on other projects can now be realistically considered thanks to this innovative example. Applied across the whole construction and building management industry the use of AR with BIM could lead to a step change in efficiency and ways of working.

For this project the AR allowed visualisation of what has been put in place, and it could easily be used to visualise what will be put in place. Allowing engineers and site operatives greater, easier insight into what following trades will be installing and where, reducing abortive and corrective works.

10 Conclusion and recommendations

The Glynn Vivian Art Gallery has performed well against established SMARTWaste benchmarks and Welsh Government targets for the construction phase.

Whilst targets have been met, further focus is required on waste prevention and reuse, rather than relying on the effectiveness of waste management infrastructure. Opportunities exist for greater efficiency and effectiveness on site, offering potential for waste and cost savings.

Cost savings are available for companies willing to consider the waste hierarchy at all stages of a project. Prevention is the key level in the hierarchy when it comes to unlocking substantial savings, as highlighted by this project. BIM offers an opportunity for designs to be tested and altered with a view to prevention of, for example clashes. Both of which can be expensive and wasteful.

The importance of segregation of waste at source has been made clear, along with focusing on and discussing waste at all stages of a project, with all involved on site. Engagement with all members of the site team is important when attempting to maintain best practice and segregation during periods of pressure on site, especially the final stages before handover. .

10.1 Client Recommendations

Additional works can have a significant impact on waste arisings. In this case the client's request for additional work led to a reliance on mixed waste skips due to the inability to predict and plan for waste streams, as well as limited space on site.

Clients need to be aware how their decisions can have knock on impacts on the management of waste. They should be encouraged to think through their potential additional needs ideally long before construction. Consider how you will use your asset? What demands will you place on it and how will that affect the asset's longevity? BIM should help clients with visualising the new asset and help with this process.

When changes do need to be made during the works, client's should allow time for proper management for design, construction and waste management planning. Client's should have an ongoing dialogue with design consultants and contractors in case changes do need to be made.

10.2 Designer Recommendations

BIM offers a viable option for the elimination of design waste. Uptake of BIM will mean more design decisions are made earlier making the process more proactive than reactive. Easy visualisation of each discipline's inputs on site, through augmented reality, allows for easy identification of errors or clashes. Effective working in BIM ensures a constant flow of information, encouraging mutual understanding and good working relationships.

Consider asset management. How will the asset be used, and how will use change over time? For example, different exhibits will be hung in the gallery on different walls in different ways over the life of the gallery. Designing for adaption will extend asset usefulness and maintain asset life.

10.3 Contractor Recommendations

The set-up of the waste compound is a key part of the waste management strategy and should be a major concern of the site waste champion during planning for work on site. It should be a priority for contractors to have a member of the site team who takes ownership for waste management.

Waste compounds should contain segregated skips from day one on site and their purpose explained to everyone. Ideally a mixed waste skip should not be available, but if it is necessary it should be located furthest away from the site works, to discourage its use.

Focus should be given to ensuring contractual obligations, specifying that all stages of the waste hierarchy are observed before disposal to landfill. This will reduce the potential impact of sub-contractor decisions on project reuse, recycling or other material recovery targets. Focus on waste and discuss waste at all stages of a project, with all involved on site.

Packaging waste was significant on this project. Suppliers can play a key role in reducing packaging as long as contractors communicate the problems they face with disposal with their suppliers. Often packaging take-back schemes can be organised with

manufacturers or suppliers, but this requires foresight and planning so agreements are in place before the waste becomes an issue.

The Environment (Wales) Bill will ban disposal by incineration or landfill for wood, paper, cardboard, glass, plastic, metal and food waste. Contractors will need to consider how they will deal with these wastes as the cost for disposal will likely increase to pay for research into alternate disposal options. Prevention offers the most cost effective solution; best practice is key to this.

11 References

1. Welsh Government. Towards Zero Waste : The Overarching Waste Strategy Document for Wales. Cardiff : Crown Copyright, 2010.

2. Sir John Egan - Construction Task Force. Rethinking Construction. London : Crown Copyright, 1998.

3. John Weaver (Contractors). Company. John Weaver (Contractors). [Online] John Weaver (Contractors), 2015. [Cited:] http://www.johnweaver.co.uk/company.html.

4. Historic Wales. [Online] July 01, 2014. [Cited: September 13, 2016.] http://historicwales.gov.uk/.

5. City and County of Swansea Council. Glynn Vivian Art Gallery Redevelopment. City and County of Swansea Council - Leisure. [Online] August 31, 2016. [Cited: August 31, 2016.] http://www.swansea.gov.uk/article/7180/Glynn-Vivian-redevelopment.

6. Wales Online. Business: Business News. Wales Online. [Online] Wales Online, June 25, 2013. [Cited: August 31, 2016.] http://www.walesonline.co.uk/business/business-news/55-jobs-lost-construction-business-4709043.

7. ARUP. Reducing waste; BIM buried services case study. 2015.

Galluogi

DYFODOL DIWASTRAFF

Oriel Gelf Glynn Vivian

Noddir gan Lywodraeth Cymru
Sponsored by Welsh Government

ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

Galluogi Dyfodol Diwastraff: Oriel Gelf Glynn Vivian

Cynnwys

Oriel Gelf Glynn Vivian

1 Crynodeb Gweithredol

Mae Galluogi Dyfodol Diwastraff (EZW) yn gynllun gan Adeiladu Arbenigrwydd yng Nghymru (CEW) sy'n ceisio sefydlu os, a sut, y gall y diwydiant adeiladu gyrraedd y targedau diwastraff a osodir allan yn strategaeth wastraff Llywodraeth Cymru, Tuag at Ddyfodol Diwastraff.

Mae CEW yn gweithio mewn cydweithrediad â'r diwydiant i geisio dirnad yn well sut y gall y diwydiant anelu at fod yn ddiwastraff, ac i ledaenu arferion gorau, atebion a chyfleoedd; ynghyd ag adnabod unrhyw rwystrau cysylltiedig i gyflawni'r targedau.

Mae Oriel Gelf Glynn Vivian yn oriel gelf gyhoeddus yn Abertawe, De Cymru. Roedd adfywio a datblygu'r oriel yn rhan o'r Fframwaith Adfywio Cynaliadwy ar gyfer Bae Abertawe. Oherwydd nifer o newidiadau yn ystod y gwaith adeiladu, a gwaith ychwanegol, cynyddodd werth y contract gwreiddiol o £5.3m i £6.3m.

Aeth y contractwyr gwreiddiol, Opco Construction, i ddwylo'r gweinyddwyr yn 2013 ar ôl cyflawni peth o'r gwaith dymchwel, gan gynnwys tynnu asbestos allan. Daeth EZW yn rhan o'r prosiect pan ddechreuodd John Weaver ar eu pecyn gwaith ym mis Mawrth 2014, oedd i'w gwblhau erbyn Mawrth 2015. Ond oherwydd problemau ar y safle, cafodd amserlen y prosiect ei hymestyn gyda'r adeilad yn agor ym mis Hydref 2016.

Contractiwyd tri chwmni i reoli'r gwastraff a gynhyrchwyd gan brosiect Glynn Vivian dros y cyfnod pan oedd EZW yn rhan o'r prosiect. Y rhain oedd;

- Derwen Plant Ltd. (Derwen) – Cwmni Cwmpawd Gwyrdd
- Stenor Environmental Services Ltd. (Stenor)
- Peter Davies Agricon Ltd. (Agricon)

Deliodd Stenor ac Agricon â'r gwastraff anadweithiol a gynhyrchwyd gan arglawdd yn cwympo yng nghefn y safle. Symudwyd llond 97 cynhwysydd o wastraff. Deliodd Derwen â'r gwastraff adeiladu a gafodd ei ddidol ar gyfer ailgylchu, adfer a thirlenwi. Drwy waith y tri chwmni rheoli gwastraff hwn, gallai'r prosiect adrodd y canlynol;

- Cyfanswm canran y gwastraff wedi'i atal neu ei ailddefnyddio = 1.8%
- Cyfanswm canran y gwastraff wedi'i ailgylchu = 82.9%
- Cyfanswm canran y gwastraff y llwyddwyd i adfer ynni ohono = 12.1%
- Cyfanswm canran y gwastraff i'w dirlenwi = 3.4%

Ar ôl llwyddo i gyflawni cyfradd adfer o 96.6% drwy ailddefnyddio, ailgylchu neu adfer deunyddiau mewn ffyrdd eraill, yn ôl cyfaint, mae prosiect Glynn Vivian yn dangos pa mor gyraeddadwy yw targed presennol Llywodraeth Cymru o 70%, yn ôl pwysau. Mae hefyd yn dangos pa mor gyraeddadwy yw'r targed 90%, yn ôl pwysau, erbyn 2019-20. Nod Llywodraeth Cymru erbyn 2050 yw osgoi tirlenwi 100% o'r holl wastraff adeiladu a dymchwel. Mae'r 3.4% o wastraff y cyfrifiwyd iddo gael ei dirlenwi'n seiliedig ar gyfraddau tirlenwi blynyddol ar gyfer cyfleusterau rheoli gwastraff Derwen.

Er llwyddo i gyflawni'r targedau uchod ystyrir bod angen mwy o ffocws ar ailddefnyddio ac atal gwastraff yn hytrach na dibynnu ar ba mor effeithiol yw'r seilwaith rheoli gwastraff. Rhaid i'r sector adeiladu gynhyrchu 1.4% yn llai o wastraff o un flwyddyn i'r llall er mwyn cyrraedd y targed Tuag at Ddyfodol Diwastraff.

Daeth arbedion cost y prosiect o ganlyniad i ystyried yr hierarchaeth wastraff, a thrwy reoli gwastraff yn effeithiol, i dros £400,000. Byddai hyn yn cyfateb i 6.3% o werth y prosiect. Roedd y costau rheoli gwastraff gwirioneddol yn cyfateb i 0.9% o werth y prosiect gan ddangos pa mor bwysig yw ystyried gwastraff ar gyfer sefyllfa ariannol a phroffidiolrwydd prosiect.

Dyma rai o lwyddiannau eraill y prosiect:

- Cafodd y rheolwyr safle eu hyfforddi i gofnodi data gwastraff ar SMARTWaste eu hunain
- Roedd y rheolwyr safle yn cymryd gwastraff o ddifrif gan fynd drwy'r sgipiau'n gyson a thynnu allan unrhyw wastraff oedd heb ei wahanu'n iawn neu y gellid ei ailddefnyddio
- Daeth John Weaver o hyd i atebion ar gyfer eu gwastraff drwy eu perthynas dda â chwmnïau gwastraff lleol
- Bu tîm John Weaver yn ymweld â Derwen i ennill dealltwriaeth o sut y caiff gwastraff ei reoli

Dyma rai o'r argymhellion ar gyfer contractwyr:

- Mae'n flaenoriaeth bod gan gontractwyr aelod o'r tîm ar y safle sy'n cymryd meddiant o reoli gwastraff. Mae hefyd yn hanfodol bwysig bod y person sy'n gyfrifol am gynhyrchu rhagolygon gwastraff mewn cysylltiad rheolaidd â thîm y safle i sicrhau bod y rhagolygon yn gyraeddadwy, rhesymol a seiliedig ar berfformiad blaenorol
- Bod pwysigrwydd gwahanu'r gwastraff ar y dechrau'n glir i holl aelodau'r tîm ar y safle
- Canolbwyntio ar, a thrafod gwastraff ym mhob un o wahanol gamau'r prosiect, a phawb ar y safle'n cyfrannu at hyn

Dyma rai o'r argymhellion ar gyfer cwsmeriaid:

- Mae cyfathrebu'n barhaus ag ymgynghorwyr dylunio a chontractwyr yn bwysig
- Yn ddelfrydol, dylid meddwl drwy'r anghenion ychwanegol a allai godi ymhell cyn y cam adeiladu ond, lle nad yw hyn yn bosib, mewn pryd i ganiatáu ar gyfer rheoli'r dyluniad a'r gwastraff yn briodol
- Bod yn ymwybodol o sut y gall penderfyniadau gael effaith ganlyniadol ar reoli gwastraff
- Ystyried sut y byddwch yn defnyddio eich ased? Pa alwadau y byddwch yn eu rhoi arno a sut y bydd hyn yn effeithio ar ei hirhoedledd?

Dyma rai o'r argymhellion ar gyfer dylunwyr:

- Mae BIM yn cynnig opsiwn hyfyw ar gyfer dileu gwastraff dylunio. Mae'n hawdd delweddu mewnbwn pob crefftwr (e.e. trydanwyr) fel y gellir adnabod yn hawdd unrhyw wallau neu wrthdaro rhwng dyluniadau'r gwahanol grefftwyr
- Ystyried sut y rheolir ac y defnyddir yr ased. Sut y bydd y defnydd yn newid dros amser – er enghraifft yn yr achos hwn wrth hongian gwahanol arddangosion ar wahanol waliau
- Ymgysylltu â chontractwyr i wella dealltwriaeth o ddeunyddiau
- Ystyried beth yw meintiau safonol y deunyddiau yn y cam dylunio

2 Beth yw

2.1 Galluogi Dyfodol Diwastraff

Menter gan Adeiladu Arbenigrwydd yng Nghymru (CEW) yw Galluogi Dyfodol Diwastraff sy'n rhoi cymorth ymarferol, cadarnhaol a rhagweithiol i brosiectau adeiladu, dymchwel a pheirianneg sifil yng Nghymru. Y nod yw sefydlu os, a sut, y gall y diwydiant adeiladu gyflawni'r targedau diwastraff a osodwyd yn strategaeth wastraff Llywodraeth Cymru, Tuag at Ddyfodol Diwastraff (1).

Mae CEW yn cynnig cyngor technegol, arbenigedd ac arweiniad ar reoli gwastraff i brosiectau sy'n gweithio gyda EZW, ynghyd â chyngor Modelu Gwybodaeth Adeiladu (BIM) i helpu i oresgyn unrhyw rwystrau i leihau gwastraff ac i ddylunio ar gyfer dadadeiladu. Mae pob prosiect yn derbyn pecyn pwrpasol wedi'i deilwrio i'w anghenion.

Mae CEW yn gweithio mewn cydweithrediad â'r diwydiant adeiladu i geisio dirnad yn well sut i weithredu'n ddiwastraff. Y nod yw rhannu arferion gorau, atebion a chyfleoedd ynghyd ag adnabod unrhyw rwystrau sy'n gysylltiedig â chyflawni targedau gwastraff Llywodraeth Cymru. Mae CEW yn cynnig cymorth ymarferol i dimau dylunio a thimau safle prosiectau adeiladu i ganfod atebion hyfyw i fod yn ddiwastraff a chyflawni amcanion y cynllun EZW sef;

- Deall a dangos pryd a sut y mae gwastraff yn digwydd yn ystod y broses adeiladu
- Deall y strategaethau, y methodolegau a'r cyfleoedd presennol i osgoi tirlenwi gwastraff a gynhyrchir ar safleoedd
- Dadansoddi pa mor ymarferol / ddichonadwy yw anfon dim gwastraff i'w dirlenwi yn yr amgylchedd presennol
- Gweithio i ddatblygu atebion i atal a chynhyrchu llai o wastraff ar y safle adeiladu gan arwain, yn sgîl hynny, at orfod rheoli llai o wastraff ac at gostau gwaredu a thirlenwi is
- Cefnogi newid ymddygiad a phrosesau sy'n annog atal a lleihau gwastraff
- Gwneud arbedion ar y safle drwy gyfleoedd / atebion rheoli gwastraff
- Lleihau traffig ar y safle drwy gludo llai o wastraff, deunyddiau a chyflenwadau er mwyn gwneud arbedion cost
- Lledaenu atebion a chyfleoedd drwy ddatblygu strategaethau rheoli gwastraff effeithiol
- Cynnig cyfleoedd addysgol a dysgu am dechnegau rheoli gwastraff eraill y gellir eu lledaenu i brosiectau eraill yn y dyfodol gan sicrhau manteision parhaus

2.2 Y Contractwr

Mae John Weaver (Contractors) yn gwmni teuluol sefydledig gyda thros ganrif o arbenigedd mewn adeiladu ac yn cyfuno gwerthoedd traddodiadol cryf o ran crefftwriaeth fedrus â deunyddiau a thechnegau adeiladu modern a rheolaeth fusnes gadarn.

Cwmni â'i ffocws ar y cwsmer yw John Weaver (Contractors) sy'n gwasanaethu prosiectau comisiynu drwy ddarparu gwasanaeth o'r radd flaenaf seiliedig ar draddodiad o ansawdd ac am gost gystadleuol. Mae'r cwmni'n ymrwymedig i amcanion Egan (2) gan lwyddo dros flynyddoedd lawer i sefydlu tîm ardderchog o gwmpas yr amcanion hyn. (3)

3 Cefndir y Prosiect

Mae Oriel Gelf Glynn Vivian yn oriel gelf gyhoeddus yn Abertawe, De Cymru. Mae adfywio a datblygu'r oriel yn rhan o'r Fframwaith Adfywio Cynaliadwy ar gyfer Bae Abertawe.

Mae'r oriel wreiddiol, a adeiladwyd dros gyfnod o ddwy flynedd rhwng 1909 a 1911, yn yr arddull baróc Edwardaidd ac yn adeilad Rhestredig Gradd II* (4). Roedd statws rhestredig yr adeilad yn golygu na ellid newid ei strwythur mewnol gwreiddiol. Cafodd estyniad i'r oriel a godwyd ym 1974 ei gysylltu i'r adeilad gwreiddiol drwy greu linc (5).

Yn 2011 caewyd yr oriel er mwyn dechrau ar y gwaith datblygu ac ailwampio gan gynnwys;

- Dymchwel y linc blaenorol rhwng adeilad 1911 a'r adeilad o'r saithdegau
- Mynedfa a siop newydd ar lefel y stryd
- Ailddylunio estyniad 1974 yr oriel a chodi linc gwydr newydd
- Lifft newydd i roi mynediad llawn i bobl i'r holl arddangosfeydd ac orielau gyda chasgliadau, yn ogystal â'r holl gyfleusterau addysgol ac astudio
- Mwy o le ar gyfer arddangosfeydd a chasgliadau
- Ardal storio a chadwraeth newydd er mwyn gallu datblygu'r casgliadau yn y dyfodol
- Ardaloedd technegol a swyddfeydd gweinyddol newydd
- Adnewyddu'r stiwdio addysg bresennol a chyfleusterau gwell er mwyn gweithio gydag ysgolion, colegau a chyfranogwyr
- Ystafell gymunedol a gofod darlithio newydd
- Llyfrgell ac archif bwrpasol i ymwelwyr gael gwneud ymchwil
- Gofod cymdeithasol newydd gyda lluniaeth a mynediad Wi-fi

Aeth y contractwyr gwreiddiol, Opco Construction, i ddwylo'r gweinyddwyr yn 2013 (6) ar ôl cyflawni peth o'r gwaith dymchwel, gan gynnwys tynnu asbestos allan. Dechreuodd John Weaver ar eu pecyn gwaith ym mis Mawrth 2014, oedd i'w gwblhau erbyn Mawrth 2015. Fodd bynnag, oherwydd problemau ar y safle, cafodd amserlen y prosiect ei hymestyn ac agorodd yr adeilad ym mis Hydref 2016.

Dechreuodd EZW weithio ar y prosiect gyda John Weaver felly rydym wedi sôn am y gwaith a wnaed o dan y contract blaenorol ond heb ei gynnwys yn y ffigurau gwastraff terfynol.

3.1 Cost

Roedd y contract gwreiddiol yn werth £5.3 miliwn a gododd i £6.3 miliwn o ganlyniad i nifer o newidiadau y bu'n rhaid eu gwneud yn ystod y cam adeiladu, ynghyd â gwaith ychwanegol.

4 Methodoleg

Cafodd y cymorth a roddodd EZW i'r safle ei ddarparu drwy:

- Ymweliadau safle ac arweiniad
- Adolygu data ar wastraff
- Adolygu cwmnïau rheoli gwastraff
- Ymweld â chwmni rheoli gwastraff Derwen gyda staff o John Weaver
- Chwilio am opsiynau gwaredu eraill

Cafodd ymweliadau safle i gynorthwyo rheoli'r gwastraff eu cynnal fel rhan o Galluogi Dyfodol Diwastraff, gan gynnwys trafodaethau â thîm y safle i siarad am broblemau safle a gwastraff, y cynnydd oedd yn cael ei wneud, atebion a gwelliannau posib. Rhoddwyd cymorth hefyd i dîm y safle ynghyd ag argymhellion ar reoli gwastraff, gan gynnwys:

- Cadw'r safle'n daclus
- Datblygu sesiynau sgwrsio anffurfiol
- Adolygu deunyddiau oedd dros ben a sut y mae'r cwmni'n delio gyda nhw
- Adolygu'r data ar wastraff a sut y cofnodir gwastraff
- Ffynhonnell arall o ddeunyddiau toi

Cafwyd mai ychydig iawn o gyswllt oedd ei angen â'r prosiect hwn oherwydd daeth yn amlwg fod y cwmni a'r staff yn ymwybodol bod angen lleihau gwastraff, ailddefnyddio deunyddiau a'u bod wedi arfer ag ailddefnyddio adnoddau o safleoedd eraill. Roedd tri rheswm yn bennaf pam fod yr arferion ar y safle wedi eu gerio i fod yn ymwybodol o wastraff:

1. Roedd gan John Weaver reolwr safle a fu'n gweithio drwy gydol y prosiect â'r holl weithwyr i godi ymwybyddiaeth o wastraff a sut i gofnodi data'n gywir ar SMARTWaste
2. Derbyniodd reolwr y safle gefnogaeth sylweddol gan y cynrychiolydd amgylcheddol o John Weaver
3. Mae John Weaver wedi cyfrannu at lawer o brosiectau cadwraeth ac mae'n arfer cyson gan y cwmni storio deunyddiau i'w hailddefnyddio gan ddefnyddio deunyddiau o safleoedd eraill a rheoli unrhyw ormodedd o ddeunyddiau (3)
4. Dim ond ychydig o waith sy'n cael ei isgontractio. Mae gan John Weaver adnodd o weithwyr uniongyrchol. Mae staff y safle wedi gwrando ar y neges i leihau gwastraff gan arwain at arferion da ar y safle a llai o wastraff.

Dangosodd Arup ar y prosiect hwn sut y gallai'r cwsmer ac arddangoswyr ddefnyddio BIM yn effeithiol i adnabod yn hawdd unrhyw ffitiadau trydanol cudd ym mhrif ofodau'r oriel. Y nod oedd y gallai arddangoswyr osod arddangosiadau a ffitiadau ar y wal yn gwbl hyderus na fyddent yn achosi difrod i wasanaethau trydanol na'n creu gwastraff diangen.

Mae'r defnydd hwn o dechnoleg uwch-realiti yn gadael i ddefnyddwyr 'ddelweddu' gwybodaeth fodel ac asedau na fyddai'n bosib ei wneud fel arall. Gall y defnyddiwr pen-draw 'gwestiynu'r' model a chanfod lleoliad unrhyw ffitiadau'n gymharol hawdd. Bydd hyn yn hwyluso dylunio arddangosfa'n ogystal â rheoli a chynnal a chadw'r cyfleusterau.

Aeth John Weaver ar ymweliad safle â chwmni Derwen i weld sut yr oeddent yn delio â'u gwastraff ac yn ei wahanu i leihau faint yr oedd yn mynd i gael ei dirlenwi.

Roedd y gwaith cyfathrebu'n cynnwys diweddaru'n gyson drwy twitter, digwyddiadau diweddaru, gweminarau a chyflwyniadau.

5 Dadansoddiad o Reoli Gwastraff

Contractiwyd tri chwmni i reoli'r gwastraff a gynhyrchwyd gan brosiect Glynn Vivian dros y cyfnod pan oedd EZW yn rhan o'r fenter. Y rhain oedd:

- Derwen Plant Ltd. (Derwen)– Cwmni Cwmpawd Gwyrdd
- Stenor Environmental Services Ltd. (Stenor)
- Peter Davies Agricon Ltd. (Agricon)

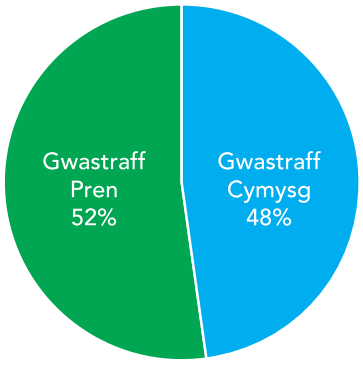
Mae'r cynllun Cwmpawd Gwyrdd yn darparu data perfformiad gwastraff wedi'i ddilysu yn erbyn PAS402:2013 Rheoli Adnoddau Gwastraff – y fanyleb ar gyfer adrodd perfformiad.

5.1 Dadansoddiad yn ôl Gwahanol Gamau'r Prosiect

5.1.1 Y Cam Dymchwel

Cynhyrchodd y gwaith dymchwel a wnaed gan Cardiff Demolition 55.5 tunnell o wastraff. Cafodd adeilad y linc ei ddymchwel a'r estyniad o'r saithdegau ei wagu a'i stripio. Cafodd y gwaith ei wneud fel rhan o'r contract gwreiddiol gydag Opco yn Chwefror 2013, cyn i EZW ddechrau gweithio gyda'r prosiect. Oherwydd i'r gwastraff hwn gael ei gynhyrchu cyn i EZW ddechrau gyda'r prosiect o dan gontract gwaith arall, nid yw wedi'i gynnwys yn y ffigurau terfynol.

Cafodd y gwastraff i gyd naill ai ei waredu fel gwastraff pren cymysg neu wastraff cyffredinol. Roedd y gwastraff cymysg yn 28.6 tunnell sef 52% a'r gwastraff cyffredinol yn 26.8 tunnell sef 48%.



Cafodd rywfaint o'r llawr parquet gwreiddiol ei gadw ar y safle a'i roi ar baledi pren er mwyn ei lanhau a'i ailddefnyddio yn yr adeilad newydd. Ni chafodd unrhyw fanylion am gyfraddau ailgylchu eu cynnwys yn yr adroddiad ar y gwastraff dymchwel.

Cynhyrchodd John Weaver lond wyth sgip o wastraff dymchwel ar ôl cymryd drosodd o Opco yn 2014 sef 67.2m^3 a 2.9% o'r holl wastraff a gynhyrchwyd. Cafodd y gwastraff mewn saith allan o'r wyth sgip ei wahanu; chwe sgip anadweithiol a sgip o wastraff bitwminaidd cymysg. Roedd y sgip heb ei gwahanu'n cynnwys cymysgedd 50/50 o ddeunyddiau anadweithiol a bitwminaidd.

Y Cam Dymchwel – John Weaver	
Cyfanswm Gwastraff m^3	67.2
Wedi osgoi ei dirlenwi m^3	52.6
Wedi osgoi ei dirlenwi %	78.3%*

* Ar sail ffigurau Derwen 2014

Cododd Derwen gyfradd safonol am waredu'r chwe sgip o wastraff anadweithiol. Cododd ffi godi a ffi fesul tunnell ar y ddwy sgip arall. Pe bai'r sgipiau i gyd wedi cael eu dosbarthu fel gwastraff cymysg heb unrhyw wahanu, byddai'r gost o symud y gwastraff wedi bod ddwywaith cymaint, gan arbed mwy na £2400.

5.1.2 Y Cam Tyllu

Y Cam Tyllu	
Cyfanswm m^3	1,279.0
Wedi osgoi ei dirlenwi m^3	1,279.0
Wedi osgoi ei dirlenwi %	100.0

Yn 2014 cwympodd arglawdd yng nghefn y safle. Arweiniodd hyn at orfod symud pridd a gwastraff anadweithiol sylweddol, 1279.0m^3 i gyd a 54.6% o'r holl wastraff a gynhyrchwyd.

Defnyddiwyd dau o'r cwmnïau rheoli gwastraff a ddewiswyd yn ystod y cam hwn sef Stenor ac Agricon. Rhyngddynt symudwyd 97 llond cynhwysydd o wastraff tyllu. Roedd maint y cynhwysydd yn amrywio ond fel arfer defnyddiwyd cynhwysydd 20 tunnell.

Cafodd bob cynhwysydd ei archwilio'n weledol gyda chofnodion yn cael eu cadw ar SMARTWaste. Dosbarthwyd y gwastraff i gyd yn ôl codau Dosbarthiadau Gwastraff Ewropeaidd (EWC), fel y gwelir o'r tabl.

Cafodd fwy na hanner y cynhwysyddion oedd yn gadael y safle eu dosbarthu fel rhai pridd a cherrig (17 05 04).

	Nifer y Cynhwysyddion		
Math o Ddeunydd	Agricon	Stenor	Cyfanswm
Concrid (17 01 01)		3	3
Brics (17 01 02)		2	2
Anadweithiol (17 01 07)	4	38	42
Pridd a Cherrig (17 05 04)	35	15	50
Cyfanswm	39	58	97

Mae opsiynau eraill yn lle talu am waredu gwastraff pridd a cherrig. Mae diffiniad Contaminated Land Applications in Real Environments (CL:AIRE) o'r cod ymarfer ar wastraff yn darparu proses glir, gyson ac effeithlon fel y gellir ailddefnyddio deunyddiau a dyllwyd ar y safle neu eu symud rhwng safleoedd i'w hailddefnyddio.

Gellir llunio cytundebau rhwng y safleoedd sy'n trosglwyddo a derbyn y gwastraff i dalu am y gost o symud a chludo'r pridd. Mae hyn yn cynnig ffynhonnell ddeunyddiau gost-effeithiol i'r safle sy'n derbyn y gwastraff ac yn ddull gwaredu yr un mor gost-effeithiol i'r safle sy'n trosglwyddo'r gwastraff. Mae angen profion i sicrhau nad yw'r pridd yn halogedig.

O ystyried na chafodd y ffrwd wastraff hon ei rhagweld, roedd y gost o £19,012.50 yn annisgwyl.

5.1.3 Y Cam Adeiladu

Y Cam Adeiladu	
Cyfanswm m^3	998.0
Wedi osgoi ei dirlenwi m^3	927.9
Wedi osgoi ei dirlenwi %	93.0

Cynhyrchwyd 998.0m^3 o wastraff fel rhan o'r cam adeiladu, 42.6% o'r holl wastraff a gynhyrchwyd. 2015 a welodd y rhan fwyaf o wastraff y cam adeiladu'n cael ei gynhyrchu, 72.9% o holl wastraff y cam adeiladu.

Llwyddwyd i osgoi tirlenwi 92.3%, 927.9m^3 o wastraff, gyda 66.1%, 659.2m^3, o wastraff yn cael ei ailgylchu a 26.9%, 268.6m^3, yn cael ei anfon i'w adfer ar gyfer ynni. Aeth 7.0% 70.1m^3 i gael ei dirlenwi.

Cafodd 61.9m^3 o wastraff anadweithiol, 6.2% o'r gwastraff adeiladu, ei symud gan Stenor. Proseswyd y rhan fwyaf o'r gwastraff adeiladu gan Derwen sef 936.1m3 a 93.8% o'r gwastraff adeiladu. Dengys Tabl X sut y cafodd y gwastraff adeiladu ei brosesu yn ystod y prosiect gan Derwen.

	Ailgylchu	Adfer	Tirlenwi	Cyfanswm
2014	48.3%	29.9%	21.9%	
	80.4	49.8	36.5	166.7
2015	67.2%	28.1%	4.7%	
	459.4	192.1	32.1	683.7
2016	67.1%	31.2%	1.7%	
	57.5	26.7	1.5	85.7
Cyfanswm	63.8%	28.7%	7.5%	
	597.3	268.6	70.1	936.1

Mae'r holl ffigurau'n seiliedig ar gyfraddau Derwen ar gyfer 2014-2016 ac nid yn benodol i'r prosiect. Unedau mewn m^3

Mae'r ffigurau hyn yn seiliedig ar ddata gwastraff a gofnodwyd gan John Weaver ar SMARTWaste a chyfraddau ailgylchu, adfer a thirlenwi blynyddol cwmni Derwen. Nid ydynt yn gyfraddau ailgylchu, adfer a thirlenwi penodol ar gyfer y prosiect.

Gwastraff pren oedd y ffrwd wastraff fwyaf, yn ôl cyfaint, sef 31.9% o'r holl wastraff adeiladu. Roedd sgip gwastraff pren ar y safle wedi'i gwahanu'n dda a'r gwastraff pren wedi'i bacio'n dynn. Roedd y gwastraff hwn o ganlyniad i;

- Waith helaeth ar do'r adeilad rhestredig Gradd II* – tynnu'r teils concrid, yr estyll pren ac adnewyddu'r trawstiau / distiau pren pydredig
- Creu waliau ffug i guddio'r systemau trydanol – yn unol ag amodau cynllunio Gradd II*
- Paledi – storiwyd y rhain ar y safle a'u defnyddio i storio deunyddiau o gwmpas y safle. Dim ond pan oedd y paledi'n cael eu torri a'u rhoi yn y sgip gwastraff pren yr oeddent yn wastraff.
- Defnyddio bordiau pren i ddiogelu'r gwaith
- Daethpwyd o hyd i bydredd gwlyb yn Hydref 2015 – bu'n rhaid codi'r llawr parquet ar lawr gwaelod yr oriel a thynnu rhai o'r distiau pren allan. Roedd y safle'n sicrhau bod y pren pydredig yn cael ei wahanu a'i roi mewn bag tunnell hyblyg. Hysbyswyd y cwmni rheoli gwastraff o'r pydredd a chafodd y bag ei symud o'r safle gyda'r sgip gwastraff pren.

Roedd y ffrydiau gwastraff sylweddol eraill yn cynnwys anadweithiol 15.5%, cymysg 18.2%, deunyddiau inswleiddio 11.7% a phlasterbord 9%.

Cyn gadael y safle roedd cynnwys y sgipiau gwastraff cymysg yn cael ei gofnodi ar SMARTWaste gan nodi cynnwys y sgip. Roedd staff y safle'n archwilio cynnwys y sgipiau'n rheolaidd drwy fod yn ymwybodol o gostau ychwanegol unrhyw wastraff cymysg ar y safle gan dynnu eitemau fel bocsys cardbord allan i sicrhau gwahanu da. Roedd hyn yn lleihau unrhyw halogi rhwng gwastraff yn y sgipiau.

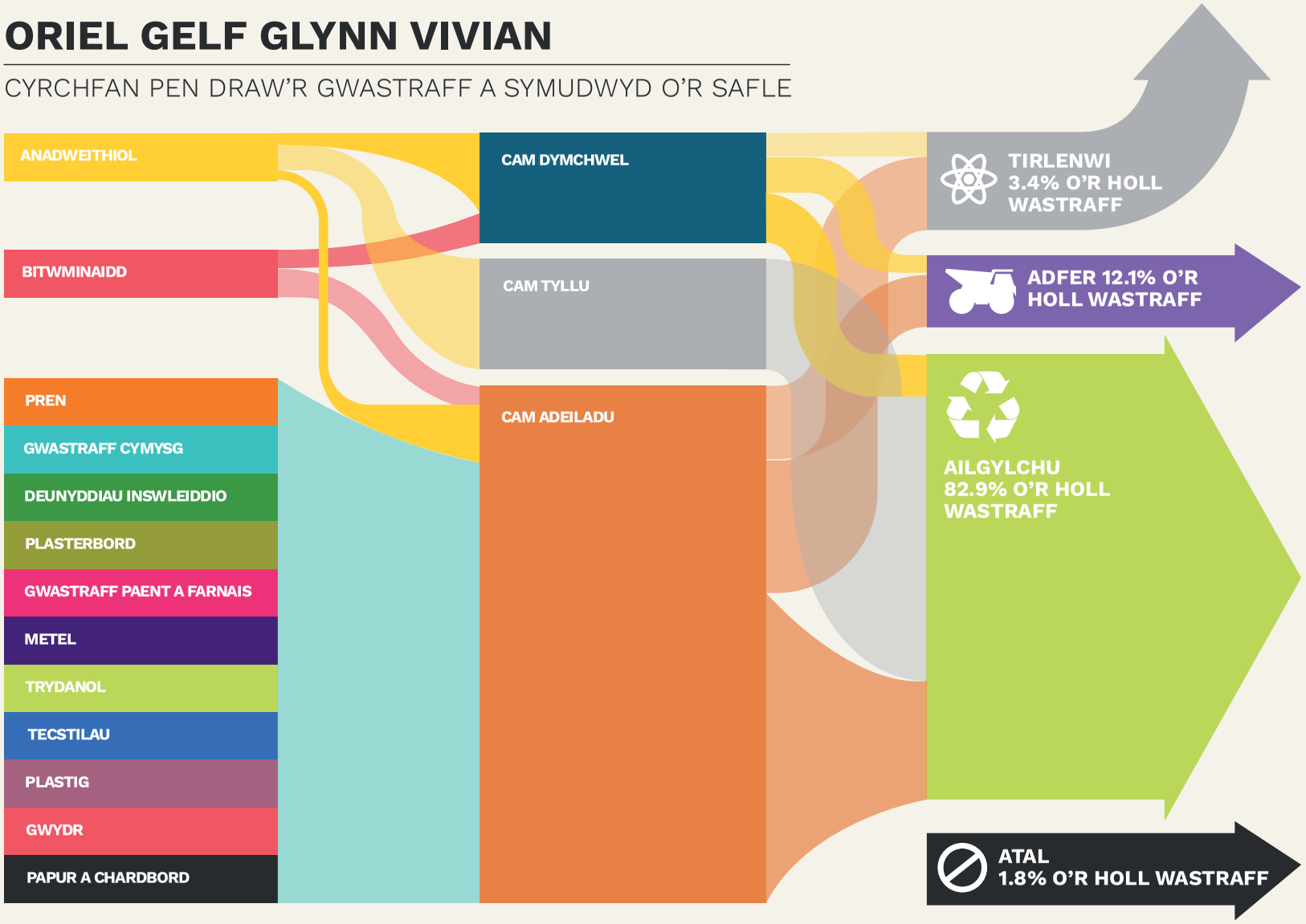
Oherwydd maint yr ystafelloedd, roedd torion plasterbord yn anochel. Llwyddwyd i leihau unrhyw wastraff plasterbord a chodi ymwybyddiaeth y staff ar y safle. Roedd y torion plasterbord yn cael eu storio ar y safle i leihau gwastraff.

	2014				2015				2016				
Deunydd	Ch1	Ch2	Ch3	Ch4	Ch1	Ch2	Ch3	Ch4	Ch1	Ch2	Ch3	Cyfanswm	% o'r Cyfanswm
Trydanol	0.0	0.0	0.0	0.6	0.6	4.6	2.1	13.2	4.9	0.0	0.0	26.0	2.6%
Gwydr	0.0	0.0	0.0	9.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	15.1	1.5%
Anadweithiol	6.1	0.0	22.6	5.8	18.4	21.1	62.3	7.0	6.1	5.5	0.0	155.1	15.5%
Deunyddiau inswleiddio	0.0	0.0	8.5	0.6	5.2	33.7	48.7	14.7	4.6	1.2	0.0	117.1	11.7%
Metel	0.0	0.0	0.8	0.0	2.8	5.8	6.7	8.3	1.8	0.9	0.0	27.1	2.7%
Cymysg	24.5	0.0	7.9	8.9	15.0	21.7	30.6	41.0	22.3	3.4	6.1	181.4	18.2%
Bitwminaidd eraill	0.0	0.0	0.0	0.0	4.3	0.6	1.2	0.0	0.0	0.0	0.0	6.1	0.6%
Papur a Chardbord	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.9	0.0	2.1	0.2%
Plasterbord	0.0	0.0	0.0	0.0	0.0	22.0	42.9	25.1	0.0	0.0	0.0	90.0	9.0%
Plastig	0.0	0.0	4.1	2.4	2.1	1.5	0.9	1.2	1.5	1.5	0.0	15.4	1.5%
Tecstilau	0.0	0.0	0.3	0.0	0.0	0.0	0.0	12.2	4.6	0.0	0.0	17.1	1.7%
Paent a farnais gwastraff (diberygl)	0.0	0.0	0.0	0.0	0.6	2.8	7.3	12.2	4.3	0.0	0.0	27.2	2.7%
Pren	0.0	45.9	18.4	18.4	24.5	36.7	85.7	73.7	9.8	4.9	0.0	317.9	31.9%
Cyfanswm	30.6	45.9	62.5	45.7	79.6	150.5	288.5	208.7	61.2	18.4	6.1	997.7	
% o'r Cyfanswm	3.1%	4.6%	6.3%	4.6%	8.0%	15.1%	28.9%	20.9%	6.1%	1.8%	0.6%		

Unedau mewn m^3

ORIEL GELF GLYNN VIVIAN

CYRCHFAN PEN DRAW'R GWASTRAFF A SYMUDWYD O'R SAFLE



5.2 Dadansoddiad yn ôl Rhaglen

5.2.1 2014

	Gwastraff yn ôl cyfaint m^3	Wedi osgoi ei dirlenwi m^3	Wedi osgoi ei dirlenwi %
Adeiladu	184.7	144.4	78.2
Dymchwel	67.2	52.6	78.2
Tyllu	1279.0	1279.0	100
Cyfanswm	1530.9	1476.0	96.4

Yn 2014 cynhyrchwyd 1530.9m^3 o wastraff. Roedd hyn yn 65.3%, yn ôl cyfaint, o'r holl wastraff a grewyd gan y prosiect.

Yr elfen wastraff fwyaf yn 2014 oedd o ganlyniad i waith tyllu. Roedd y 1279.0m^3 o wastraff a gynhyrchwyd yn 83.5% o'r holl wastraff yn 2014 a 54.6% o holl wastraff y prosiect. Roedd yr holl wastraff hwn yn annisgwyl, ar ôl i arglawdd yng nghefn y safle gwympo. Costiodd symud y deunydd a gwympodd o'r safle £19,012.50, traean o holl gost y gwaith rheoli gwastraff.

Dosbarthwyd llawer o'r gwastraff tyllu fel pridd a cherrig, a allai fod wedi cael ei symud o'r safle heb ei ddosbarthu fel gwastraff. Mae cod ymarfer diffiniad CL:AIRE o wastraff yn cynnig opsiwn arall fel y gellir ailddefnyddio'r deunyddiau a dyllwyd ar safle neu eu symud rhwng safleoedd i'w hailddefnyddio. Gellid bod wedi lleihau'r costau cludo a'u rhannu rhwng safle Glynn Vivian a safle a dderbyniodd y gwastraff, gyda'r safle hwnnw'n elwa o opsiwn arall yn lle gorfod cludo deunydd i mewn o'r newydd.

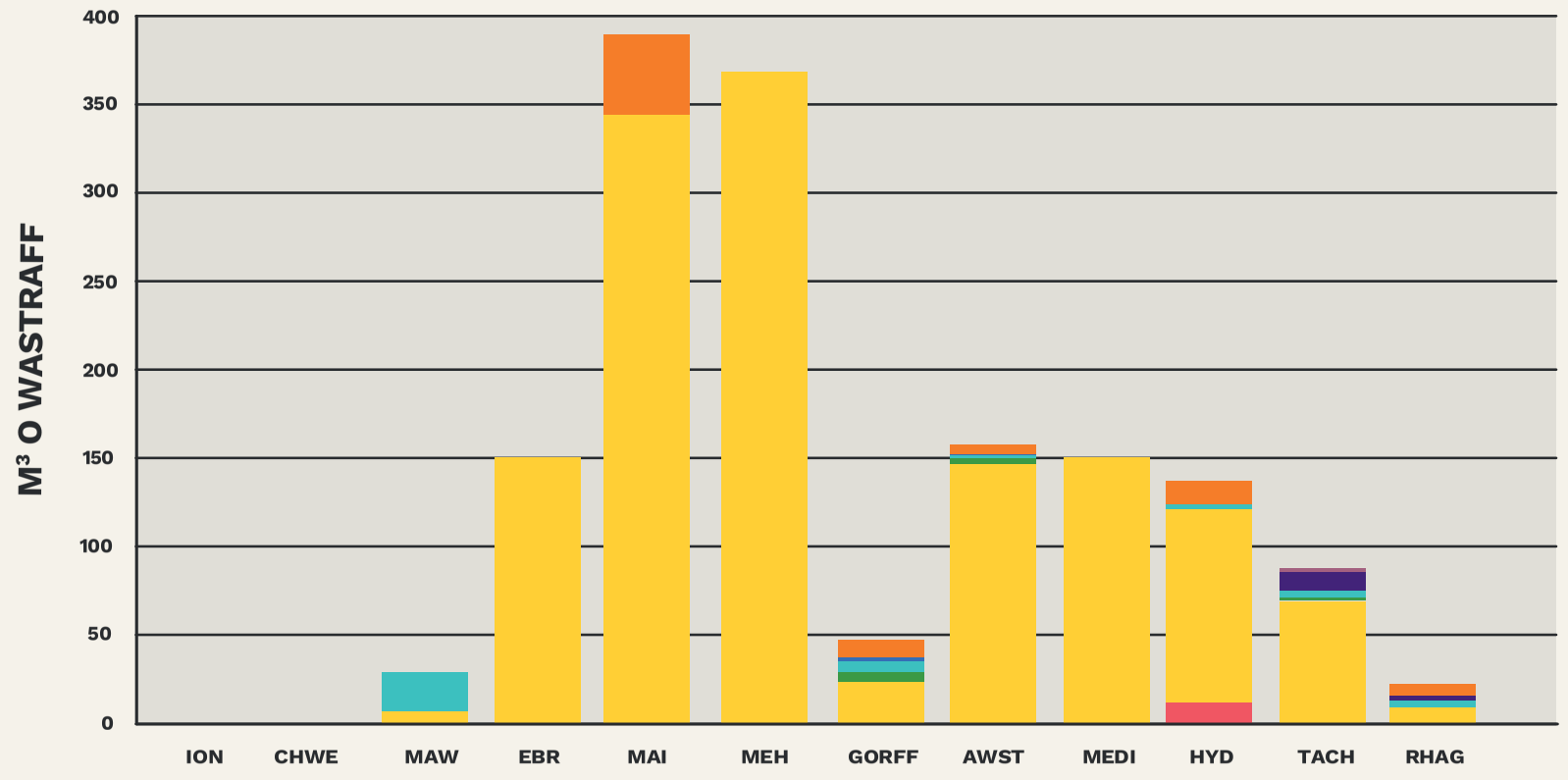
Yn 2014 roedd lefel uchel o wahanu gwastraff gyda 117 o'r 121 cynhwysydd, 96.7%, wedi eu gwahanu wrth adael y safle. Helpodd hyn i osgoi tirlenwi 96.4% o wastraff, 1476.0m^3, ar gyfer y flwyddyn. Roedd 107 cynhwysydd yn wastraff anadweithiol a'r 10 sgip arall wedi'u gwahanu'n cynnwys gwastraff

Roedd gweddill y gwastraff yn gymysg ac wedi'i symud mewn pedair sgip o wastraff cymysg.

Chwarter	Trydanol	Gwydr	Anadweithiol	Deunydd inswleiddio	Metel	Cymysg	Bitwminaidd arall	Plastig	Tecstilau	Pren	Cyfanswm Terfynol
Ch1	0	0	6.1	0	0	24.5	0	0	0	0	30.6
Ch2	0	0	859.7	0	0	0	0	0	0	45.9	905.6
Ch3	0	0	317.5	8.5	0.8	7.9	0	4.1	0.3	18.4	357.5
Ch4	0.6	9	188.3	0.6	0	8.9	9.2	2.4	0	18.4	237.4
Cyfanswm Terfynol	0.6	9	1371.6	9.1	0.8	41.3	9.2	6.5	0.3	82.7	1531.1

Tabl o'r holl wastraff yn 2014. Unedau m^3

GWASTRAFF MISOL YN ÔL MATH 2014 m^3



ADEILADU ARBENIGRWYDD YNG NGHYMRU

CONSTRUCTING EXCELLENCE IN WALES

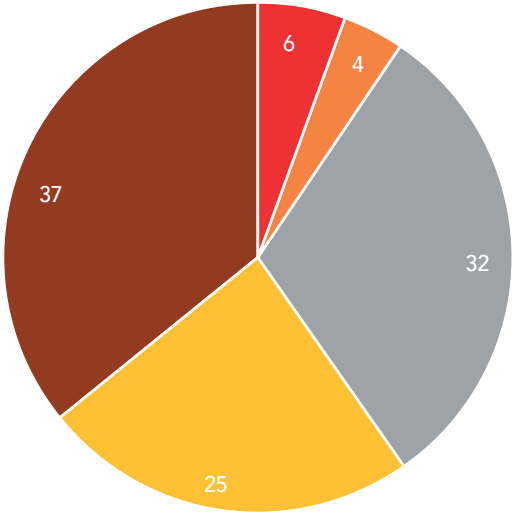
5.2.2 2015

	Gwastraff mewn m^3	Wedi osgoi ei dirlenwi m^3	Wedi osgoi ei dirlenwi %
Derwen	683.7	651.6	95.3
Stenor	43.7	43.7	100
Cyfanswm y Gwastraff	727.4	695.3	95.6

Cafodd y rhan fwyaf o gam adeiladu'r prosiect ei gyflawni yn 2015. Cynhyrchwyd 727.4m^3 o wastraff sef 31.0% o'r holl wastraff a gynhyrchwyd.

Symudodd Derwen 94.0% o wastraff, yn ôl cyfaint, yn 2015. Daeth hyn i gyfanswm o 175.2 o dunelli, 683.7m^3, gyda'r gwaith o'i symud yn gofyn defnyddio 112 o gyfanswm yr 147 o sgipiau a ddefnyddiwyd gan Derwen ar gyfer y prosiect hwn. Roedd y gwahanu'n dda gyda 55 o'r 112 o sgipiau (49%) wedi cael eu gwahanu.

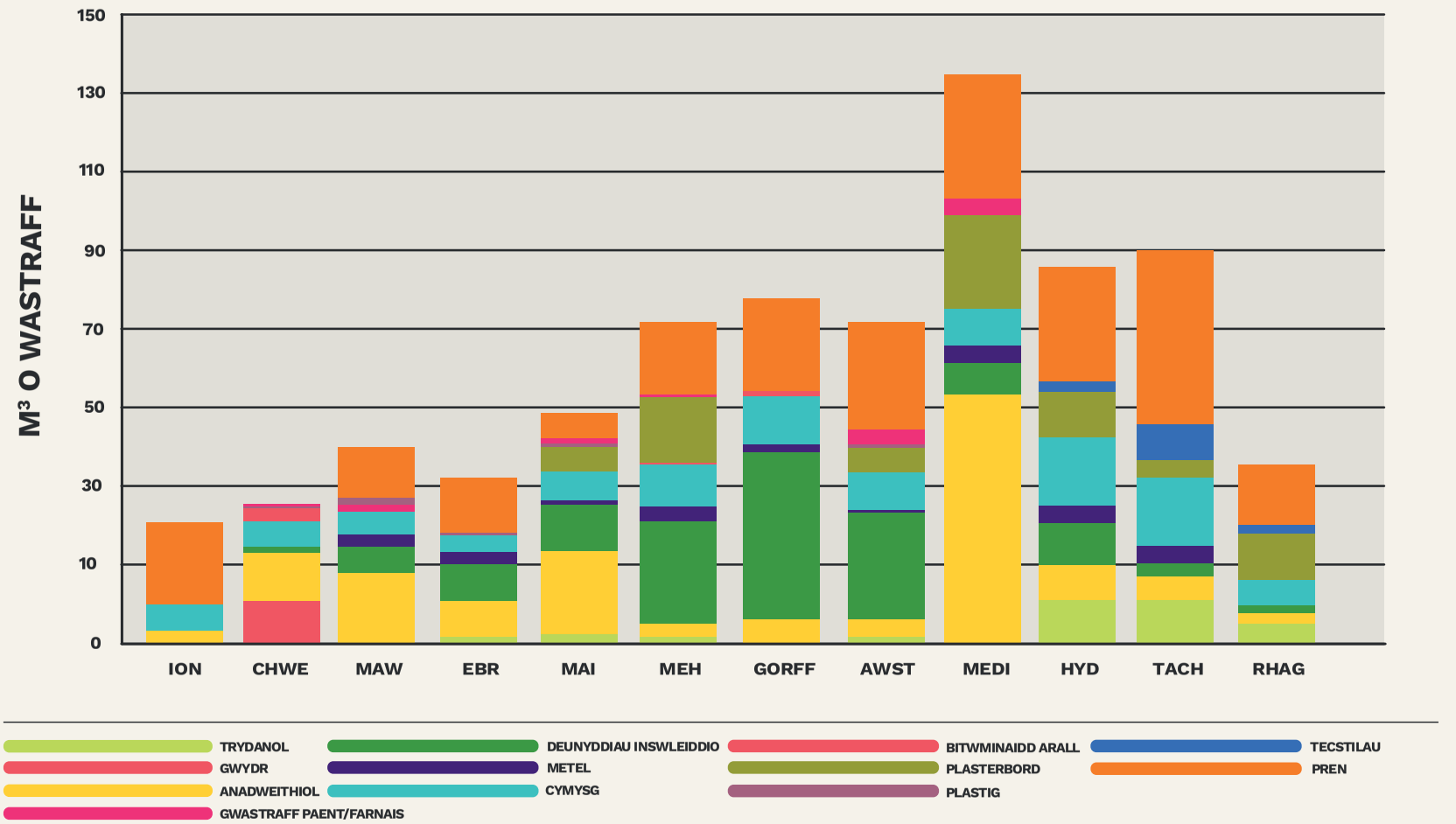
Ym mis Medi cafodd 43.7m^3, 6% o wastraff 2015 ei symud gan Stenor. Cafodd fwy o wastraff anadweithiol (13.1 tunnell) ei gynhyrchu ym mis Mai a gwastraff gypsum (8.5 tunnell) ym mis Medi. Gellir priodoli hyn i'r gwaith tyllu ar gyfer siafft y lifft am y naill a'r gwaith plasterbord am y llall.



	Trydanol	Gwydr	Anadweithiol	Deunydd insiwleiddio	Metel	Cymysg	Bitwminaidd arall	Plasterbord	Plastig	Tecstilau	Gwastraff paent a farnais (diberygl)	Pren	Cyfanswm Terfynol
Ch1	0.6	6.1	18.4	5.2	2.8	15.0	4.3	0.0	2.1	0.0	0.6	24.5	79.6
Ch2	4.6	0.0	21.1	33.7	5.8	21.7	0.6	22.0	1.5	0.0	2.8	36.7	150.5
Ch3	2.1	0.0	62.3	48.7	6.7	30.6	1.2	42.9	0.9	0.0	7.3	85.7	288.5
Ch4	13.2	0.0	7.0	14.7	8.3	41.0	0.0	25.1	1.2	12.2	12.2	73.7	208.7
Cyfanswm Terfynol	20.5	6.1	108.8	102.3	23.6	108.3	6.1	90.0	5.7	12.2	22.9	220.6	727.3

Tabl o'r holl wastraff yn 2015. Unedau m^3

GWASTRAFF MISOL YN ÔL MATH 2015 m^3



ADEILADU ARBENIGRWYDD YNG NGHYMRU

CONSTRUCTING EXCELLENCE IN WALES

5.2.3 2016

Gwastraff yn ôl cyfaint m^3	Wedi osgoi ei dirlenwi m^3	Wedi osgoi ei dirlenwi %
85.7	84.2	98.2

Yn 2016 roedd y gwastraff i gyd yn wastraff adeiladu ac wedi ei symud gan Derwen mewn sgipiau gwastraff adeiladu cymysg, 25.2 tunnell i gyd, 85.7m^3. Ni chafodd y gwastraff hwn ei wahanu. Mae'r cofnodion ar SMARTWaste yn cynnwys amcangyfrifon gweledol o'r gwastraff yn y 18 sgip a ddefnyddiwyd;

Deunydd	Cyfaint m^3	Canran
Anadweithiol	11.6	13.5%
Pren	14.7	17.2%
Metel	2.8	3.3%
Deunydd inswleiddio	5.8	6.8%
Plastig	3.1	3.6%
Papur a Chardbord	2.1	2.5%
Cymysg	31.8	37.1%
Tecstilau	4.6	5.4%
Gwastraff paent a farnais (diberygl)	4.3	5.0%
Trydanol	4.9	5.7%

Table of waste streams 2016

Gwaith gorffen yn bennaf oedd y gwaith a wnaed yn 2016 ynghyd â gwaith ychwanegol ar gais y cwsmer. Mae gwaith ychwanegol, a gweithgareddau heb eu cynllunio, yn creu problemau wrth flaengynllunio rheoli gwastraff. Ni all contractwyr ragweld pa ffrydiau gwastraff fydd yn cael eu cynhyrchu ac mae'n arwain yn aml at atebion ad hoc sy'n dibynnu ar sgipiau gwastraff cymysg. Yn yr achos hwn, roedd lle hefyd yn broblem, gyda lle i ddim ond un sgip ar y safle.

Diffiniad Cod Ymarfer EWC	Canran
Pecynnu	23.6%
Gwastraff Dinesig arall	23.2%
Pren, gwydr a phlastig	14.6%
Concrid, brics, teils a cerameg	13.2%
Deunyddiau inswleiddio ac adeiladu eraill yn cynnwys asbestos	6.8%
Cyfarpar trydanol	5.7%
Tecstiliau	5.4%
Gwastraff Paent	5.0%
Metelau	2.1%
Pridd	0.4%

Table of waste by EWC code 2016

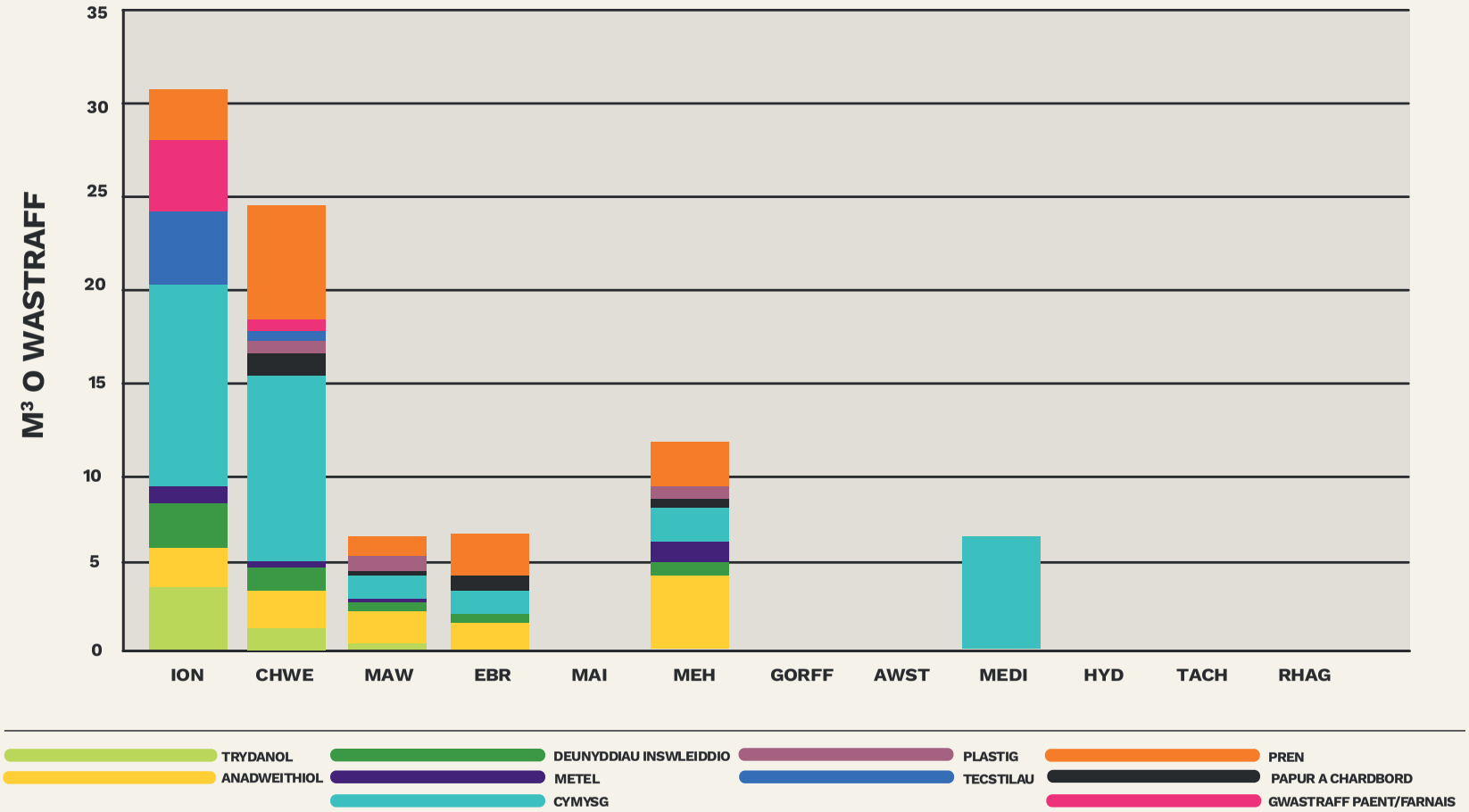
Yr hyn y gallwn ei weld o'r tabl uchod yw mai gwastraff pecynnu a dinesig oedd y rhan fwyaf o'r gwastraff yn ôl cyfaint yn 2016, sef 46.8%. Tynnwyd sylw EZW dro ar ôl tro at y broblem o or-becynnu ar safleoedd adeiladu ac anogir cyflenwyr i becynnu llai lle medrant.

Mae'r gwastraff o swyddfeydd a ffreutur y safle hefyd wedi cael sylw gyda chasgliadau gwastraff ffreutur yn cael eu treialu yn Nhorfaen a Cheredigion fel rhan o brosiectau EZW eraill. Mae'r treialon hyn wedi cynnwys gwahanu gwastraff bwyd a deunyddiau ailgylchu yn swyddfeydd a ffreutur y safle. Roedd y gwastraff yna'n cael ei gasglu drwy gasgliadau dinesig lleol y cynghorau.

Roedd y diffyg gwahanu gwastraff ar y safle, oedd yn arwain at gymysgu ac mae'n debyg at halogi deunyddiau ailgylchu, wedi trosglwyddo'r cyfrifoldeb am ailgylchu i'r cwmni rheoli gwastraff. Roedd y cyfraddau osgoi tirlenwi gan gyfleusterau rheoli gwastraff Derwen yn 2016 yn uchel, gyda dim ond 1.74% o'r gwastraff a broseswyd yn mynd i'w dirlenwi. Mae'r llwyddiant hwn yn trosi'n dda o'i gymhwyso ar gyfer y prosiect hwn gyda dim ond 1.5m^3 o wastraff yn mynd i'w dirlenwi. Fodd bynnag llwyddwyd i wneud hyn nid oherwydd ymdrechion nac arferion y safle ond oherwydd llwyddiant arferion Derwen.

Cafodd 57.5m^3 67.1% o'r gwastraff ei ailgylchu a 26.7m^3 31.2% ei anfon i'w adfer ar gyfer ynni.

GWASTRAFF MISOL YN ÔL MATH 2016 m^3



ADEILADU ARBENIGRWYDD YNG NGHYMRU

CONSTRUCTING EXCELLENCE IN WALES

5.3 Dadansoddiad yn ôl Opsiwn Rheoli Gwastraff

5.3.1 Atal

Cyfanswm yr arbedion cost drwy atal oedd £25,270.

Roedd y prosiect yn golygu cadw'r adeilad Gradd II* gwreiddiol a wnaed gyda'r bwriad o gadw cymaint o'r nodweddion gwreiddiol â phosib. Roedd hyn yn cynnwys:

Fframiau Ffenestri – cafodd 20 o'r fframiau ffenestri eu hadfer ar y safle ac anfonwyd pump arall i'w hadfer oddi ar y safle. Amcangyfrifiwyd y byddai hyn wedi bod yn ddwy dunnell o wastraff pren ac wedi costio £267 i'w waredu. Byddai ffenestri newydd wedi costio dros £25,000 ar sail £1,000 am bob ffenestr newydd yn yr un arddull baróc Edwardaidd â'r gwreiddiol.

Cyfanswm = tua £25,270

Coed a distiau / trawstiau to – cafodd waith trwsio ei wneud ar ddistiau'r to. Atgyweiriwyd y distiau oedd mewn cyflwr da ac ailddefnyddiwyd unrhyw ddarnau y gellid eu hailddefnyddio, lle'r oedd hynny'n ymarferol.

5.3.2 Ailddefnyddio

Daeth yr arbedion mesuradwy drwy ailddefnyddio i £57,194.

Roedd y prosiect yn cynnwys llawer iawn o waith cadwraeth. O'r herwydd cafwyd fod John Weaver wedi arfer â chadw ac nid gwaredu deunyddiau, lle gellid eu hailddefnyddio. Cafwyd fod tîm y safle'n ailddefnyddio deunyddiau'n rheolaidd i leihau gwastraff a'i fod hefyd yn rhan o'r brîff y dylid cadw cymaint â phosib o'r adeilad gwreiddiol.

Dyma rai enghreifftiau o ailddefnyddio;

1. Brics – Cafodd gwastraff brics a gynhyrchwyd wrth greu agoriadau newydd yn yr adeilad eu storio ar baledi a'u cadw ar y safle i'w hailddefnyddio neu yn lle brics oedd wedi malu. Amcangyfrifwyd fod hyn wedi atal 2.5 tunnell o wastraff brics. Byddai gwaredu 2.5 tunnell o wastraff (brics) anadweithiol wedi costio £144.
2. Llawr parquet – storiwyd 14 paled o lawr parquet derw ar gyfer eu glanhau a'u hailddefnyddio. Amcangyfrifwyd fod hyn wedi atal 12 tunnell o wastraff pren. Byddai gwaredu'r pren hwn wedi costio £1,542 ar sail ffi fesul tunnell o wastraff pren a ffi am godi bob sgip. Mae hyn yn tybio 1.15 tunnell fesul sgip ar sail llond sgip gyfartalog o wastraff pren. Byddai llawr parquet derw newydd, am £60 y m2, wedi costio tua £55,500 yn ychwanegol. Cyfanswm = tua £57.050.
3. Codwyd y bordiau ar gyfer y safle gan isgontractwyr a wnaeth hefyd eu tynnu i lawr gyda'r bwriad o'u hailddefnyddio ar safle arall.
4. Defnyddiwyd bordiau pren i ddiogelu peth o'r bensaernïaeth yn yr hen adeilad. Cawsant eu hailddefnyddio wedyn fel patresi, fframiau platfform ac estyll allanol.
5. Coed a distiau / trawstiau'r to – cafodd waith trwsio ei wneud ar ddistiau'r to. Cafodd y distiau mewn cyflwr da eu trwsio ac ailddefnyddiwyd unrhyw ddarnau y gellid eu hailddefnyddio, lle'r oedd hynny'n ymarferol.

5.3.3 Ailgylchu

Cyfanswm y gyfradd ailgylchu ar gyfer y prosiect hwn oedd 82.9%, gyda'r arferion ailgylchu'n arbed £310,244.

Gwnaed darpariaeth ar gyfer ailgylchu ar y safle gyda gwahanu'n cael ei annog ar gyfer gwastraff pren, plasterbord, gwydr, cardbord a gwastraff cymysg. Cafodd 181 o'r 258 o gynwysyddion (70.2%) a adawodd y safle eu gwahanu, gan hwyluso eu hailgylchu wedyn gan y cwmnïau rheoli gwastraff a helpu i gadw gwerth y deunyddiau ailgylchu.

Storiwyd rhai mathau o ddeunyddiau ar wahân ar y safle cyn eu cludo i iard John Weaver i gywasgu'r deunyddiau ailgylchu er mwyn sicrhau ailgylchu cost-effeithiol. Cafodd 11 o dripiau cludo eu gwneud i gywasgu 12.1 tunnell o wastraff a Derwen yn gyrchfan derfynol i'r holl wastraff.

- 9 o sgipiau plasterbord – 11.4 tunnell
- 1 sgip gymysg– 0.7 tunnell (10% Anadweithiol, 75% Inswleiddio, 15% Ffreutur / Swyddfeydd)

Cafodd y platwydr ei dynnu'n ofalus wrth adeiladu'r to. Fel gwastraff, cafodd ei gadw ar wahân a'i gludo'n uniongyrchol i GlassTech Recycling yn ôl y trefniant gyda Derwen. Ar y pryd byddai GlassTech wedi allforio'r gwastraff hwn i Bortiwgal i gael ei drin ymhellach neu ei lawrgylchu'n ddeunydd inswleiddio. O ganlyniad i welliannau diweddar i systemau GlassTech, bydd yn awr yn mynd i gael ei aildoddi.

- 1 sgip wydr – 2.07 tunnell

Llwyddodd ailgylchu'r gwastraff anadweithiol drwy sgipiau wedi'u gwahanu, a symudwyd gan Stenor ac Agricon, i osgoi tirlenwi 1279m^3 o wastraff anadweithiol. Costiodd hyn £19,012.50 i gael ei symud mewn 98 o wagenni 20 tunnell ond gallai fod wedi costio tua £240,000 a TAW ar ben hynny i'w waredu mewn sgipiau gwastraff cymysg. Llwyddodd hyn i arbed £271,000 ar sail £115 y dunnell a 325 o ffioedd codi sgip £50 yr un.

Os cymerwn na fyddai dim gwahanu wedi'i wneud ar gyfer ailgylchu, a chymhwyso ffioedd sgipiau gwastraff cymysg i'r holl wastraff, byddai'r gost o waredu'r gwastraff hwn i Derwen wedi bod tua £47,000. Y gost wirioneddol oedd £37,774.44. Roedd yr arbedion felly'n fwy na £9225 20.0% drwy gwahanu ar y safle ar gyfer ailgylchu.

5.3.3.1 Derwen

Cofnododd Derwen gyfraddau ailgylchu o 48.3% yn 2014, gan godi i 67.2% yn 2015 a 67.1% yn 2016. Mae'r cyfraddau hyn yn awgrymu bod 171 tunnell, 62.0% o'r 275.8 o dunelli o wastraff a broseswyd gan Derwen, wedi cael ei ailgylchu. O'i ddadansoddi fesul blwyddyn;

Blwyddyn	Cyfradd Ailgylchu	Tunelli a ailgylchwyd
2014	48.3%	36
2015	67.2%	118
2016	67.1%	17

5.3.3.2 Stenor Environmental Services

Yn 2014 symudodd Stenor Environmental Services (Stenor), a leolir yn Abertawe, wastraff tyllu a gwaith pridd. Crëwyd y gwastraff hwn ar ôl i arglawdd yng nghefn y safle gwympo. Cafodd y gwastraff ei sgrinio a'i wahanu gan Stenor gan lwyddo i adfer 100% o'r gwastraff.

Symudwyd 60 llwyth mewn wagenni 20 tunnell gyda'r cynnwys wedi'i gofnodi ar SMARTWaste fel;

- Concrid 3 wagen
- Brics 2 wagen
- Cerrig 1 wagen
- Anadweithiol 40 wagen
- Pridd 14 wagen

Ym mis Medi 2015 yn ystod y cam adeiladu, symudodd Stenor dair wagen 16 tunnell o wastraff anadweithiol o'r safle.

5.3.3.3 Peter Davis Agricon Ltd.

Yn 2014 symudodd Peter Davis Agricon Ltd. (Agricon), a leolir yn Abertawe, 39 cynhwysydd o wastraff pridd ac anadweithiol ar ôl i arglawdd yng nghefn y safle gwympo. Cafodd y gwastraff ei sgrinio a'i wahanu gan Agricon gan lwyddo i adfer 100% ohono.

5.3.4 Adfer ar gyfer Ynni

Mae Derwen yn trosi gwastraff dros ben yn danwydd. Y cyfraddau dros y cyfnod hwn oedd;

Blwyddyn	Cyfradd Adennill Ynni	Tunelli a adenillwyd
2014	29.9%	64.4
2015	28.1%	192.1
2016	31.2%	26.7

Drwy gymhwyso'r cyfraddau hyn i'r 984.8m^3 o wastraff a symudodd gwmni Derwen ar gyfer y prosiect hwn, awgrymir bod 283.3m^3, 30.3% wedi'i anfon i'w adfer ar gyfer ynni.

Canran yr holl wastraff a gynhyrchwyd ac a anfonwyd i'w adfer ar gyfer ynni felly = 12.1%

5.3.5 Tirlenwi

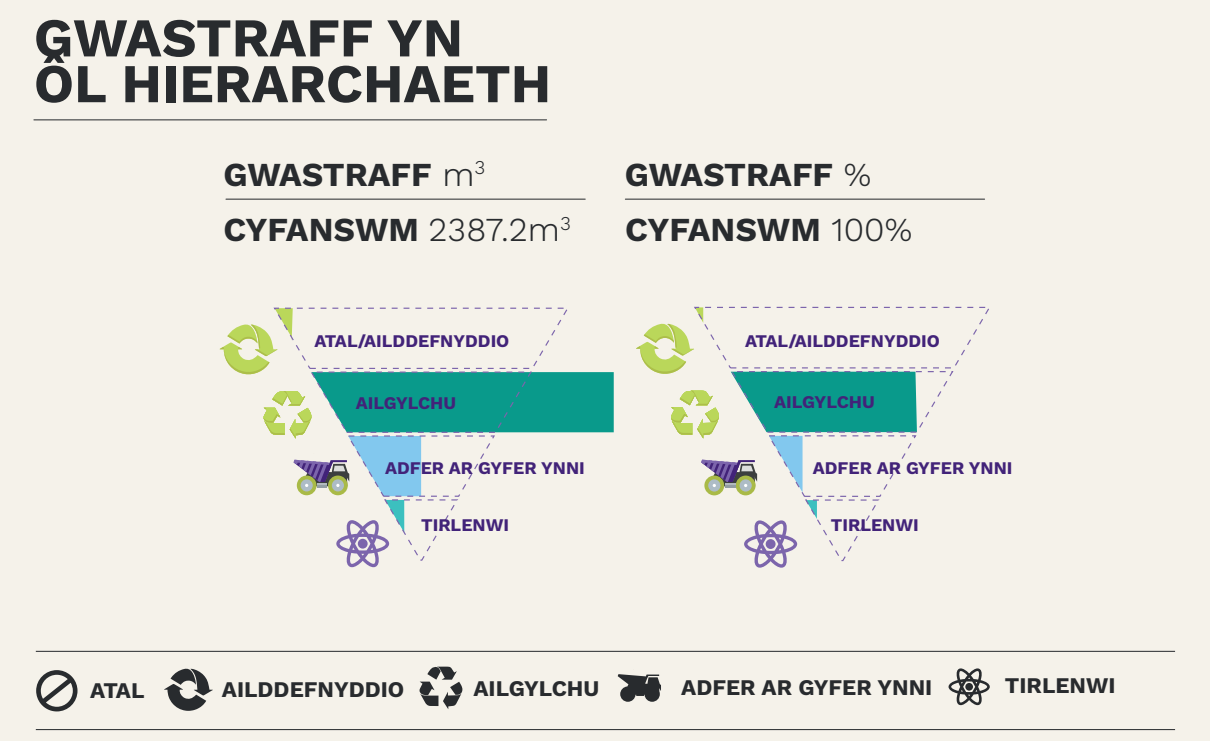
Y cyfraddau tirlenwi ar gyfer Derwen oedd;

Blwyddyn	Cyfradd Tirlenwi	Tunelli a yrrwyd i safle tirlenwi
2014	21.9%	215.5
2015	4.7%	683.7
2016	1.74%	85.7

Drwy gymhwyso'r cyfraddau hyn i'r 984.8m^3 o wastraff a symudodd gwmni Derwen ar gyfer y prosiect hwn, awgrymir bod 80.8m^3, 8.2% wedi'i anfon i'w dirlenwi.

Ni chofnodwyd fod unrhyw wastraff arall wedi mynd i'w dirlenwi.

Canran yr holl wastraff a anfonwyd i'w dirlenwi felly = 3.4%



5.4 Dadansoddiad yn ôl y Math o Ddeunydd

Mae'r adran yma'n seiliedig ar gyfaint y gwastraff yn ôl y math o ddeunydd, o'i gofnodi ar SMARTWaste gan dîm y safle.

5.4.1 Anadweithiol

Symudwyd y gwastraff anadweithiol o safle Glynn Vivian mewn 114 o gynwysyddion wedi'u gwahanu gan dri chontractwr gwastraff sef Derwen, Stenor ac Agricon. Roedd maint y cynwysyddion yn amrywio o wagenni 20 tunnell i sgipiau 8 iard. Roedd dosbarthiad y gwastraff anadweithiol yn cynnwys;

- Concrid 66.3m^3 4.4%
- Brics 50.8m^3 3.4%
- Teils a cerameg 13.2m^3 0.9%
- Pridd a cherrig 470.0m^3 31.5%
- Cymysgedd 891.8m^3 59.8%

Cynhyrchwyd gwastraff anadweithiol drwy gydol y prosiect yn enwedig ym mis Mai / Mehefin 2014, Hydref 2014 ac eto ym mis Medi 2015. Y cyfanswm oedd 1492.0m^3, 63.7% o holl wastraff y prosiect.

Roedd y defnydd trwm ym mis Mai / Mehefin o ganlyniad i wastraff o'r cam tyllu. Arweiniodd arglawdd a gwympodd yng nghefn y safle at ffrwd wastraff annisgwyl yn cynnwys concrid, pridd a cherrig, brics a gwastraff anadweithiol. Dosbarthwyd y rhan fwyaf o'r gwastraff naill ai fel pridd a cherrig neu wastraff anadweithiol. Symudwyd y gwastraff hwn gan Stenor ac Agricon mewn wagenni 20 tunnell yn bennaf. Roedd cost y gwastraff annisgwyl hwn a'r costau cludo'n £19,012.50.

Roedd y gost symud gan Derwen yn gost am symud 50.9 tunnell o wastraff anadweithiol mewn 11 o gynwysyddion. Cododd Derwen gyfradd safonol fesul sgip am yr 11 cynhwysydd hwn. Pe bai'r gyfradd codi gwastraff cymysg a ffi fesul tunnell wedi eu cymhwyso, byddai'r gwaith gwaredu wedi costio pum gwaith mwy.

Dosbarthwyd llawer o'r gwastraff anadweithiol fel pridd a cherrig, a allai fod wedi cael ei symud o'r safle heb ei ddosbarthu fel gwastraff. Mae cod ymarfer diffiniad CL:AIRE o wastraff yn cynnig opsiwn arall fel y gellir ailddefnyddio deunyddiau a dyllir ar safle neu eu symud rhwng safleoedd i'w hailddefnyddio. Gellid bod wedi lleihau'r costau cludo a'u rhannu rhwng safle Glynn Vivian a'r safle a dderbyniodd y gwastraff, gyda'r safle hwnnw'n elwa o opsiwn arall yn lle gorfod cludo deunydd i mewn o'r newydd.

5.4.2 Pren

Cyfanswm y gwastraff pren o'r prosiect oedd 317.9m^3, 13.6% o'r holl wastraff a gynhyrchwyd ar gyfer y prosiect hwn. Cafwyd dau gyfnod sylweddol o gynhyrchu gwastraff pren yn ystod y prosiect, ym Mai 2014 a Thachwedd 2015.

Crewyd gwastraff pren yn ystod y gwaith ar y to gan seiri coed John Weaver. Cafodd y teils concrid a'r estyll pren eu tynnu a'r distiau pren pydredig eu hadnewyddu. Cafodd distiau'r to oedd mewn cyflwr da eu trwsio ac ailddefnyddiwyd unrhyw ddarnau y gellid eu hailddefnyddio, lle'r oedd hynny'n ymarferol. Roedd sgip gwastraff pren yn rhan o gompownd gwastraff y safle lle'r oedd y gwahanu'n dda a'r sgip yn cael ei phacio'n dynn.

Storiwyd y paledi ar y safle a defnyddiwyd hwynt i storio deunyddiau o gwmpas y safle. Cawsant hefyd eu symud i safleoedd eraill i'w defnyddio mewn modd tebyg. Ystyriwyd y paledi i fod yn wastraff dim ond pan gawsant eu malu ac yna cawsant eu taflu i'r sgip gwastraff pren.

Bu'n rhaid codi'r llawr parquet ar lawr gwaelod yr oriel ynghyd â rhai distiau pren ar ôl darganfod pydredd gwlyb ym mis Hydref 2015. Roedd tîm y safle'n gwneud yn siŵr bod y pren pydredig yn cael ei wahanu a'i roi mewn bagiau tunnell hyblyg (FIBC). Cysylltwyd â'r cwmni rheoli gwastraff i'w hysbysu o'r pydredd a chafodd y bagiau eu symud o'r safle ar yr un pryd â'r sgip gwastraff pren.

Cafodd 14 paled o lawr parquet ei adfer, storio, glanhau a'i ailddefnyddio ar y safle. Gan atal tua 12 tunnell o wastraff pren. Yn yr un modd cafodd 20 o'r fframiau ffenestri eu hadfer ar y safle ac anfonwyd pump arall i gael eu hadfer oddi ar y safle. Amcangyfrifir y byddai hyn wedi creu dwy dunnell o wastraff pren. Dyma enghreifftiau eraill o osgoi gwaredu drwy ailddefnyddio;

- Codwyd y bordiau ar gyfer y safle gan isgontractwyr a ddaeth yno hefyd i'w tynnu i lawr gyda'r bwriad o'u hailddefnyddio ar safle arall.
- Defnyddiwyd bordiau pren i ddiogelu peth o'r bensaernïaeth yn yr hen adeilad. Cawsant eu hailddefnyddio wedyn fel patresi, fframiau platfform ac estyll allanol.

Llwyddwyd i osgoi tua 20 tunnell o wastraff drwy ailddefnyddio gan arbed tua 17 sgip o wastraff (ar sail 1.15 tunnell ar gyfartaledd o wastraff pren i bob sgip gwastraff pren). Llwyddodd hyn i arbed £3780 pe bai wedi'i waredu fel gwastraff cymysg neu £2500 fel gwastraff pren. 38.0% am y naill a 57.5% am y llall yn ychwanegol ar ben y costau gwaredu pren gwirioneddol.

Roedd costau Derwen am symud y gwastraff pren yn seiliedig ar gyfradd fesul tunnell a ffi codi sgip. Y gyfradd fesul tunnell oedd 53.6% o'r gyfradd gwastraff cymysg gan arbed 21.1% ar ben y costau a arbedwyd drwy ailddefnyddio. Byddai gwaredu gwastraff pren wedi bod 110% yn ddrytach heb yr enghreifftiau o ailddefnyddio a gwahanu gwastraff yma.

5.4.3 Plasterbord

Cynhyrchwyd 90.0m^3 o wastraff plasterbord, 13.2 tunnell i gyd. Roedd yna'n cael ei symud o'r safle gan Derwen. Mae'n cyfateb i 9.0% o'r gwastraff adeiladu a 3.8% o'r holl wastraff a gynhyrchwyd. Cynhyrchwyd y gwastraff gan waith a wnaed rhwng Mai a Rhagfyr 2015 gyda'r gwastraff mwyaf o 24.5m^3 ym mis Medi.

Oherwydd dimensiynau'r ystafelloedd yn yr adeilad presennol roedd peth gwastraff torion plasterbord yn anochel. Codwyd ymwybyddiaeth o wastraff plasterbord gyda'r staff ar y safle gan lwyddo i'w leihau cymaint ag yr oedd modd. Er enghraifft, cafwyd fod torion plasterbord yn cael eu storio ar y safle i'w defnyddio lle'r oedd hynny'n ymarferol, gan leihau gwastraff.

Roedd natur gyfyng y safle'n golygu nad oedd lle i sgip plasterbord bwrpasol yn ystod y gwaith plasterbordio. Storiwyd y gwastraff plasterbord o gwmpas y safle mewn bagiau tunnell gyda John Weaver yna'n eu cludo'n ôl i'w iard ar gyfer cywasgu'r gwastraff plasterbord.

Cafodd naw cynhwysydd plasterbord o amrywiol faint eu cludo i iard John Weaver. Roedd hyn yn gyfanswm o 11.4 tunnell o wastraff plasterbord oedd yna'n cael ei gywasgu er mwyn ei waredu'n fwy cost-effeithiol.

Roedd costau Derwen o waredu gypsum yn 26.1% yn rhatach y dunnell na'i waredu fel gwastraff cymysg.

5.4.4 Inswleiddio

Cynhyrchodd y prosiect 117.1m^3 o wastraff inswleiddio sef 11.7% o'r holl wastraff adeiladu a 5.0% o'r holl wastraff a gynhyrchwyd. Cafodd ei gynhyrchu rhwng Mehefin 2014 a Mehefin 2016 ar ffurf 'llinell amser gromen' gyda'r gwastraff mwyaf ym mis Gorffennaf 2015.

Aethpwyd â pheth o'r gwastraff inswleiddio, 0.53 tunnell, i iard John Weaver i'w gywasgu er mwyn ei waredu'n fwy cost-effeithiol. Derwen oedd y gyrchfan derfynol ar gyfer y gwastraff hwn. Cafodd y gwastraff inswleiddio ei waredu mewn sgipiau gwastraff cymysg am y gost uchaf a godir gan Derwen.

5.4.5 Cymysg

Cynhyrchwyd gwastraff cymysg drwy gydol y prosiect. Cyrhaeddodd y gwastraff hwn ei anterth ym mis Tachwedd 2015 cyn gostwng eto yn 2016. Cofnodwyd 181.4m^3 o wastraff cymysg, 18.2% o'r gwastraff adeiladu a 7.7% o'r holl wastraff.

Roedd staff y safle'n archwilio cynnwys y sgip gwastraff cymysg yn gyson drwy fod yn ymwybodol o gost gwastraff ar y safle. Roeddent yn tynnu allan eitemau fel bocsys cardbord i sicrhau gwahanu da ac i leihau unrhyw halogi o fewn y sgipiau ar y safle.

Roedd sgipiau gwastraff cymysg yno drwy gydol y prosiect a chwmni Derwen yn gyfrifol am eu symud o'r safle. Cyn gadael y safle roedd cynnwys pob sgip gwastraff cymysg yn cael ei amcangyfrif a'i gofnodi ar SMARTWaste. Roedd peth o'r cynnwys a gofnodwyd yn wastraff swyddfa oedd yn isel iawn ar y safle ond nid yn cael ei gasglu ar wahân.

5.4.6 Gwastraff Swyddfeydd a Ffreutur

Roedd cynnydd cyson yn y gwastraff swyddfeydd a ffreutur hyd at fis Tachwedd 2015 cyn gostwng wrth i nifer y staff ar y safle ostwng. Cyd-ddigwyddodd y lleihad yn y gwastraff wrth i wastraff y ffreutur ddod yn ganran sylweddol o'r gwastraff misol. Er enghraifft dosbarthwyd 18% o'r gwastraff ym Mehefin 2016 fel gwastraff ffreutur / swyddfa.

Yn aml iawn, mae gwastraff ffreutur a swyddfa ar safle'n cael ei gymysgu â gwastraff bwyd gan halogi deunyddiau ailgylchu fel mai tirlenwi yw'r unig opsiwn gwaredu ymarferol. Dangosodd dreialon gan EZW yn Nhorfaen a Cheredigion fod opsiwn gwaredu arall yn bosib. Casglwyd y gwastraff ffreutur a swyddfa fel rhan o gasgliadau gwastraff dinesig rheolaidd y cyngor, am ffi gymharol isel. Roedd hyn yn cynnwys casgliadau gwastraff bwyd a deunyddiau ailgylchu.

Roedd defnyddio casgliadau dinesig y cyngor yn Nhorfaen a Cheredigion yn annog gwahanu'r bwyd gwastraff a'r deunyddiau ailgylchu. Llwyddodd hyn i gadw gwerth y deunyddiau ailgylchu drwy atal eu halogi gan hefyd ganiatáu i'r gwastraff bwyd gael ei waredu drwy dreulio anaerobig yn hytrach na thirlenwi.

Mae'r manteision yn cynnwys:

- Osgoi tirlenwi mwy o wastraff bwyd a deunyddiau ailgylchu
- Llai o gasgliadau sgipiau gwastraff cymysg o safleoedd adeiladu; gan leihau nifer y lorïau sy'n gysylltiedig â safleoedd adeiladu
- Sgipiau cymysg yn pwyso llai gan leihau'r costau gwaredu gwastraff
- Mwy o ailgylchu
- Mwy o ddeunyddiau ar gyfer cyfleusterau treulio anaerobig

Y gobaith yw lledaenu'r treialon hyn ar draws Cymru.

5.4.7 Deunyddiau Toi

Roedd y gofynion cadwraeth ar gyfer to'r adeilad gwreiddiol yn cynnwys tynnu'r teils concrid oddi ar y to presennol cyn mynd ati i atgyweirio'r to. Cafodd yr estyll pren eu tynnu oherwydd bod angen rhai newydd ac atgyweiriwyd distiau'r to cymaint ag y bo'n bosib gan dynnu unrhyw bren pydredig. Cafodd y teils concrid eu hadnewyddu gyda llechi.

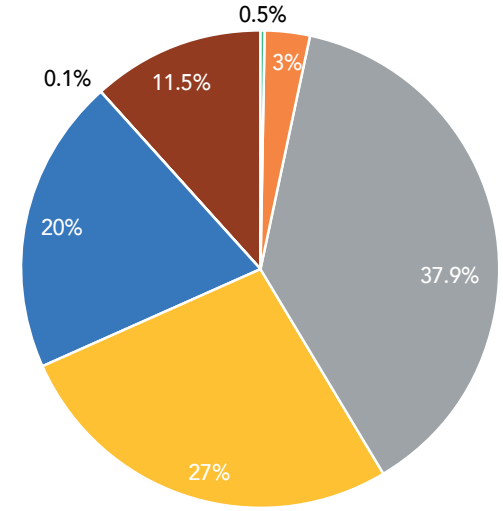
Tynnwyd y teils concrid yn ofalus a'u storio ar baledi oherwydd roedd rhai mewn cyflwr da. Cafodd teils oedd wedi torri eu gwaredu yn y sgip anadweithiol. Gwnaed ymholiadau gyda chyfleusterau ailddefnyddio lleol a chwmnïau darnau pensaernïol ail-law. Yn anffodus, oherwydd nad oedd y teils o ansawdd da nid oedd galw amdanynt. Cafodd teils y to eu dosbarthu i unrhyw un a allai wneud defnydd ohonynt, fel arfer aelodau o'r cyhoedd oedd eisiau ychydig o deils i wneud gwaith atgyweirio ar eu cartrefi.

Roedd rhan o'r to'n wydr fel y gallai golau naturiol ddod i mewn i'r adeilad. Roedd angen ei dynnu a'i adnewyddu gyda gwydr newydd. Cafodd y gwydr ei dynnu'n ofalus a'i gadw ar wahân i'r gwastraff arall. Cafodd yna ei symud yn syth i'r cwmni ailgylchu gwydr GlassTech a fyddai wedi allforio'r gwastraff i Bortiwgal ar gyfer ei drin ymhellach neu ei lawrgylchu'n ddeunydd inswleiddio. Fodd bynnag, o ganlyniad i welliannau diweddar i systemau GlassTech bydd yn awr yn mynd i gael ei ailddoddi.

5.5 Dadansoddiad yn ôl Cost

5.5.1 Y Costau Rheoli Gwastraff Gwirioneddol

Ar gyfer y prosiect cyfan trefnodd John Weaver i symud 258 cynhwysydd o wastraff o'r safle. Roedd 151 (58.5%) o'r cam adeiladu, naw (3.5%) o'r cam dymchwel a 97 (38.0%) o'r cam tyllu.



Cyfanswm Costau Derwen =	£37,774.44
Cyfanswm Costau Stenor ac Agricon =	£19,012.50
Cyfanswm Costau Rheoli Gwastraff =	£56,786.94

Roedd y sgipiau gwastraff cymysg yn cyfrif am 47.0% o'r costau rheoli gwastraff ond dim ond traean o'r holl sgipiau. Cyfrannodd y casgliadau gwastraff cymysg 14% yn ychwanegol at y costau felly o'i gymharu â chynwysyddion eraill.

5.5.2 Y Costau Rheoli Gwastraff Posib

Heb ystyried yr hierarchaeth wastraff, gallai'r costau rheoli gwastraff fod wedi bod dros £400,464. Mae'r gost bosib yma'n seiliedig ar beidio â gwahanu gwastraff a gwaredu'r holl wastraff ar sail cyfraddau sgipiau gwastraff cymysg. Mae hefyd yn cyfrif am gostau ychwanegol a fyddai wedi cael eu hachosi heb atal neu ailddefnyddio'r gwastraff. Rhoddir y manylion yn adran 5.3.

Cyfanswm yr arbedion cost drwy atal =	£ 25,270
Yr arbedion mesuradwy drwy ailddefnyddio =	£ 57,194
Drwy wahanu'r gwastraff ar gyfer ailgylchu, gwnaed arbedion o =	£318,000
Cyfanswm =	**£400,464**

Gellid bod wedi gwario bron i saith gwaith yn fwy na'r gost rheoli gwastraff wirioneddol ar y prosiect hwn. Gwnaed arbedion o dros £400,000.

5.6 Dadansoddiad yn erbyn Meincnodau

Mae data ar wastraff ar gael yn y system SMARTWaste ar gyfer cannoedd o brosiectau a gwblhawyd yng Nghymru. Gall prosiectau adrodd ar sail cyfaint neu dunelli o wastraff ar gyfer amrywiaeth eang o wahanol fathau o brosiectau. Dadansoddwyd y data i greu dangosyddion perfformiad ar gyfer y gwastraff a gynhyrchwyd am bob £100k a phob 100m2 ar gyfer cyfaint a / neu dunelli o wastraff a gynhyrchwyd.

Yma cymharir perfformiad y cam adeiladu â meincnod SMARTWaste ar gyfer adeilad cyhoeddus.

Mae BREEAM (BRE Environmental Assessment Method) yn ddull asesu amgylcheddol a ddefnyddir yn eang ar gyfer adeiladau a chymunedau. Mae'n rhoi sylw i faterion amgylcheddol a chynaliadwyedd gyda chredydau'n cael eu defnyddio fel rhan o'r meini prawf asesu.

5.6.1 SMARTWaste

	Data o'r Cam Adeiladu	Meincnod SMARTWaste*	Cymhariaeth
$m^3/100m^2$	21.2	21.7***	-3.3%
$m^3/£100k$	15.8	21.1**	-25.1%

*ar gyfer adeilad cyhoeddus
**ar sail deg prosiect
***ar sail wyth prosiect

Mae prosiectau adeiladau cyhoeddus newydd ar SMARTWaste yn 21.7m3/100m2 a 21.1m3/£100k ar gyfartaledd. Cyflawnodd gam adeiladu prosiect Glynn Vivian 21.2m3/100m2 a 15.8m3/£100k. Mae'r canlyniadau hyn yn golygu bod y prosiect yn 3.3% llai gwastraffus am y naill, a 25.1% llai gwastraffus am y llall na'r meincnodau sefydledig.

5.6.2 BREEAM

	Data o'r Cam Adeiladu	1 credyd	2 credyd	3 credyd	Enghreifftiol
$m^3/100m^2$	21.2	<13.3	<7.5	<3.4	<1.6

Cyflawnodd brosiect Glynn Vivian 21.2m3/100m2 o wastraff dros y cam adeiladu. Roedd hyn yn 1.6 gwaith y cyfaint oedd ei angen i ennill credyd BREEAM.

6 Modelu

6.1 Modelu Gwybodaeth Adeiladu (BIM)

Caiff ei gydnabod yn eang yn y sector amgylchedd adeiledig fod trosi darluniau'n adeilad ar y ddaear yn aml yn achosi gwrthdaro annisgwyl, yn enwedig gyda chysylltiadau cymhleth a gwasanaethau mecanyddol a thrydanol. Mae'n arfer cyffredin i unrhyw wrthdaro gael ei ddatrys yn adweithiol ar y safle, gan wastraffu deunyddiau ac amser yn aml. Drwy ddefnyddio meddalwedd, nod BIM yw dileu'r gwastraff hwn.

Fodd bynnag mae BIM yn ymwneud yn gymaint â phobl a phroses ag â meddalwedd, gan roi cyfle i fod yn fwy effeithlon a hefyd i fabwysiadu dulliau gweithio gwell. Mae'r dull cydweithredol sydd ei angen i greu dyluniad effeithiol drwy BIM yn sicrhau bod gwybodaeth yn llifo'n gyson rhwng y gwahanol grefftwyr. Mae BIM yn golygu bod y gweithredwyr yn gallu delweddu mewnbwn ei gilydd gan annog cyd-ddealltwriaeth a pherthynas weithio dda.

6.2 Defnyddio BIM yn Glynn Vivian

Roedd y ffaith bod yr oriel Edwardaidd wreiddiol yn adeilad rhestredig Gradd II* wedi cyfyngu ar ddatblygu'r adeilad. Nid oedd modd newid ei strwythur gwreiddiol mewnol. Defnyddiwyd waliau ffug i guddio'r systemau trydanol gan roi gofod newydd dirwystr ar y wal ar gyfer arddangoswyr.

Dangosodd Arup sut y gallai'r cwsmer ac arddangoswyr ddefnyddio BIM i adnabod yn hawdd unrhyw ffitiadau trydanol cudd ym mhrif ofodau'r oriel. Y nod oedd y gallai arddangoswyr osod arddangosiadau a ffitiadau ar y wal yn gwbl hyderus na fyddent yn achosi difrod i wasanaethau trydanol drwy wneud hynny.

6.2.1 Paratoi'r Model

Ar gyfer y prosiect hwn defnyddiodd Arup (7) "Matterport" sef sganiwr symudol yn cynnwys camera a synwyryddion 3D sy'n troi 360 gradd ar ben treipod pum troedfedd. Mae'r camera ac amrediad o synwyryddion 2D a 3D yn cylchdroi i greu darlun o edrychiad a dimensiynau'r gofod.

LiDAR oedd y dechnoleg synhwyro a ddefnyddiwyd. Mae'n mesur pellter drwy daflu golau at darged gyda laser a dadansoddi'r golau a adlewyrchir. Mae'r wybodaeth a gesglir gan y sganiwr yn cynhyrchu data 'cymylau pwynt' sy'n gallu storio maint a lliw'r gwrthrychau a sganiwyd.

Drwy ailadrodd hyn pob 5-6 troedfedd, gall y dechnoleg gyplysu'r data a sganiwyd i greu darlun cywir o'r amgylchedd. Mae'r sganiwr hefyd yn gallu casglu data ffotograffig a'i grwpio gyda'i gilydd mewn amgylchedd sy'n debyg iawn i Google Street View.

Cafodd y data cymylau pwynt yna ei brosesu a'i drosi'n fformat cymylau pwynt addas i'w ddefnyddio mewn pecyn BIM parametrig a data-gyfoethog. Defnyddiwyd y cwmwl pwynt hwn fel cyfeirnod yn yr amgylchedd BIM, i greu darlun cywir. Gwnaed hyn drwy osod elfennau parametrig fel waliau, lloriau a thoeau i gyfateb i'r cwmwl pwynt.

6.2.2 Defnyddio'r Model

Fel y gallai staff yr oriel a'r arddangoswyr gael mynediad at y data a'i ddefnyddio'n ymarferol yn yr oriel, trodd Arup at uwch-realiti. Mae technolegau newydd yn gymorth i dimau dylunio ac adeiladu gyda delweddu syniadau a dyluniadau. Mae Realiti Rhithiol (VR) drwy bensetiau ac amgylcheddau 'trochi', ynghyd ag Uwch-Realiti (AR), yn caniatáu i ddylunwyr, datblygwyr a defnyddwyr ddelweddu'r dyluniad gorffenedig heb orfod ei adeiladu'n gyntaf.

Mae angen marcwyr cyfeiriol ar y technolegau AR presennol fel bo'r data yn yr amgylchedd rhithiol yn gallu gorchuddio'r gwir amgylchedd yn gywir. Ni ystyriwyd fod marcwyr fel tagiau RFID a barcod yn opsiynau hyfyw i'w defnyddio mewn amgylchedd oriel. Defnyddiwyd nodweddion yr adeilad ei hun drwy gymhwyso Lleoleiddio a Mapio Ar y Cyd (SLAM). Drwy SLAM mae dyfais Prosiect Tango'n defnyddio pwyntiau ar wynebau i gysylltu wynebau gwirioneddol i wynebau rhithiol, digidol.

Platfform technoleg gan Google yw Project Tango sy'n caniatáu i ddatblygwyr greu profiadau sy'n ymgorffori mapio 3D ac uwch-realiti.

6.3 Canlyniadau BIM

Mae'r defnydd hwn o dechnoleg uwch-realiti yn gadael i ddefnyddwyr 'ddelweddu' gwybodaeth fodel ac asedau na fyddai'n bosib fel arall. Gall y defnyddiwr pen-draw 'gwestiynu'r' model a chanfod lleoliad unrhyw ffitiadau'n gymharol hawdd. Bydd hyn yn hwyluso dylunio arddangosfa'n ogystal â rheoli a chynnal a chadw'r cyfleusterau.

Mae defnyddio technolegau BIM yn rhoi cyfle delfrydol i'r diwydiant adeiladu gofnodi adeiladau mewn ffordd ddeallus. Drwy gyfuniad gofalus o sganio a modelu, gellir cynhyrchu data clyfar a'i ailddefnyddio ar gyfer llu o bwrpasau. Mae'n cynnig ffordd effeithlon o ddatgelu gwybodaeth fodel y tu ôl i rwystrau ffisegol.

7 Diogelu at y Dyfodol – Cymhwyso Bil yr Amgylchedd

Mae'r prosiect wedi amlygu problemau y gallai'r diwydiant eu hwynebu yn y dyfodol. Yn benodol, o ran y gwaharddiadau sydd i ddod ar losgi a thirlenwi gwastraff pren, papur, cardbord, gwydr, plastig, metel a gwastraff bwyd o dan Fil yr Amgylchedd (Cymru).

Pe bai'r Bil yn cael ei gymhwyso i'r prosiect hwn gallai fod angen ateb arall i waredu 50.0m3 o wastraff a gynhyrchwyd. Bydd felly angen gwneud ymchwil i ddeall pa opsiynau gwaredu eraill, ynghyd â'r seilwaith priodol, fydd angen eu hystyried er mwyn gallu gwneud y newidiadau sy'n ofynnol o dan y ddeddfwriaeth.

8 Sialensiau Allweddol

8.1 Gwastraff

Roedd y prosiect yn rhagweld sialensiau rheoli gwastraff penodol yn codi o:

- Safle cyfyng heb lawer o le o gwbl i storio deunyddiau - mae'r safle mewn ardal adeiledig iawn yn union gerllaw ffordd brysur sy'n mynd â thraffig allan o'r ddinas. Mae'r ardal yma o Abertawe'n cael ei hadnewyddu'n barhaus gyda'r hen lyfrgell (gyferbyn â'r safle) yn cael ei throi'n rhan o Brifysgol Fetropolitan Abertawe - yr Ysgol Gelf
- Mae'r safle ar fryn serth gyda'r safle o'r herwydd yn un llechweddog - bu'n rhaid cyfyngu'r gwaith o gludo i ac o'r safle i gerbydau llai nad oedd modd eu llenwi'n llawn, gan olygu mwy o lwythi i ac o'r safle
- Y statws rhestredig Gradd II* - oherwydd bod angen adfer ac ailwampio'n sensitif, nodwyd potensial i gynhyrchu gwastraff ychwanegol. Roedd potensial i gynhyrchu gwastraff peryglus oherwydd y deunyddiau gwreiddiol a allai fod wedi cael eu defnyddio
- Ffrydiau gwastraff tebygol - gan gynnwys plastig, pren, pecynnu, brics (er i lawer o'r rhain gael eu tynnu, eu glanhau a'u paratoi ar gyfer eu hailddefnyddio), concrid a phlasterbord

Llwyddwyd i wahanu'r gwastraff yn dda er y diffyg lle. Defnyddiwyd bagiau tunnell o gwmpas y safle oedd yna naill ai'n cael eu symud gan gerbyd y cwmni i'w hailgylchu'n ôl wrth y sgipiau yn eu hiard, neu drwy ddod â'r sgipiau i waith penodol oedd yn cael ei wneud, lle'r oedd lle iddynt.

Drwy ddefnyddio cerbyd y cwmni i symud deunyddiau dros ben, dangoswyd fod cerbyd safle'n amhrisiadwy i atal gwastraff ac fel nad oedd angen prynu mwy o ddeunyddiau, ar lefel cwmni.

8.2 Ymddygiad/Diwylliant

Gall ymddygiad a diwylliant ar safle arwain at wastraff sylweddol yn aml, neu at agwedd ddihid at wastraff a'i wahanu.

Cafwyd fod y staff a gyflogir yn uniongyrchol gan John Weaver yn ymwybodol iawn o wastraff a sut y mae gwastraff a gynhyrchir ganddynt yn effeithio ar gostau ac ymarferoldeb y prosiect. Dilynodd hyn ddwy flynedd o hyfforddiant i'r staff i godi ymwybyddiaeth ar bob lefel yn y cwmni.

Cafodd y rheolwyr safle hefyd eu hyfforddi ar sut i gofnodi data gwastraff ar SMARTWaste. Cafwyd eu bod yn archwilio cynnwys y sgipiau'n rheolaidd ac yn tynnu allan unrhyw wastraff nad oedd wedi'i wahanu'n iawn neu y gellid ei ailddefnyddio. Os nad oedd sgip ar gael ar gyfer y safle oherwydd diffyg lle, byddai John Weaver yn dod â chyfleusterau storio dros dro i'r safle cyn cludo'r gwastraff yn ôl i'w iard i'w gywasgu ar gyfer ei ailgylchu.

Gyda'r rheolwyr a'r holl staff ar y safle'n ymwybodol o wastraff daeth yn rhan annatod o ddiwylliant y safle. Pan gyflogwyd isgontractwyr i wneud gwaith ar y safle, cafodd ymwybyddiaeth o wastraff ei godi â'r isgontractwyr hyn ynghyd â lleihau gwastraff a defnyddio eu deunyddiau'n effeithiol.

8.3 Sut y mae EZW wedi Dylanwadu ar Reoli Gwastraff ar gyfer Tîm y Prosiect?

Roedd Oriel Gelf Glynn Vivian yn brosiect heriol dros ben, o ran ei safle, y rhaglen a'r dyluniad cymhleth. Roedd yr adeilad blaenorol, ac o ganlyniad y safle, ar lethr serth heb fawr ddim lle i ddadlwytho a chadw deunyddiau adeiladu. Hefyd, roedd storio, didoli a gwaredu gwastraff yn anodd dros ben. O ganlyniad, bu'n rhaid blaenoriaethu'r dasg o reoli gwastraff er mwyn gwneud hynny yn y ffordd orau bosibl.

Llwyddwyd i ganfod ffyrdd o leddfu effeithiau gwastraff gyda chymorth cynllun Galluogi Dim Gwastraff (EZW) o eiddo Adeiladu Arbenigrwydd yng Nghymru (CEW). Oherwydd natur y prosiect adnewyddu, a chan fod contractwr arall eisoes wedi gwneud y gwaith dymchwel, penderfynwyd canolbwyntio ar y feysydd lle gellid gwneud gwahaniaeth, er enghraifft ailddefnyddio pethau oedd eisoes ar y safle fel rhan o'r gwaith adnewyddu ac wrth adeiladu'r estyniadau newydd.

Darparwyd ymgynghorydd gan EZW a oedd yn galw heibio i weithio gyda thîm y safle i'w helpu i ganfod ffyrdd newydd a gwahanol o leihau gwastraff. Rhannwyd gwybodaeth fuddiol iawn a sefydlwyd perthynas dda gyda thîm y safle. Roedd hyn yn gam pwysig tuag at gyflawni'r deilliannau gorau.

Hefyd, darparodd CEW adnodd Modelu Gwybodaeth am Adeiladu (BIM) ar gyfer y prosiect i weld a fyddai hynny'n helpu i leihau gwastraff. Gan fod y dyluniad cymhleth eisoes yn ei le, byddai wedi bod yn afresymol ceisio defnyddio'r model hwn ar gyfer y cynllun cyfan. Ac felly penderfynwyd canolbwyntio'r agwedd BIM ar ddefnyddwyr terfynol yr adeilad, gyda'r nod o leihau cynnyrch gwastraff y dyfodol wrth i'r oriel newid ac addasu gofodau arddangos yn gyson. Pe byddid wedi defnyddio BIM o'r cyfnod dylunio dechreuol, byddai wedi bod o gymorth i gydlynu llawer o fanylion cymhleth, a hynny yn ei dro wedi helpu i leihau gwastraff y prosiect.

Yn ddi-os, bu'r wybodaeth a gasglwyd wrth weithio gyda CEW a dilyn cynllun Galluogi Dim Gwastraff o fudd i'r Contractwyr John Weaver a thîm y prosiect. Byddent hwy yn croesawu unrhyw gyfle i gydweithio eto yn y dyfodol.

9 Llwyddiannau

9.1 Targedau Llywodraeth Cymru

Nod Tuag at Ddyfodol Diwastraff (TZW), sef dogfen strategaeth drosfwaol Llywodraeth Cymru ar gyfer delio gyda gwastraff yng Nghymru, yw creu manteision i'r amgylchedd, yr economi ac i gymdeithas. Mae TZW yn gosod targed bod y diwydiant adeiladu a dymchwel yng Nghymru'n paratoi ar gyfer ailddefnyddio, ailgylchu neu adfer fel arall o leiaf 70% o ddeunyddiau, yn ôl pwysau, erbyn 2015-16. Y targed ar gyfer 2019-20 yw 90%.

Drwy gyflawni cyfradd ailddefnyddio, ailgylchu neu adfer fel arall o 96.6%, yn ôl cyfaint, mae prosiect Glynn Vivian yn dangos pa mor gyraeddadwy yw'r targed presennol o 70%, yn ôl pwysau. Mae hefyd yn dangos pa mor gyraeddadwy yw'r targed 90%, yn ôl pwysau, erbyn 2019-20.

Nod Llywodraeth Cymru erbyn 2050 yw gallu osgoi tirlenwi 100% o wastraff adeiladu a dymchwel. Gellir priodoli'r 3.4% o wastraff y cyfrifwyd iddo gael ei dirlenwi ar y prosiect hwn i arferion y cwmni rheoli gwastraff. Ni allai Derwen ddarparu cyfraddau prosiect penodol ar gyfer ailgylchu, adfer a thirlenwi, dim ond perfformiad eu holl waith. Mae hyn yn ei gwneud yn amhosib profi llwyddiant gydag osgoi tirlenwi 100% o wastraff hyd nes y bydd y cwmnïau rheoli gwastraff naill ai'n osgoi tirlenwi 100% neu'n cofnodi cyrchfan pen draw'r gwastraff ar gyfer prosiectau penodol.

Er llwyddo i gyflawni'r targedau uchod ystyrir bod angen mwy o ffocws ar ailddefnyddio ac atal gwastraff yn hytrach na dibynnu ar effeithlonrwydd y seilwaith rheoli gwastraff. Rhaid gwastraffu 1.4% yn llai o flwyddyn i flwyddyn er mwyn gallu cyflawni'r targedau yn Tuag at Ddyfodol Diwastraff ar gyfer y sector.

9.2 Ymwybyddiaeth o Wastraff

Roedd gwastraff yn uchel ar agenda John Weaver a'r gweithwyr ar y safle ac yn glir i aelodau o dîm EZW a fu'n ymweld â'r safle. Cafwyd fod y staff safle a gyflogir yn uniongyrchol gan John Weaver yn ymwybodol o faterion gwastraff a'u heffaith ar y prosiect a chostau'r prosiect.

Hyfforddwyd y Rheolwyr Safle i gofnodi data gwastraff ar SMARTWaste eu hunain. Cafwyd eu bod yn archwilio cynnwys y sgipiau'n rheolaidd ac yn tynnu allan unrhyw wastraff nad oedd wedi'i wahanu'n iawn neu y gellid ei ailddefnyddio.

Os nad oedd sgip ar gael ar gyfer y safle oherwydd diffyg lle, byddai John Weaver yn dod â chyfleusterau storio dros dro i'r safle cyn cludo'r gwastraff yn ôl i'w iard i'w gywasgu cyn ei waredu.

Roedd y gwaith a wnaed gan y cynrychiolydd amgylcheddol ar y safle, dros y ddwy flynedd ddiwethaf, i'w edmygu'n fawr. Er i'r prosiect gynhyrchu mwy o wastraff na'r disgwyl oherwydd gwaith tyllu'r ddaear a gwaith ychwanegol, daeth John Weaver o hyd i'r atebion gorau ar gyfer eu gwastraff drwy eu perthynas dda â chwmnïau gwastraff lleol.

Gellid codi ymwybyddiaeth o wastraff mewn cyfarfod cyn-gosod wrth ddod â chontractwyr ar y prosiect gan felly sicrhau bod ymwybyddiaeth wedi'i godi ar y dechrau cyn dod i'r safle.

9.3 BIM

Dylai'r defnydd arloesol o BIM ac uwch-realiti (AR) ar y prosiect hwn ddarparu manteision sylweddol yn y dyfodol. Bydd modd rheoli asedau a'r cyfleusterau yn Oriel Gelf Glynn Vivian yn well drwy fod yn gallu gweld gwasanaethau cudd heb wneud gwaith archwilio ymwthiol. Bydd hyn yn arbed amser, arian a deunyddiau sylweddol drwy gydol oes yr oriel.

Gellir yn awr ystyried gwneud defnydd tebyg o BIM ar brosiectau eraill diolch i'r esiampl arloesol hon. O'i gymhwyso ar draws y diwydiant adeiladu a rheoli adeiladu gallai defnyddio AR gyda BIM arwain at newid sylfaenol mewn effeithlonrwydd a ffyrdd o weithio.

Ar gyfer y prosiect hwn roedd AR yn caniatáu delweddu'r hyn oedd eisoes yn ei le a gellid yn hawdd ei ddefnyddio i ddelweddu'r hyn sydd eto i'w roi yn ei le. Bydd yn rhoi amgyffred gwell a llawer haws i beirianwyr a gweithredwyr ar y safle o'r hyn y bydd plymwyr a thrydanwyr etc yn ei osod a lle, gan leihau gwaith ofer a chywiro.

10 Casgliad ac Argymhellion

Mae Oriel Gelf Glynn Vivian wedi perfformio'n dda yn erbyn meincnodau SMARTWaste a thargedau Llywodraeth Cymru ar gyfer y cam adeiladu.

Er llwyddo i gyflawni'r targedau, mae angen mwy o ffocws ar ailddefnyddio ac atal gwastraff yn hytrach na dibynnu ar effeithiolrwydd y seilwaith rheoli gwastraff. Mae cyfle i fod yn fwy effeithlon ac effeithiol ar safle gan greu potensial i wneud arbedion gwastraff a chost.

Mae arbedion cost ar gael i gwmnïau sy'n fodlon ystyried yr hierarchaeth wastraff ym mhob un o wahanol gamau eu prosiect. Atal yw'r lefel allweddol yn yr hierarchaeth er mwyn gwneud arbedion sylweddol, fel y mae'r prosiect hwn wedi'i ddangos. Mae BIM yn rhoi cyfle i ddyluniadau gael eu profi a'u newid gyda golwg ar atal unrhyw wrthdaro, er enghraifft. Gall y ddau beth fod yn ddrud a gwastraffus.

Mae pwysigrwydd gwahanu gwastraff ar y dechrau wedi'i brofi ynghyd â chanolbwyntio ar drafod gwastraff ym mhob un o wahanol gamau'r prosiect, gyda phawb ar y safle. Mae ymgysylltu â holl aelodau'r tîm ar y safle'n bwysig wrth geisio cynnal arferion gorau a gwahanu ar adegau o bwysau ar y safle, yn enwedig yn ystod y cyfnod terfynol cyn trosglwyddo.

10.1 Argymhellion i Gwsmeriaid

Gall gwaith ychwanegol gael effaith sylweddol ar wastraff. Yn yr achos hwn arweiniodd gais y cwsmer i wneud gwaith ychwanegol at orfod dibynnu ar sgipiau gwastraff cymysg oherwydd na ellid rhagweld a chynllunio ar gyfer ffrydiau gwastraff, yn ogystal â diffyg lle ar y safle.

Mae angen i'r cwsmer ddeall y gall eu penderfyniadau gael effaith ganlyniadol ar reoli gwastraff. Dylid eu hannog i feddwl drwy unrhyw anghenion ychwanegol a allai godi, yn ddelfrydol ymhell cyn y cam adeiladu. Ystyried sut y byddwch yn defnyddio eich ased? Pa alwadau y byddwch yn eu rhoi arno a sut y bydd hyn yn effeithio ar ei hirhoedledd? Dylai BIM helpu cwsmeriaid i ddelweddu'r ased newydd a helpu gyda'r broses hon.

Pan fydd angen gwneud newidiadau yn ystod y gwaith, dylai'r cwsmer ganiatáu amser ar gyfer rheoli'r gwaith dylunio, adeiladu a gwastraff yn drylwyr. Dylai'r cwsmer gynnal deialog barhaus ag ymgynghorwyr dylunio a chontractwyr rhag ofn bod angen gwneud newidiadau.

.10.2 Argymhellion i Ddylunwyr

Mae BIM yn cynnig opsiwn hyfyw ar gyfer dileu gwastraff dylunio. Bydd defnyddio mwy ar BIM yn golygu gwneud penderfyniadau dylunio'n gynt gan wneud y broses yn fwy rhagweithiol nag adweithiol. Bydd gallu delweddu mewnbwn pob crefftwr yn hawdd, drwy uwch-realiti, yn golygu gallu adnabod unrhyw gamgymeriadau neu wrthdaro'n hawdd. Mae gweithio'n effeithiol gyda BIM yn sicrhau llif cyson o wybodaeth gan annog cyd-ddealltwriaeth a pherthynas weithio dda.

Ystyried rheoli asedau. Sut y bwriedir defnyddio'r ased a sut y bydd y defnydd yn newid dros amser? Er enghraifft, bydd gwahanol arddangosion yn cael eu hongian yn yr oriel ar wahanol waliau mewn gwahanol ffyrdd dros oes yr oriel. Bydd dylunio ar gyfer addasiadau'n ymestyn defnyddioldeb yr ased ac yn hwyhau ei oes.

10.3 Argymhellion i Gontractwyr

Mae sefydlu'r compownd gwastraff yn rhan bwysig o'r strategaeth rheoli gwastraff a dylai fod yn un o brif bryderon pencampwr gwastraff y safle wrth gynllunio gwaith ar y safle. Dylai fod yn flaenoriaeth bod gan gontractwyr aelod tîm ar y safle sy'n cymryd meddiant o reoli gwastraff.

Dylai compowndiau gwastraff gynnwys sgipiau gwahanu gwastraff o'r diwrnod cyntaf ar y safle a dylid egluro eu pwrpas i bawb. Yn ddelfrydol ni ddylid defnyddio sgip gwastraff cymysg ond, lle bo'i hangen, dylid ei lleoli mor bell â phosib o waith y safle er mwyn cymell gweithwyr i beidio ei defnyddio.

Dylid canolbwyntio ar sicrhau'r ymrwymiadau cytundebol gan nodi y dylid cadw at holl gamau'r hierarchaeth wastraff cyn gwaredu gwastraff i'w dirlenwi. Bydd hyn yn lleihau effaith bosib penderfyniadau'r isgontractwyr ar dargedau ailgylchu, ailddefnyddio ac adfer fel arall y prosiect. Dylid canolbwyntio ar, a thrafod gwastraff ym mhob un o wahanol gamau'r prosiect, gyda phawb ar y safle'n cyfrannu at hyn.

Roedd y deunyddiau pecynnu gwastraff yn sylweddol ar y prosiect hwn. Gall cyflenwyr chwarae rôl allweddol drwy becynnu llai cyn belled ag y bo'r contractwyr yn

cyfathrebu problemau gyda'i waredu i'w cyflenwyr. Yn aml iawn gellir trefnu cynllun derbyn pecynnu'n ôl gyda gweithgynhyrchwyr neu gyflenwyr ond mae angen rhagweld a chynllunio hyn fel bo'r cytundeb yn ei le cyn i'r gwastraff ddod yn broblem.

Bydd Bil yr Amgylchedd (Cymru) yn gwahardd gwaredu gwastraff pren, papur, cardbord, gwydr, plastig, metel a gwastraff bwyd drwy losgi neu dirlenwi. Bydd angen i gontractwyr ystyried sut i ddelio â'r gwastraff hwn oherwydd mae'n debyg y bydd y gost o'i waredu'n cynyddu i dalu am ymchwil i opsiynau gwaredu eraill. Atal yw'r ateb mwyaf cost-effeithiol ac mae arferion gorau'n allweddol i hyn.

11 Cyfeiriadau

1. **Llywodraeth Cymru**. Tuag at Ddyfodol Diwastraff: Strategaeth Wastraff Drosfwaol ar gyfer Cymru. Caerdydd: Hawlfraint y Goron 2010.

2. **Syr John Egan – Y Gweithlu Adeiladu**. Rethinking Construction. Llundain: Hawlfraint y Goron 1998.

3. **John Weaver (Contractors)**. Cwmni. John Weaver (Contractors). [Ar-lein] John Weaver (Contractors), 2015. [Ffynhonnell:] http://www.johnweaver.co.uk/company.html.

4. **Cymru Hanesyddol**. [Ar-lein] Gorffennaf 01, 2014. [Ffynhonnell: Medi 13, 2016.] http://historicwales.gov.uk/.

5. **Cyngor Dinas a Sir Abertawe**. Ailddatblygu Oriel Gelf Glynn Vivian. Cyngor Dinas a Sir Abertawe - Hamdden. [Ar-lein] Awst 31, 2016. [Ffynhonnell: Awst 31, 2016.] http://www.swansea.gov.uk/article/7180/Glynn-Vivian-redevelopment.

6. **Wales Online**. Business: Business News. Wales Online. [Ar-lein] Wales Online, Mehefin 25, 2013. [Ffynhonnell: Awst 31, 2016.] http://www.walesonline.co.uk/business/business-news/55-jobs-lost-construction-business-4709043.

7. **ARUP**. Reducing waste; BIM buried services case study. 2015.