A Community Approach to Tidal Power in Cornwall and South Devon

Written by: Sophie Stevens

Supervisor: Dr Helen Smith

Hand in date: 08/05/12

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Acknowledgements

I would like to acknowledge the following persons who have made the completion of this report possible:

My project supervisor Helen Smith, for her approachable manor and vital support throughout the project, the hardworking volunteers from Wadebridge Renewable Energy Network; Stephen Frankel, Jerry Clark and David Atfield who so kindly agreed to meet me and openly provide information about the WREN project.

Abstract

This report explores the potential for tidal energy exploitation and starts to examine the possibilities for a community involvement approach at a series of areas around Cornwall and South Devon.

Tidal technology devices are investigated, with a brief consideration of the current guidelines on implementation. Some insight is given into the developmental stage of tidal technology, with some of the recent technology developments.

The concept of community energy projects is explored in some detail, available financial models for community ownership are summarised and an overview is given of current notable projects working to implement tidal energy projects for community benefit.

By looking briefly at the potential tidal resource in Cornwall and South Devon it is indicated that Padstow on the River Camel is a good site, resource-wise, for the implementation of a tidal range based device, whereas the Tamar Estuary near Devonport Dockyard is shown to have comparatively the best tidal stream resource within the selected locations for study.

Finally a case study is presented on Wadebridge Renewable Energy Network (WREN); a social enterprise set up and run by the community to reduce energy consumption and implement renewable energy technologies; their initial ideas for a community tidal project are presented.

Methodology

Information contained within this document was gathered from a variety of different sources. During the initial research stage internet search engines were used to gain information about current community tidal projects as well as information about tidal devices.

Correspondence with the WREN project was made initially with Professor Stephen Frankel via email. Further information on the project was gained through organising a meeting with Stephen Frankel, Jerry Clark and David Atfield (see Appendix 1). The WREN business plan was also consulted heavily for the WREN case study.

All data for the resource assessment was gained through the utilisation of the Admirality software TotalTide™ to which the university has a paid membership. The software is produced by the UK Hydrographic Office (UKHO) to predict tidal height and tidal stream figures.

1. Introduction

There are many instances of community owned energy schemes throughout the UK. The community energy movement adopted wind power for initial project development due to it being a proven, commercial technology. Baywind Energy Cooperative became the first community to own wind turbines in 1996. The Co-operatives UK report (Willis, 2012) found that since that time the number of communities either already producing renewable energy or in the planning stages of an energy co-operative has risen to a total of 43. These include a mixture of wind, solar and hydro technologies. Following the developments of the community movement could we see tidal power as a viable option for community ownership in the near future?

Eventually, the benefits of community owned projects can theoretically be transferred to all renewable energy technologies, maximising the economic and social benefits so that they directly benefit those living alongside them. Many of the locations in which renewables are best suited tend to be around relatively remote communities often where previous thriving economies are in decline. This is definitely true for a lot of Cornish towns and villages whose economies have been struggling since the decline of Cornish mining. Is there potential for the area to benefit from a small scale community tidal project and how might such a project be structured?

2. Context

2.1. Government Targets

With finite energy resources in decline and the increasing concern for climate change, it has been widely recognised that there is a necessity to increase the deployment of renewable energy technologies. The UK government has responded by introducing specific targets to cut emissions and increase the amount of renewable energy generated.

The Climate Change Act 2008 introduced a legally binding target of a 34% cut in emissions by 2020 leading to an 80% cut by 2050 (DECC, 2008). Additionally the European Commission introduced the Renewables Directive (2009/28/EC) which binds the government to meet the target of 15% of the country's energy consumption to be met by renewables by 2020. These both make up a seemingly ambitious energy plan which will need huge input by all levels of society if it is to be met.

In order to meet the targets it will be necessary to explore all possible options for renewable energy and where necessary develop those technologies that are in the earlier development stages, enabling them, ultimately, to reach their full potential.

2.2. Tidal Power Potential in Cornwall

Energy from wave and tidal power has the potential to generate up to 27GW in the UK alone by 2050 (DECC, 2012a). Cornwall has over 300 miles of Atlantic coastline providing an extensive potential resource for the installation of tidal energy devices. Not only that but the area also has to offer a particularly prosperous marine engineering sector and a supply chain of companies experienced in offshore construction mostly stemming from the docks at Falmouth. Local expertise also includes valuable skills such as geotechnical investigation, diving, marine drilling and pipeline installation and socketing (Invest in Cornwall, 2012). There are also a variety of companies offering services such as environmental consultancy, project management and operations and maintenance which can be utilised to ensure the smooth execution and long term management of potential marine energy projects. This combination makes for an exceptional mix in the region of tidal deployment well worth exploiting.

At the current development stage of the technology is there a device and a location that would be a feasible option?

3. Literature Review of Existing Standards

3.1. Tidal

Being a relatively new industry, there are currently no published standards specifically applicable to conducting tidal energy projects. The marine renewable energy sector has seen numerous pre-commercial devices being deployed worldwide but there has not yet been a move towards a dominant technology (Ingrad et al., 2011). With so many new devices being proposed, it is difficult to accurately compare them and move the developments forward to the commercial stages. This is partly due to a lack of common standards, of which there have been none officially published, however there have been several contributions to the formulation of protocols and guidelines.

In 2005 The Electric Power Research Institute (2005) published a technical update to their Renewable Energy Technical Assessment Guide containing example tidal projects and methods for predicting details such as data management and energy production. In 2006 The Department of Trade and Industry (2006) published a preliminary protocol for the performance testing of full scale tidal current energy devices. The document was produced to set out requirements of common procedure specifically for the participants of the Marine Renewable Deployment Fund (MRDF). In

2007, Annex II of the IEA (2007) report makes proposals for recommended practices for the testing and evaluating of ocean energy converters at the testing phase of development. In 2011 a European Commission funded project EquiMar (Ingrad et al., 2011) published detailed protocols on the process of carrying out a tidal project, from resource assessment right through to guidance on multi-megawatt arrays and project assessment. EMEC (2012) has also been working on a variety of guidelines funded by the Scottish government.

The continued development of standards will involve careful reassessment in line with current developments and will depend heavily on the emergence of leading technologies.

3.2. Community renewables

Similarly for community renewables there have been a number of published guidelines by a variety of different bodies. The majority of these are based around wind power, for example the Sharenergy report (Halle, 2011). There are other guides, such as one produced by a collaboration of Co-operatives UK and The Co-operative (Willis, 2012) which presents details of how to run a successful energy co-operative and is more applicable to a variety of technologies (namely solar PV and hydropower). Also a community energy toolkit published by Community Energy Scotland (n.d.) has been produced to help community groups to develop renewable energy projects. There is also) Transition Towns, set up in 2004, which is one of a number of action groups aiming to provide a network to inspire, encourage, support and train communities to create initiatives that reduce CO_2 emissions (Transition Network, 2011).

4. Tidal Energy

4.1. Tidal Range Devices

Tidal range is the head different difference between low tide and high tide. Tidal range devices make use of this head difference to produce electricity. This is done traditionally by allowing water to flow across a boundary freely in one direction and then holding it back as the tide ebbs. When the height difference across the boundary is highest, the water is released and runs through a hydroelectric turbine to produce energy (DECC, 2010a).

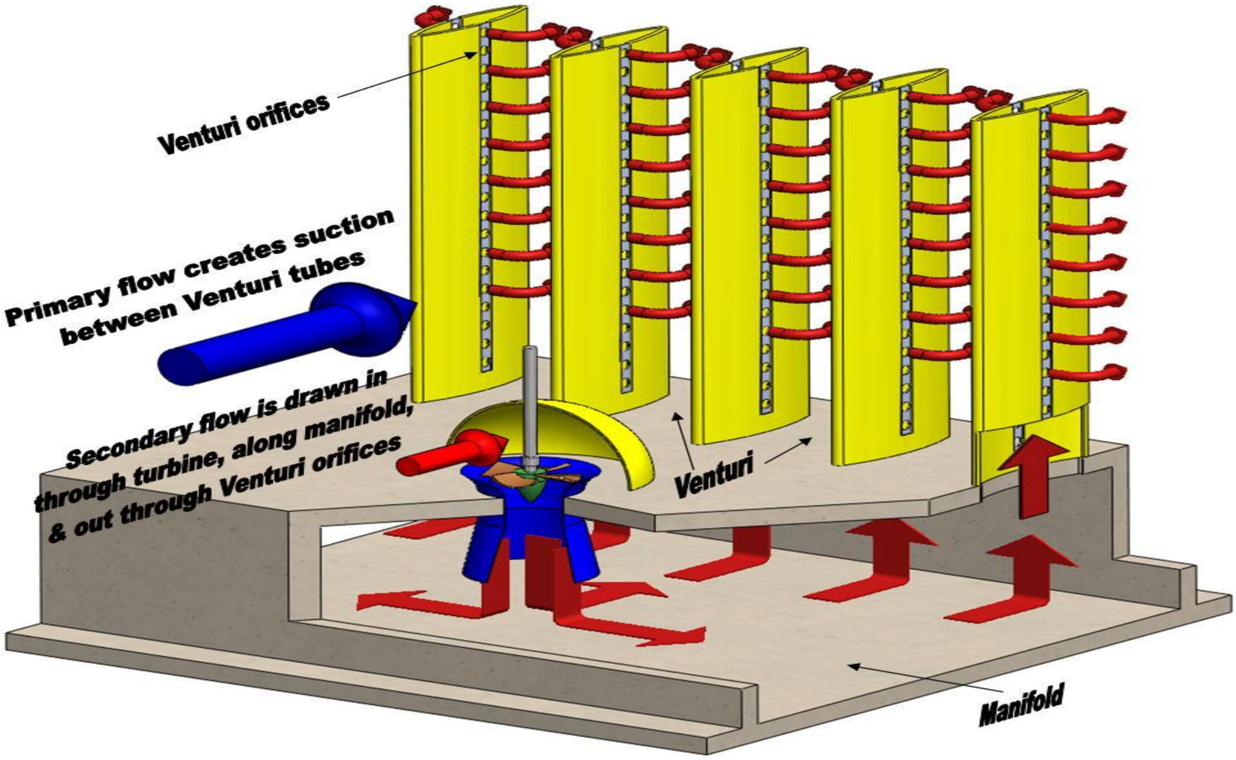
There are two main types of tidal range device; barrages and lagoons. Barrages involve building a wall spanning an entire estuary, effectively creating a dam, but can cause issues with physical impacts such as sediment transportation/build up.

There are also a number of proposals for pioneering devices in the early stages of development such as those included in the Severn Embryonic Technologies Scheme (SETS), which potentially inflict fewer impacts on the environment.

4.1.1. Spectral Marine Energy Converter (SMEC)

SMEC is being developed by company VerdErg, the system uses venture principle to concentrate the energy of a large flow of water with a low head into a smaller flow of water with a high head i.e. accelerating a jet of water. This jet can then be used to drive a turbine.

Figure 1 - Basic Principles of the SMEC



Source: (VerdErg, n.d. (a))

SMEC is fully porous, having minimal effect on the natural flow of the stream of water which brings less environmental impacts to the surrounding area (VerdErg, n.d.(b)).

4.1.2. Tidal Bar

The Tidal Bar was proposed by Roll-Royce/Atkins specifically to operate with very low heads of water. The design incorporates an axial flow, rotating turbine concept, for use within a tidal barrage type structure, considerably lighter than a conventional barrage structure; built out of less concrete and so theoretically cheaper (DECC, 2010a).

4.2. Tidal Stream Devices

Tidal stream devices harness the kinetic energy contained within tidal currents via the process of hydrokinetic energy conversion. This type of energy converter is constructed without altering the natural pathway of the water stream (Khan, M. J. et al, 2009). This often results in less of an environmental impact than if utilising a tidal barrage type of device. Many devices utilise similar technology to wind turbines, with either a horizontal or vertical axis turbine rotating due to the tidal stream currents passing over them, but there are also other more unique designs.

The majority of tidal energy devices fall into the following main categories (EMEC, 2007):

1. Horizontal Axis Turbine
2. Cross Axis Turbine
3. Oscillating Hydrofoil

For a hydrokinetic converter, the level of power output is directly related to the flow velocity (Khan, M. J. et al, 2009).

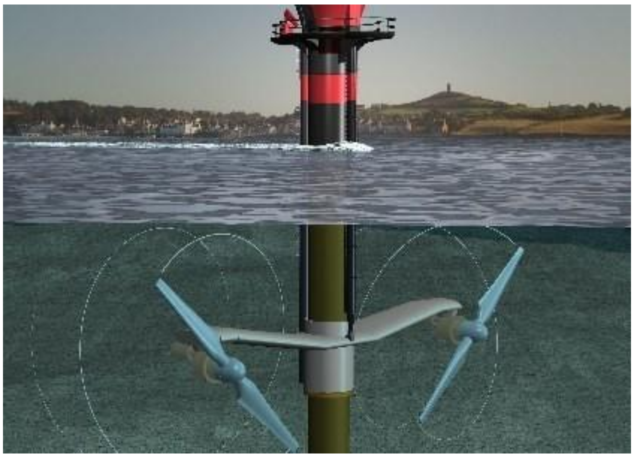
4.2.1. Horizontal Axis Turbine

This type of device is very similar to a conventional wind turbine and is the most advanced device technology (GRE, 2012). A turbine, placed in a tidal current, with a rotational axis parallel to the incoming water stream will rotate and drive a generator. The turbine can be mounted on a fixed tower or on a tethered floating structure (if for some reason fixed towers prove too expensive or problematic).

The most successful device of this type is the SeaGen Device developed by Marine Current Technologies who, in 2008, installed a 1.2MW device in Strangford Narrows, Northern Ireland. This was the first commercial scale tidal turbine (MCT, 2012).

The Seagen device consists of two horizontal axis turbines mounted on a cross bar extending out on either side of a single fixed tower (see Figure 2). Seagen's exclusive features include having blades that will pitch 180° allowing it to produce electricity both in the ebb and flow tides and being able to lift its blades fully out of the water for maintenance.

Figure 2 – Seagen Device



Source: (SWN, 2012).

4.2.2. Vertical Axis Turbine

As the name suggests, with this type of device, the rotational axis of the blades will stand vertical, pointing up towards the surface of the water.

One company developing the concept of a vertical axis turbine is FreeFlow 69, based in Fowey, Cornwall. The design is said to be either mountable on the seabed or suspended on pontoons. The device is also designed to work on both the flood and ebb tides. An advantage of the design includes having the gearbox and generator above water level, making maintenance much' easier and is thought to reduce corrosion. A reduced-scale prototype of the turbine, named Osprey, has been tested with promising results.

4.2.3. Oscillating hydrofoil

Oscillation of hydrofoils can be exploited by using the vertical 'pumping' action to operate hydraulic cylinders; pressurising fluids which are then in turn used to drive a generator.

4.2.4. Evopod

There are all kinds of other designs being developed, each with their own advantageous features. Oceanflow Energy Limited is developing Evopod; a floating semi-submerged turbine support platform that offers easy access for maintenance and a more straightforward installation process. Matthew Parsons of Oceanflow Development clarified the device is rated at 37kW and has a cut-in speed of 0.7m/s.

It is expected that hydrokinetic energy conversion will see similar bulk energy production in tidal power plants as those found on land as wind farms. Khan, M. J. et al. (2009) predict that tidal power plants will face similar network integration issues (to those encountered by wind farms) except the resource is more predictable than wind so there will be less resource predictability issues.

4.3. Tidal Energy – What Support is there?

The government recognises that tidal energy is an emerging technology and has implemented some financial incentives to try and move the technology forward, helping to secure jobs and investment in the marine energy industry.

4.3.1. Renewables Obligation Certificates (ROCs)

The Renewables Obligation came into effect in England, Scotland and Wales in 2002 and works by placing an obligation on energy suppliers to source a certain percentage of their energy from renewable sources. The issuing of ROCs to energy generating companies hold a certain value (depending on the market) and can be sold to suppliers who require them to meet their obligation.

Different renewable technologies are set at different banding levels. The current level for tidal power is set at 2 ROCs per MWh (currently 3 ROCs in Scotland). The government announced plans in October 2011 to boost support for wave and tidal projects by increasing the ROCs awarded to 5 ROCs per MWh in the whole of the UK (including Scotland). If these changes are brought forward, they are proposed to take effect in 2013. On reflection the decision not to implement changes until 2013 may incur a slight lull in development so that registered projects will be able to claim the full 5 ROCs.

4.3.2. Marine Renewable Deployment Fund (MRDF)

Of the £50million MRDF budget, £42million was earmarked in 2004 for wave and tidal stream energy demonstration, to provide capital grants and revenue support to early stage commercial generation technologies that have completed their research and development phase. However, the strict requirements for the MRDF prevented companies from qualifying and the money was only allocated until March 2011 (DECC, 2012b) and DECC announced that no funding has been allocated for future years.

5. Community Energy

It is widely accepted that the term ‘community’ can refer to two different meanings – communities of ‘locality’ and communities of ‘interest’ (Bolinger, 2001). A community of locality is a group of people inhabiting a specific geographical area whereas a community of interest is a group sharing a specific interest. Community energy groups are most often comprised of the former; a group of people residing in a particular area who have decided to form a collective in order to raise equity, in the form of shares, to be able to pay for the means to be able to generate their own electricity. The project can either be owned outright or it may be supplemented by a bank loan.

Research undertaken by Walker and Devine-Wright (2007) into the understanding of “community” renewables showed a wide range of interpretations. Some explanations involved organisations established perhaps with charitable status but without commercial interests, some had physical implications i.e. involving public buildings and others focussed on the involvement of local people either financially or in the development of the project.

5.1. Models for community ownership

The variety of community projects set up over the past 10 years have utilised an assortment of organisational structures and ownership models (Walker, et al., 2010). Community projects may have differing levels of community ownership. A project may be owned outright by a community group or it may be co-owned with a commercial company or other body for example community ownership of one turbine in a larger wind farm (Walker, 2008).

The legal form selected by an organisation will define its engagement with stakeholders, whether it can achieve charitable status and whether it can raise capital through share issues (Thorlby, 2011).

5.1.1. Cooperative

Cooperatives operate in a similar way to a standard limited company except for the fact that voting rights are allocated equally amongst shareholders, regardless of the number of shares held (Energy4All, 2007). This method of approach is opposed to the ‘one vote per share’ method implemented by most limited companies, in addition to the fact that some shares may hold additional or restricted voting rights. People either from the geographical community or through a shared interest in the project are able to buy shares and become members of the cooperative. With investment through share ownership – the ‘community’ is limited to those who are able and willing to invest. Some cooperatives get around this by having the buy-in amount very low so as not to exclude those with less money.

5.1.2. Community Interest Company (CIC)

A Community Interest Company (CIC) is fundamentally an amalgam of a charity and a limited company. A CIC is established in order to trade for the good of the community rather than for private profit motives. The Community Interest Company Regulations 2005 set out the specific requirements for the operation of CIC’s. All applications for CIC status are passed by the CIC regulator who must be satisfied that the company has met the necessary requirements.

There are two main components to the CIC structure:

The ‘asset lock’ – All profits must be permanently retained within the company and used exclusively for community benefit or transferred to another organisation which has an asset lock (e.g. a charity or another CIC).

A ‘Community Interest Statement’ - must be submitted with the application to register, which must verify that the company will serve the community. It must describe the activities intended by the company and must be signed by the company directors.

Each year the company must submit a statement detailing its activities and the community benefit gained.

Other common legal structures are summarised in Table 1.

Table 1 - Structures Available in the UK for Community Organisations and social Enterprises

Legal structure	Key features of ownership and governance	Charitable status possible?	Inclusion of 'asset lock'	Powers to issue shares or bonds?
Company Limited by Guarantee	Common and flexible legal structure, similar to a normal private company, used by many not-for-profit organisations. Members cannot own shares, but are guarantors, providing a nominal guarantee (often £1), providing limited liability. Regulated by Companies House.	Yes, (provided profits not distributed to members)	Yes, but not permanent. Could be written into company articles, but could also be amended by shareholders	No – shares Yes – bonds
Community Interest Company (CIC)	A relatively new form of private company best suited to social enterprises providing a community benefit and which provides an alternative to charitable status. CICs can take any form of private company (limited by guarantee, limited by private shares, or a public limited company), but also have additional features. They must pass a community interest test and are protected by an 'asset lock' on all assets, including a cap on any dividend payments. The CIC model allows a broad range of purposes and provides limited liability and allows directors to be salaried. Regulated by Companies House and the CIC Regulator	No	Yes	Yes – shares Yes – bonds Dividends can be paid if limited by shares, but are capped at 20 per cent or 35 per cent of gross profits, whichever is lower.
Trust	Trustees own and manage assets for the benefit of others, according to the agreed aims of the Trust – but are personally liable as Trusts are unincorporated organisations. Often used where there is a fund of money to be given away. Regulated by the Charities Commission.	Yes	Yes, if written in to Trust's deed	No – shares Yes – bonds

Co-operative Society (IPS*)	Trading organisations run for the mutual benefit of their members, with profits mainly reinvested in the business. Profit sharing amongst members is possible, but limited and must be equitable. There is a maximum investment in shares per person of £20k, all withdrawable. One member, one vote, regardless of size of shareholding. Limited liability. Registered by the Financial Services Authority.	Unlikely	Yes, but not permanent. Could be written into articles, but could also be amended by members	Yes – shares Yes – bonds Shares and bonds can be offered to the public and are withdrawable. Limited dividends and interest can be paid.
Benefit of the Community Society 'Ben Com' (IPS)	Trading organisations run for the benefit of non-members, with no profit distribution allowed. There is a maximum investment in shares per person of £20k, all withdraw able. One member, one vote, regardless of size of shareholding. Limited liability. Registered by the Financial Services Authority. Limits the personal liability of board members.	Yes	Yes	Yes – shares Yes – bonds Shares and bonds can be offered to the general public. Shares can also be withdrawn by members. Interest can be paid on shares, but not dividends.

Source: (Thorlby, 2011, p18.)

* IPS = Industrial and Provident Society. According to the FSA (n.d.) an IPS is "an organisation conducting an industry, business or trade, either as a cooperative or for the benefit of the community, and is registered under the Industrial and Provident Societies Act 1965."

5.2. The Benefits of Community Owned Renewable Energy:

Community ownership offers themes of self-sufficiency, local determination, engagement and empowerment (Walker, 2008). Specifically, community owned renewables present a plethora of advantages, over institutional or private sector ownership, some of which are discussed below:

5.2.1. Local income and regeneration

Owning assets will bring many benefits to a community organisation, providing a foundation from which to generate a self-supporting income stream. Income can be generated through various avenues:

- Initial creation of local ethical investment opportunity
- Return on investment
- Sale of electricity/heat

- Creation of employment

This income can be used to raise money for local services/facilities required or awarded to local groups providing social, environmental or cultural benefit within the community. Such groups may include youth groups, schools, charities, sports clubs, art groups and many more. In the long term this will reduce the need for public sector investment in such assets (Thorlby, 2011).

5.2.2. Enhance Local Energy Security

The generation of community owned renewables can either be exported straight to the grid or alternatively it can be used locally first; only exporting when there is no local demand. This offsets the energy that would have been drawn from the grid and provides energy security advantages to the community.

5.2.3. Local Approval

There is evidence to suggest that community ownership (by part or outright) of a particular technology results in greater local acceptance of that project. A study undertaken by Warren and McFadyen (2010) comparing public attitude towards various wind farms; one community owned and several owned by developers and it was found that local attitudes could become more positive if future wind farms were owned by local communities.

5.2.4. Planning Permission

Despite the fact that community benefits are not commonly considered legitimate material considerations within the planning decision making procedure (CSE et al., 2009), fewer problems may be faced, generally, when obtaining planning permission (Walker, 2008).

5.2.5. Local Control

Projects managed and controlled by the local community means local input and consideration of the issues raised by the community as a collective as well as giving empowerment to the local people. Deciding factors such as the scale of development, siting and orientation as well as securing sites that might otherwise be exploited by the private sector will be motivational for setting up a community initiative that is specific to local needs.

5.2.6. Education

Community owned renewable projects get everyone involved – schools, church groups, local councils and members of the public (Frankel, 2012). This is a great opportunity for people to learn about alternative energy and all aspects of setting up a community enterprise. Community groups involve individuals coming together from a wide range of backgrounds, experiences and abilities which is a great opportunity for the sharing and transfer of skills.

5.3. Community Energy – What Support is there?

5.3.1. Government Initiatives

A community can be motivated to begin a community project for a variety of reasons but one of the main drivers is having adequate policy in place which will make a project generate an income. There have been various initiatives set up in order to aid the development of community owned renewables but there is always an overabundance of applications for such projects indicating that there could be more legitimate support in place.

5.3.1.i. Present

The European Commission is currently accepting applications for funding through a programme entitled Life+ which is offering up to 50% funding. In March 2012, the Scottish government announced plans to introduce a new £103million investment fun called REIF (Renewable Energy investment Fund) which will focus on supporting communities and rural businesses to develop renewable projects, focussing wave and tidal developers as well as district heating projects (Scottish Government, 2012).

5.3.1.ii. Past

There have been a number of other initiatives, all of which are now closed. These include The Community Renewables Initiative (CRI); a grant scheme that closed in April 2007 after a 5 year pilot programme but was successful in delivering over 150 exemplar community projects in the UK (EC, 2012). The Big Green Challenge which was originally set up by the charity NESTA, in 2008, designed to stimulate and support community-led responses to climate change through offering prize money to 4 winning projects (NESTA, 2010). DECC then agreed to provide grant funding to support a further 17 of the applicants. A total of 355 groups came forward in the initial stages demonstrating an impressive level of enthusiasm and motivation by such community groups. The Low Carbon Communities Challenge (LCCC) was launched by DECC in September 2009 and looked to offer financial and advisory support to 22 'test' communities to help them reduce home energy consumption and cut their carbon emissions. Over 300 communities expressed their interest in the LCCC (DECC, 2010b).

5.3.2. Other Support

There are a number of non-governmental support schemes such as the Energy Share match fund (supported by British Gas) as well as a number of organisations interested in promoting and supporting community ownership such as Communities for Renewables CIC which is being launched by Regen SW and the Green Trust. Other organisations such as Cooperatives UK, the Development Trust and Community Shares (Hoggett, 2010) are working towards similar achievements. One organisation, Energy4All, was born out of the Baywind project and was established to help other communities achieve similar outcomes to Baywind. Now owned by a total of 7 separate cooperatives, predominantly wind orientated, it is now looking to extend its repertoire to hydro and anaerobic digestion projects.

Having looked into the mechanics of community involvement in some detail; particularly with reference to community owned energy schemes, along with a brief overview of the both the support available for tidal energy projects and community renewables; existing projects combining the two elements will now be investigated.

6. An Overview of Community Tidal Projects in Negotiation

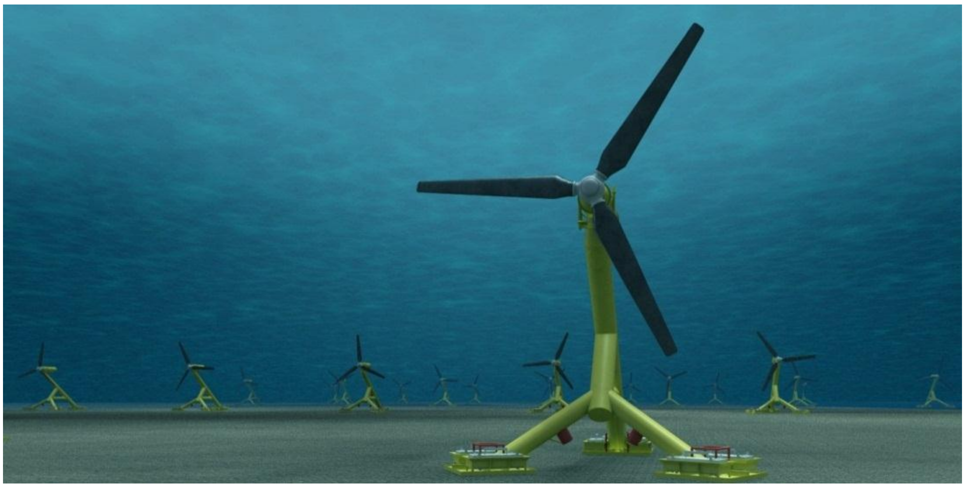
There are three notable community tidal projects in negotiations, all of which are located within Scotland, briefly discussed in the following section of the report.

6.1. Isle of Islay

A community-owned charity called The Islay Energy Trust (IET) was established in order to distribute funds generated by renewable energy projects to the community of Islay. The trust aims to exploit the marine energy resources in The Sound of Islay in order to maximise the economic profit as well as create jobs and a means for investment within the community.

IET has signed a 'Memorandum of Understanding' with Scottish Power Renewables (SPR) to develop a project aiming to demonstrate commercial viability of developing a tidal array. The £10-15 million project was initially thought to consist of 2 small arrays each containing around 5 devices to give each array a capacity of 2-4MW but it has recently been announced that the plan is to install ten 1MW Hammerfest Strom (HS1000) fully submerged tidal turbines (see Figure 3) near Port Askaig.

Figure 3 - Hammerfest Strom HS1000 Tidal Turbines



Source: (Hammerfest Strom, 2011).

A prototype of the device has been tested in Norway for a period of 5 years. Deployment is expected in 2013 and the projected output is 30Gwh per year.

Maxwell, et al. (2008) found in their business case analysis that a commercial rate of return is achievable under the Scottish Governments proposed levels of revenue and support.

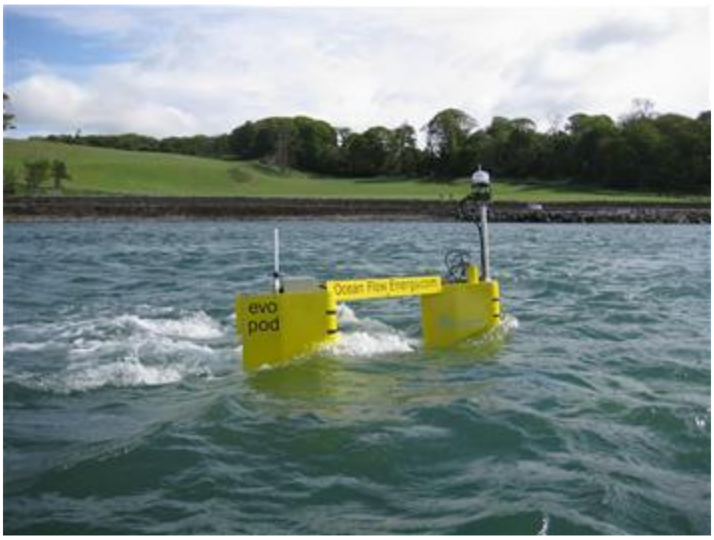
6.2. South Kintyre

The South Kintyre Development Trust (SKDT) is a not for profit organisation set up as a company limited by guarantee. The organisation is a registered a charity and is a member of the Community Powerdown Consortium; designed to empower remote and rural communities and enable them to reduce their carbon footprint (SKDT, n.d.). The project is funded by the Climate Challenge Fund introduced by the government in Scotland. SKDT recently paired up with Oceanflow Development (a Scottish based subsidiary of Oceanflow Energy Ltd) currently developing a tidal stream device named Evopod.

Having already deployed a 1kW, 1/10th scale version of the Evopod design in Strangford narrows (see Figure 4) and successfully exporting power from the device in 2008/9, Oceanflow Energy is currently developing a 1/4th scale unit, rated at 37kW. The plan is to deploy the device in South Kintyre connecting to the 11kV grid in the spring/summer of 2012.

The collaboration between SKDT and OceanFlow Development aims to establish a tidal farm that will generate profit maximising benefit to the community (Aquamarine Power Ltd, 2010). The partnership will also help to develop a proven device that will be suitable for deployment throughout the world whilst giving credit to the tidal industry for Scotland and the UK.s

Figure 4 - Evopod 1/10th Scale Demonstrator at Strangford Narrows



Source: (Oceanflow Energy, n.d.)

The project is an exciting development for the tidal industry but it is evident that it is heavily reliant on funding from the Scottish government as well as the subsidies awarded through the Renewables Obligation.

6.3. North Yell, Shetland

Nova Innovation is a Scottish company currently developing a horizontal axis, 3 bladed fully yawing, gravity device for the Bluemull Sound in Shetland. They have secured a Crown Estate lease for the 30kW device which will be grid connected as well as powering a local ice plant for supply to local fishing boats. It is expected that the generated power will help to regenerate the fragile and remote economy of North Yell (Nova Innovation, 2011a). Community Energy Scotland is guiding the project which is expected to be deployed in 2012.

The company is focussed around using tidal technologies to help regenerate remote Scottish communities with intentions in training community members to be able to manage projects themselves. Their philosophy is that of starting out small with economies of scale that the technology can handle before progressing to larger generation capacities at a conserved pace, drawing similarities in development to that of the development of the Danish wind industry (Connor, G., 2011). The aim of this approach is to minimise investment risk and maximise profits.

There has been limited information publicly released about this project which suggests a lot of the details are yet to be established.

7. Available Resource

This section of the report looks to make an initial assessment of the available resource potential for small scale tidal power in estuarine locations within Cornwall and South Devon. A collection of four areas in the region are considered to get an idea of the available potential. The sites chosen depend heavily on the tidal data available from the Total Tide software package and are listed below:

- Wadebridge and Padstow (The River Camel)
- Falmouth (The Carrick Roads and the Helford River)
- Plymouth (The Sound of Plymouth and the Rivers Tamar and Lynher)
- Dartmouth (The River Dart)

The assessment considers both the potential for both tidal range and tidal stream technologies and includes a methodology for further assessment of both categories of available resource.

7.1. Tidal Range

A total of 11 locations are considered for the tidal range data (see Figure 5). The locations are chosen at varying locations within each area in order to give a representation of the local variations in tidal range, for instance as the location moves further inland.

Figure 5 - Areas Selected for Initial Assessment of Available Resource

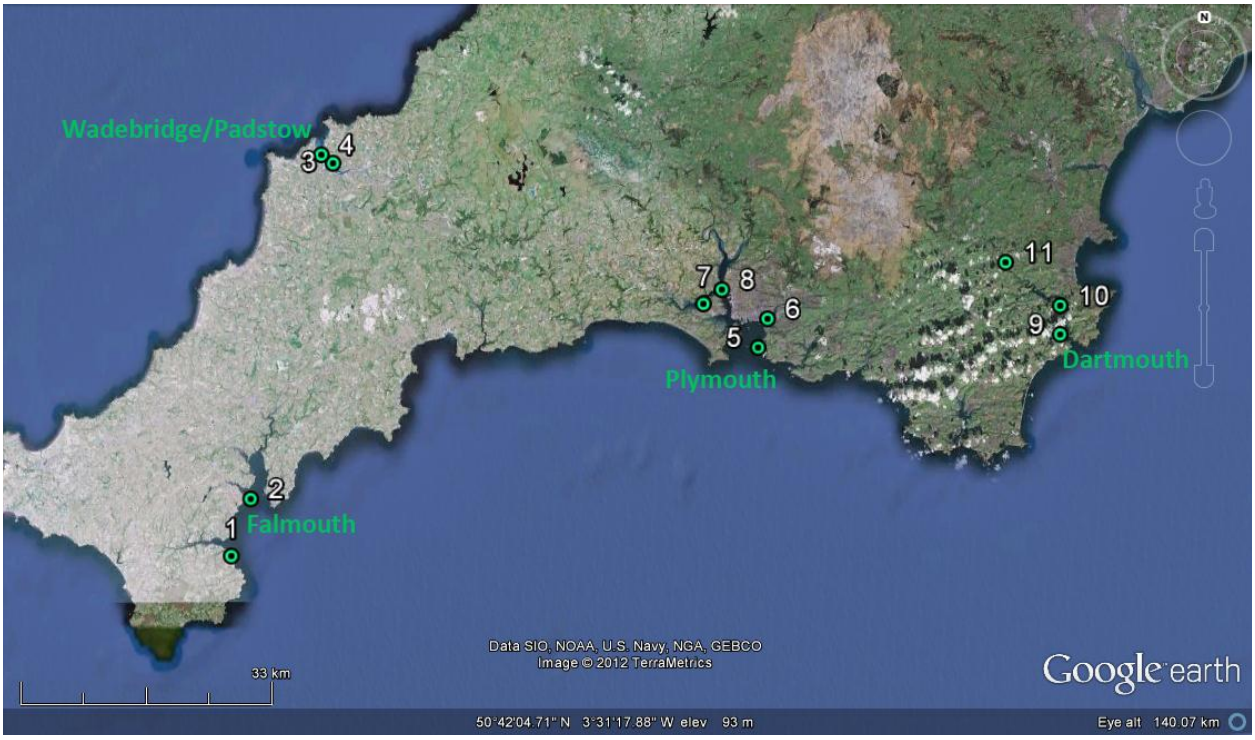


Table 2 shows the allocated numbers for each location, with a brief descrpition.

Table 2 - List of Data Locations and Assigned Numbers

No.	Location	Coordinates
	FALMOUTH	
1	Helford Estuary	50°05'N 5°05'W
2	Falmouth Harbour	50°09'N 5°03'W
	WADEBRIDGE & PADSTOW	
3	Stoptide, Camel Estuary	50°31'N 4°50'W
4	Padstow, Camel Estuary	50°33'N 4°56'W
	PLYMOUTH	
5	Plymouth Sound	50°20'N 4°08'W
6	Plym Estuary	50°22'N 4°07'W
7	Maryfield, River Lynher	50°23'N 4°14'W

8	Saltash, River Tamar	50°24'N 4°12'W
	DARTMOUTH	
9	Dartmouth	50°21'N 3°35'W
10	Dittisham, River Dart	50°23'N 3°35'W
11	Totnes, River Dart	50°26'N 3°41'W

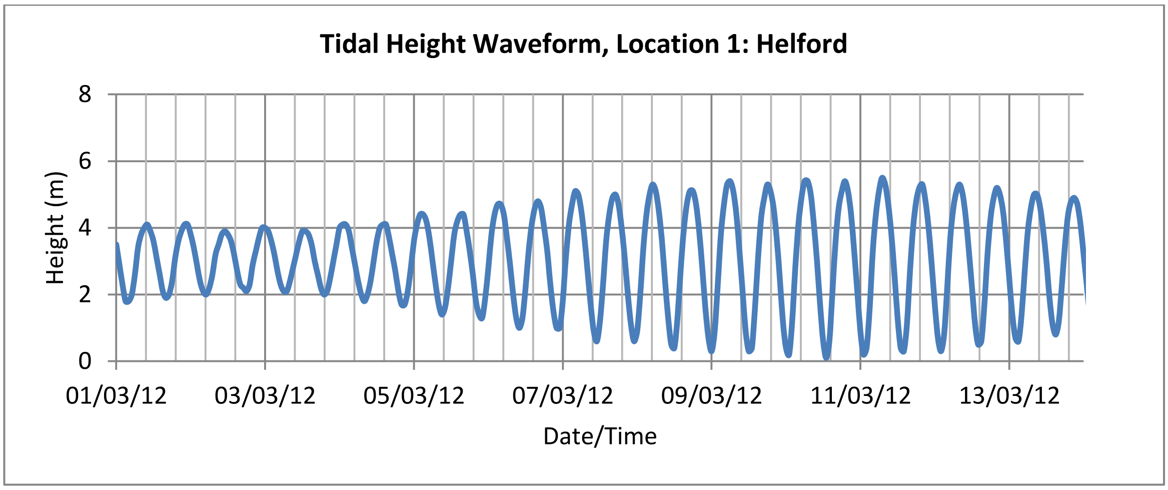
7.1.1. Expectations

It is expected that as the location moves further up a river, the tidal heights encountered will decrease due to the tides having a smaller effect on the flow of the river.

7.1.2. Methodology

Tidal Height data is collected from Total Tide software. A period of 1 month is used, measurements are taken every hour to generate tidal height waveforms (see Appendix 2). From each graph (an example is shown in Figure 6) the maximum tidal range is calculated at spring tide and the minimum at neap tides. These values are used to calculate the average tidal range for each location.

Figure 6 - Tidal Height Waveform



The results are summarised in Table 3.

Table 3 - Tidal Range Summary Table

Location	Spring Range (m)	Neap Range (m)	Average Range (m)
1	5.3	1.5	3.4
2	5.2	1.4	3.3
3	3.3	0.9	2.1
4	7.1	2.1	4.6
5	4.8	1.5	3.2
6	5.3	1.2	3.3
7	5.4	1.1	3.3
8	5.3	1.5	3.4

9	4.8	1.4	3.1
10	4.9	1.5	3.2
11	3.5	0.9	2.2

7.1.3. Resource Interpretation

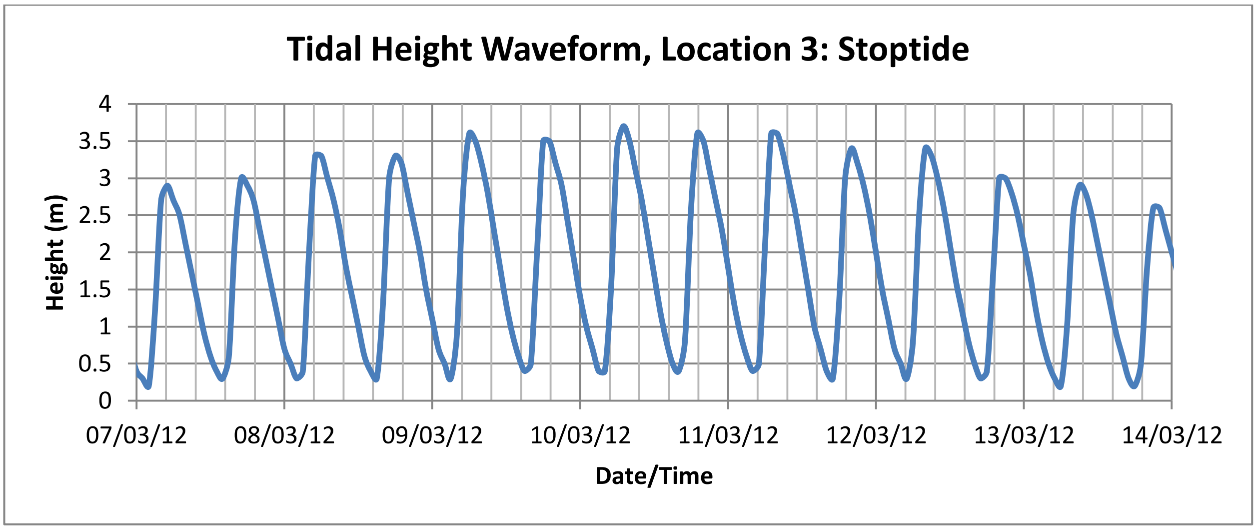
From analysis of the tidal profiles it can be seen that over the study period, of the locations included, 72% see an average range of between 3.1m and 3.4m, with only Padstow exceeding this range whilst the two sites Stoptide and Totnes see smaller values of 2.1m and 2.2, respectively. As expected, these points are relatively much further inland.

By far the greatest average tidal range of 4.6m is found at Padstow (Location 4). As the study location moves further up the river to Stoptide (Location 3) the range is reduced to an average of 2.1m. The distance over which this variation is seen is estimated at 1.75km (using Google Earth) which gives an approximated tidal range depreciation of 1.43mm per metre length.

7.1.4. Observations/Discussion

The tidal profiles show that depending on location, the profiles show varying levels of symmetry. The profile for Stoptide (see Figure 7) is vastly asymmetric, with each flood tide lasting just 3 hours making the ebb tide 9 hours long. This is likely to be caused by the bathymetry of the site and must be considered when selecting a device especially if the device is unidirectional.

Figure 7 - Tidal Waveform at Stoptide



7.1.5. Method for Further Assessment

7.1.5.i. Energy and Power Calculations

In order to calculate the potential energy at a particular site, it is necessary to determine the volume of water expected to pass over the proposed span of river, and therefore it's mass.

Two fundamental parameters are required to carry out this calculation: Tidal range, R and basin surface area, A (Smith, 2010).The mass, m, can then be calculated using:

$$m = \rho A R$$

The maximum potential energy stored (PE) can then be calculated as:

$$PE = mgh = \rho ARgh$$

$$where\ h = height\ of\ centre\ of\ gravity\ of\ the\ mass\ of\ water = \frac{R}{2}$$

Hence;

$$PE = \frac{\rho AR^2 g}{2}$$

In order to calculate the rated power is then necessary to first determine the flow rate, Q, using:

$$Q = \frac{AR}{2t}$$

$$where\ t = time\ periodn\ over\ which\ the\ body\ of\ water\ moves\ (the\ period\ of\ the\ ebb\ or\ flood\ tide)$$

This enables the rated power to be calculated:

$$P = gQh$$

It is then possible to calculate the annual energy output by multiplying by the numbers of operating hours in a year.

7.2. Tidal Stream

A total of 18 locations for assessment of tidal stream resources are considered. These 18 locations are summarised in Table 4, at each location numbers ascend as the location moves up the estuary (see Appendix 3 for specific point maps).

Table 4 - List of Tidal Stream Study Points

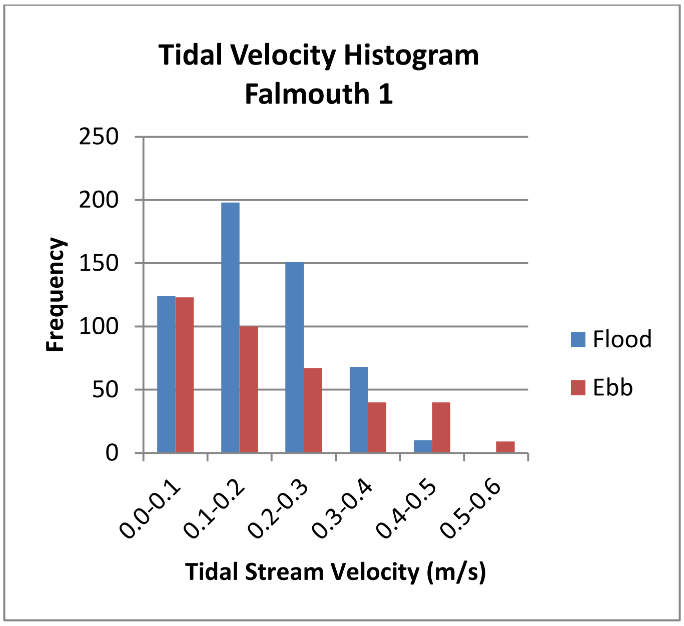
No.	Coordinates	Area
1	50°08.54'N 5°01.56'W	Falmouth: Carrick Roads
2	50°09.44'N 5°02.76'W	
3	50°10.04'N 5°02.36'W	
4	50°10.84'N 5°01.66'W	
5	50°11.44'N 5°02.76'W	
6	50°34.47'N 4°57.73'W	Padstow: River Camel Estuary
8	50°21.63'N 4°07.37'W	Plymouth: River Plym Estuary
9	50°21.83'N 4°07.77'W	
10	50°20.20'N 3°33.49'W	Dartmouth: River Dart Estuary
11	50°20.74'N 3°34.38'W	

12	50°21.64'N 3°34.66'W	
13	50°21.93'N 3°34.87'W	
14	50°22.36'N 4°11.32'W	Plymouth: River Tamar Estuary
15	50°22.92'N 4°11.45'W	
16	50°23.30'N 4°11.77'W	
17	50°23.47'N 4°11.62'W	
18	50°23.80'N 4°12.56'W	
21	50°23.00'N 4°14.70'W	

7.2.1. Methodology

Data is taken at hourly intervals over the period of 1 month in order to include both spring tides and neap tides. Tidal velocities are then separated into spring tides and neap tides, according to their bearing, as well as into velocity bins with increments of 0.1. These bins are then used to generate tidal velocity histograms (see Appendix 4), an example of which is shown in Figure 8.

Figure 8 - Tidal Velocity Histogram for Location 1: Falmouth



Additionally, for each location, a tidal velocity profile is plotted showing the magnitude of the stream velocities, again with the flood and ebb tides separated out (see Appendix 5).

7.2.2. Resource Interpretation

The highest velocities are found at points 14, 15 and 16 along the Hamoaze near Devonport Dockyard, Plymouth, which see highest velocities in the region of 0.7-0.9m/s . It is apparent even at this stage that the implications of this location is likely cause issues with shipping routes which should be carefully considered for any further study. As there is clearly good available resource, it may still be viable to consider a location slightly further up river for example point 18 which still sees a very healthy tidal resource.

There are velocities in the range of 0.6-0.7m/s found at both Dartmouth and Padstow, whereas Falmouth sees slightly slower velocities with the highest being 0.5m/s right out at the entrance to the Carrick Roads.

7.2.3. Observations/Discussion

Interestingly, separating out the flood and ebb tides shows there is a noticeable variation in the velocities of each, some of these being largely different for instance locations 1 and 2 in the Carrick Roads, location 6 in the Camel Estuary and locations 14, 15 and 16 in the Tamar. This has been put down to local bathymetry and proves it is very important to conduct detailed testing of a site when considering tidal devices so that the device can be matched appropriately with the resource.

It is found generally that tidal stream velocities decrease as the geographical location moves up river. However there is one exception at Dartmouth where point 10, the point furthest out to sea seas much lower velocities than points 11 and 12 which are further up the river mouth. This is likely to also be caused by the local bathymetry of the particular site.

7.2.4. Method for Further Assessment

7.2.4.i. Energy and Power Calculations

A ‘conventional’ horizontal axis tidal stream turbine will see power availability, P, of:

$$P = 0.5\rho A v^3$$

$$where\ \rho = seawater\ density, A = swept\ area\ of\ turbine\ and\ v = tidal\ velocity$$

A power coefficient, C_p, can be added to account for losses dues to Betz law and device inefficiencies as follows:

$$P = C_p 0.5\rho A v^3$$

For a hydrokinetic converter, the level of power output is directly related to the flow velocity (Khan, M. J. et al, 2009) so the higher the velocity, the higher the potential energy yield.

7.3. Discussion

Tidal stream data varies much more depending on location/bathymetry than tidal height data. Both types of resource are found primarily to decrease as the location moves further up river. Padstow is highlighted as the best site for tidal range implementation, purely from a resource perspective whereas the Hamoaze area, Plymouth, hosts the greatest tidal stream resources.

7.4. Further Study

7.4.1. Environmental Impacts

This data is only representative of 1 month. Further study would need to incorporate a longer study period to give more accurate and reliable results; preferable the duration of a full year for a more detailed resource assessment.

Further site study must involve the consideration of environmental impacts including physical issues (sedimentary changes and seabed impact), ecological impacts (underwater noise and possible collision effects on wildlife) as well socio-economic issues (navigation issues, employment opportunities and fishing interests).

7.4.2. Technology Selection Considerations

The process of tidal technology selection involves careful consideration of a number of factors, the immediate factors include the range of flow speeds available, water depth, seabed geology and the benthic environment (Maxwell, Owen, Ogilvie, and Scott, 2008).

8. Case Study - Wadebridge Renewable Energy Network: Could this be the way forward in Cornwall?

8.1. Wadebridge

The North Cornwall town of Wadebridge, with a population of around 8,300 inhabitants and 3,750 homes, straddles the River Camel as it makes it journey out into the estuary at Padstow. The electricity consumption for the community of Wadebridge is estimated at 57GWh per annum.

8.1.1. Economy

In terms of employment, a study carried out in 2006 classified Wadebridge as being ‘poorly self-contained’, with roughly half of the residents working in Wadebridge itself, the other half commuting to Padstow. The average yearly adult wage in Cornwall is £21,000, making yearly earned income in Wadebridge around £87m.

8.2. Motivations

If Wadebridge were to continue as usual, the community’s current yearly electricity bill of over £6million could increase to £11million by 2020, potentially increasing the number of homes in fuel poverty. The number of renewable energy technologies installed would be limited only to those able to afford them. Commercial developers may exploit the best renewable energy sites for profit gain and Wadebridge may not see any of these profits. The local renewable industry would not develop as the demand would not be there.

8.3. Formation

In this context a small group of residents came up with the idea for an initiative that would set the ball rolling in order to transform the community of Wadebridge into a ‘community powered town’. Wadebridge Renewable Energy Network was formed as a social enterprise (a cooperative) in 2010. The key initiators of the project are local rare breed livestock raiser, Stephen Frankel, and Jerry Clark, a major contributor to the Green Building Magazine. Stephen Frankel clarifies (see Appendix 6) that the local motivation for the project was to “create local economic resilience, common purpose and enhance the quality of life”.

8.4. The WREN Initiative

WREN set out an ambitious yet commendable list of main objectives:

- Generate 30% of the town’s electricity from renewable sources by 2015.
- Implement energy efficiency measures in order to reduce electricity consumption by at least 5% by 2015.
- Increase resilience against future energy price rises and generate profits of over £200,000 per year for a community fund (owned and managed cooperatively).
- Reduce the cost of energy to the local economy (projected figures are to save the area £1m off the £7m currently being spent per year).
- Attract capital investment to the area, maximising the percentage of which is spent locally.
- Engage the entire community.
- Develop a resilient initiative (subject to rigorous academic evaluation) with the intention that other communities will be able to adopt it also.
- Build wider economic resilience by developing the Camel Low Carbon Enterprise (incorporating other nearby communities such as Padstow and St Minver).

8.5. Legal Structure

WREN is an Industrial and Provident Society for Community Benefit (IPS Ben Com), because its benefits are not restricted exclusively to its membership, and must submit annual returns to the Financial Services Authority. The society adopted the standard set of rules published by Co-operatives UK. WREN also chose to have an asset lock so that it cannot be converted into another form; its assets must be kept within companies with similar objectives.

8.5.1. Membership

Membership is open to anyone over the age of 16 who agrees with WREN’s objectives and who pays the £1 membership fee.

8.6. Technology

8.6.1. Overview of Technologies

Solar PV has so far been the biggest contributor to WREN's renewable energy technologies with a combined installed capacity of 80kW in November 2011. Large-scale wind is expected to contribute greatly with two potential projects being investigated – one up to 12MW and the other up to 9MW.

Further opportunities being considered include the following technologies:

- Hydro
- Anaerobic digestion
- Renewable heat generation
- Low carbon transport
- Marine energy

8.6.2. Tidal Opportunities

WREN is currently exploring 4 initial possibilities for tidal energy generation, which are briefly discussed in this section.

In January 2012 it was announced by DECC that the South West is to become the World's first Marine Energy Park bringing together "physical and commercial assets" in order to "create a positive business environment in order to attract investment" (CC, 2012). This work is being undertaken primarily by Regen South West. WREN has been in contact with Regen SW with the idea that WREN could become part of this venture, perhaps becoming a development site for one of the companies involved. The appealing feature of this possibility is that it would potentially have government funding already allocated to move the project forward.

WREN has also been in conversing with company VerdErg who are developing the Spectral Marine Energy Converter (SMEC). The device utilises an intermittent wall which it sits within in order to generate electricity. WREN chose this device as a possibility because one of its benefits is that it has minimal effects on the environment (Frankel, 2012 – see Appendix 1). A preliminary study was carried out by Paul Bird of VerdErg which found there would be an estimated average electricity generation of 49kWe and energy of 430MWh per year, before advising further, more detailed study. The problem with this option was financial viability; with the lack of funding available, such a project is unlikely to be possible at this stage, however WREN is not ruling out the idea of a tidal project. One possibility being investigated is that of combining the this technology (or one similar) with the installation of flood defences in order to reduce direct costs

Jamie Johnson, a masters student from Plymouth University, is currently carrying out a project looking at tidal flows in various parts of the estuary. He is setting sensors up, collecting data and seeing where it might lead, identifying any places where there's enough water at enough speed to put a raft type turbine in place. This project is on-going.

The last area of interest is the possibility of regenerating an old sea mill situated in one of the side creeks off the estuary (Clark, 2012 – see Appendix 1). It is basically a wall already built around an area where there used to be a waterwheel installed and the idea is to use the existing wall to implement some sort of tidal device.

All of these ideas are still very much in the early stages of development but they demonstrate that in any location it is important to consider all options and how they might together contribute to a viable project.

8.7. Finances

8.7.1. Income

WREN is currently looking for partnerships with companies who can contribute financial value to the WREN initiative. From the profit gained by their involvement, they will allocate a significant share to the community fund.

It is projected that grant money will cover the overheads for the start-up and early growth stages (2 years) to allow the scheme to establish itself. This amount has been forecasted as around £77,000 for 2 years.

Once established income will come from projects owned by WREN, funded by re-investment of a proportion' of the community fund.

8.7.1.i. The WREN Community Fund

WREN's income will come from the partnerships it makes with other companies as well as eventually earning an income from its own projects. The board of directors has beset a limit of 20% of this income is to be spent on operation and administration, leaving 80% accrued to the community fund.

Of the money raised in the community fund it is expected that 40% will be available as grant funding for local community ventures, with the remaining 60% re-invested into additional income generating projects.

The fund will be controlled by members who will vote on how the funds are distributed.

8.7.2. Expenditures

The expenditures of the enterprise will consist largely of the following:

- Project management
- Office/shop rental
- Office consumables
- Administration
- Accounting
- Technical, legal and financial advice

8.8. Lessons learned/issues raised

The main problem identified by Stephen Frankel was a lack of resources, he said "we will become a self-sustaining organisation, but until the commercial returns from the energy economy are available, it is difficult to function at the right scale within the tidal area as any other" (see Appendix 6). A major drawback was the recent drastic reduction in the solar PV Feed-in Tariff payment value (from 41p to 21p/kWh) which has caused major uncertainty within the entire PV sector. Despite this, the WREN project has already made a commendable effort in initiating such an ambitious project and is well on its way to achieving its goals.

8.9. Next steps

The next move is to secure partnerships with suitable companies in order to really get the project moving. WREN will continue with its solar PV installations and continue to work on getting a wind energy project up and running, with major developments expected in 2012.

9. Discussion

Overall community ownership leads to economic restoration, social structure as well as public understanding and support for renewable energy. The number of community energy projects is growing steadily, despite the current lack of government support. However community groups, especially those just starting up, would really benefit from increased support to keep them afloat. The community movement has begun to move onto other technologies since its initial adoption of wind technology as they become financially viable. The movement to solar PV was helped considerably by the income generated by payments from the Feed-in Tariff but confidence in the tariff has unfortunately recently dropped dues to the recent cuts.

There are a variety of legal structures that have been developed over time in order to suit the needs of community owned energy projects. The most widely recognised of which is the cooperative model which has been utilised for a variety of projects worldwide. Other structures include the relatively newly established CIC and the IPS Ben Com both which fully adopt the aspect of an asset lock, which was one of the key objectives applicable to the WREN's project adopted to ensure that the income generated is guaranteed to stay within, and benefit the local community.

WREN has set out a creditable enterprise structure which will undoubtedly be looked to as guidance and inspiration for other groups of individuals, in Cornwall and further afield, who might be aspiring towards similar objectives that WREN sets out to achieve. The holistic approach taken by WREN to explore all possible areas of renewable energy is notable, which is a beneficial methodology. By continuing to investigate, extensively, the potential energy resources in and around Wadebridge and by adopting a statistical approach in the areas of financial analysis as well as resource assessment, maximum advantage can be realised from the environmental resources, underpinning the community ownership benefits within the local area.

As far as community tidal goes, it is pleasing to see a small group of pioneers working hard, despite the technology's still early developmental stage, to get the technology recognised in the field of community renewables. In a number of the cases presented, the motivations seem to be clustered around the incentive to get the technology on its way to becoming commercial; by setting an example to the industry. The biggest downfall to these projects is their inability to attract financial investment simply because there is a huge amount of investment risk involved with the implementation of such a project. This is where robust and supportive policy, in the form of start-up grants and financial incentives tailored to meet the basic requirements of the tidal industry, is called for; to allow the technology to become less of a financial burden and more of a prized asset, capable of generating a secure and reliable income for remote and rural communities throughout Cornwall and the rest of the UK.

It is recognisable that the few existing community tidal projects, seeming to be making slight progress, are all found within Scotland. This highlights the fact that the Scottish Government has shown increased support for marine renewables in recent years; perhaps it would be beneficial for the rest of the UK to draw some valuable lessons in a policy context and general approach from the support the Scottish Government offers. Perhaps we are beginning to see the stages of this with the current ROC changes that are being considered, time will tell.

Admittedly, Scotland does have exceptional tidal resources but there is also great potential for Cornwall to be pioneers in the industry especially due to the existing infrastructure with regards to the marine industry. A study undertaken for WREN by the development company VerdErg found good potential resource along the Camel Estuary for the implementation of their SMEC device. This dissertation report finds similar tidal range values at varying locations studied within Cornwall and South Devon which indicates there is potential for successful deployment.

10. Conclusions

The WREN initiative is exemplar in setting out ambitious targets with the methodology needed to progress the project forward. It sets an excellent case for other communities who may be aspiring to follow similar ambitions; to reap the multiple benefits of community owned energy schemes. For the WREN project, continued academic assessment of the business plan and project goals will help to refine it in, making it robust and established. The lessons learnt and the changes made will help to progress the community energy movement forward.

Initial assessment within the study area reveals what appears to be promising resources for tidal utilisation however further study is recommended in order to draw better conclusions and to calculate the energy available.

Once tidal energy technology moves further towards the commercial stage of development, it will become less risky and more financially attractive to investors. The idea is that these investors will make mutually beneficial partnerships with the communities they wish to benefit from, by making optimum use of renewable resources and equally designating a large percentage of the income to be awarded back to the community in the form of community benefit company such as WREN. This will allow the community to develop new opportunities in the form of jobs, education and understanding and to regenerate its economic and social structures.

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12. Appendices

Appendix 1 - Meeting with Wadebridge Renewable Energy Network (WREN)

Location:	**The Energy Shop, Wadebridge.**	
Date/Time:	**Wednesday 18th April 12am**	
Present:	**Stephen Frankel (Chair)**	**= SF**
	David Atfield (Academic and Student Liaison)	**= DA**
	Jerry Clarke (Technical Director)	**= JC**
	Sophie Stevens (Renewable Energy Student)	**= SS**

SS: Hello thank you for agreeing to meet me in person, I am here to find out about WREN as a general enterprise and to try and gauge what stage you are at with the various projects that are going on, specifically the tidal project.

SF: Ok I'll just say why I was interested in hearing from you, since it was me you got in touch with by email - basically we are interested in all sources of renewables and also interested in how people feel about different potential programmes and it's quite an interesting area because the people who make the loudest noises are often completely unrepresentative so our wish is to involve everybody.

We have here at on the estuary at Wadebridge at least four aspects to do with tidal potential and if you want to see how they relate to community interests it would be really helpful for us if you could draw these disparate strands together so that we have a more coherent understanding of what they would add up to in terms of a potential resource. It's something we'd like to do ourselves but don't have the time! Does that make sense?

SS: Yes I get the picture. So what are the four strands you mention?

SF: The things we've got are …on a bigger scale - Region South West – Johnny GAUDI? – they are interested in general terms in marine energy potential…

They are involved in the Marine Energy Park which is a sort of shiny thing people like to talk about… but we are interested in it and we'd like to complement it in some way.

Then we've got a company called Verderg who we contacted initially. The point about their approach is it has MINIMAL ecological implications because the tidal periodicity is changes but the tidal heights aren't changed.

What's Jamie Johnson up to exactly?

DA: He's doing a masters looking at tidal flows in various parts of the estuary. He's got some monitors, setting sensors up, collecting data and seeing where it might lead, identifying any places where there's enough water at enough speed to put a raft type turbine in place.

Then we are looking at sea mills as well, there was in one of the side creeks off the estuary a centuries old sea mill, basically a sea wall around an area. They used to let the water in at high tide, block it off and save it up till there's a bit of a head, use it on the way in and on the way out through a sort of water wheel to drive machinery. So we're looking at the modern potential for that idea. The walls are still there, there are a couple of gaps in it… and it would need some serious dredging work but it makes sense as a potential idea.

SF: It's a sort of back to the future idea really. So that's about it for the moment.

DA: There was a scoping study done a couple of years ago when they were looking at the Severn Barrage, they did look at the idea of doing a barrage at the mouth of the river Camel as a test for the Severn Barrage and that had potential for about 28 megawatts, so that study is out there somewhere, I don't actually see it going ahead, people with sailing and fishing interests might have something to say about it.

SF: Then there's the whole flood issue – this is all a high risk flood area.

Our outgoing mayor Steven Knightley is very occupied with the issue of flood risk

and so there's an interesting idea of complementing the economics of the Verderg type system but the payback was very long term… but then tidal protection has no income at all… so the idea of complementing tidal generation with flood defence is an interesting one. (*They say later SK has invited the Environment Agency to come and talk about flood projections…)*

SS: So that means building a wall and putting devices within it?

SF: Yes the Verderg (SMEC) idea is a kind of intermittent wall so you're channelling water into devices – normally it's open but you can shut them off if you want to.

SS: I see

JC: I think it would be fair to say that so far WREN has had little involvement

with the community about tidal issues, apart from some slightly negative press coverage!

Clearly an issue which is always in their minds is "Who are the interested parties, the stakeholders and what are their agendas?" How do they overlap, how are they different, who are the key players.

If you wanted a successful community engagement strategy, that's what you would have to do – look at Who are these people, what do they know , how can we best communicate with them

SF: All the chat I've heard in town was that the idea of fishing was what really got people interested and made them think it might be a good idea…

What questions do you want to ask us to help you with your dissertation?

SS: I'd like to know more about your involvement in other types of community owned projects in the area, whether any money from those might go into a tidal project maybe, how does the WREN company actually work?

SF: How do we fund it? Basically it works with commercial partners and WREN itself will form an energy company. Any development on a major scale, major wind project, would be a partnership with a commercial partner and a community interest company so that the benefits come to a community fund.

JC: On the wind power side we have a commercial partner who processes the whole thing for us but who is actively involved with WREN so is making sure the benefits come back to the community. Ideally we'd like to do the same with tidal projects but the cost effectiveness of tidal is still very much in the research stage, there's no guarantee there'd be any financial benefit from it.

SS: Well the technology is still at that stage as well

SF: We'd love it if one of the development sites for the Eco Park could be here – perhaps with one of the developers like Verderg.

DA: One of the things we ARE doing with the community is installing SMART meters in properties to monitor energy usage and looking at whether their usage affects consumption and if so by how much.

JC: Do you know about the LEAF fund – it was some money for community projects – some of the work we did from that was looking at local housing stocks, doing index

Surveys on them, working out what would be needed to bring them up to scratch and we've also been looking at all the big heat users in the area to see how we could convert them to biomass – that's all on-going.

The spin off from all this is we may be able to get something back on a community basis for voltage regulation – that's one thing – for most of the country the voltage is much higher than it needs to be and if we could knock 10% off voltage without affecting anything very much that would save a lot of energy, Another way is to try and insulate some of the solid stone housing stock, probably internally because most people don't want to change the external appearance of their house and then there's trying to get people to change their heating from oil to biomass. That's based on the Renewable Heat Incentive, that's only up and running for commercial use at the moment but we're hoping we can benefit from it.

SS: I'd like to know a bit more about the funding for WREN?

SF: WREN is a sustainable enterprise – so it's a company but where individuals can't benefit; essentially it is aiming towards being self-sustaining. Profit goes to the local community investment. By 2014 we aim to have management costs covered by a percentage of the income, so that the company can move from being entirely voluntary to being professionalised. In order to get to that point we are looking for project support from companies in order to pay for on-going administration costs…

The actual income will either come from commercial partners running existing projects, who need their own profits but who are community interest companies so the profits will go to community funds rather than shareholders.

SS: So are they companies based around the area?

SF: Yes and in addition WREN will have an energy company. At the moment wind is the most important in terms of income potential so we are hoping to build up our own wind projects and we are funded to do that and then we are hoping to build up energy projects, for example schools and others so that we can give them advantageous heating supplies.

We can send you a copy of the business plan.

SS: Yes please that would be very interesting. What are issues with the Verderg project?

SF: The issue is HOW MUCH of the estuary you contain because the way the SMEC system works, you need to contain a lot of water and the difficulty is the sensible places where you could contain the estuary, the volume is quite modest, if you could contain it further up by Padstow, there's a lot more water there.

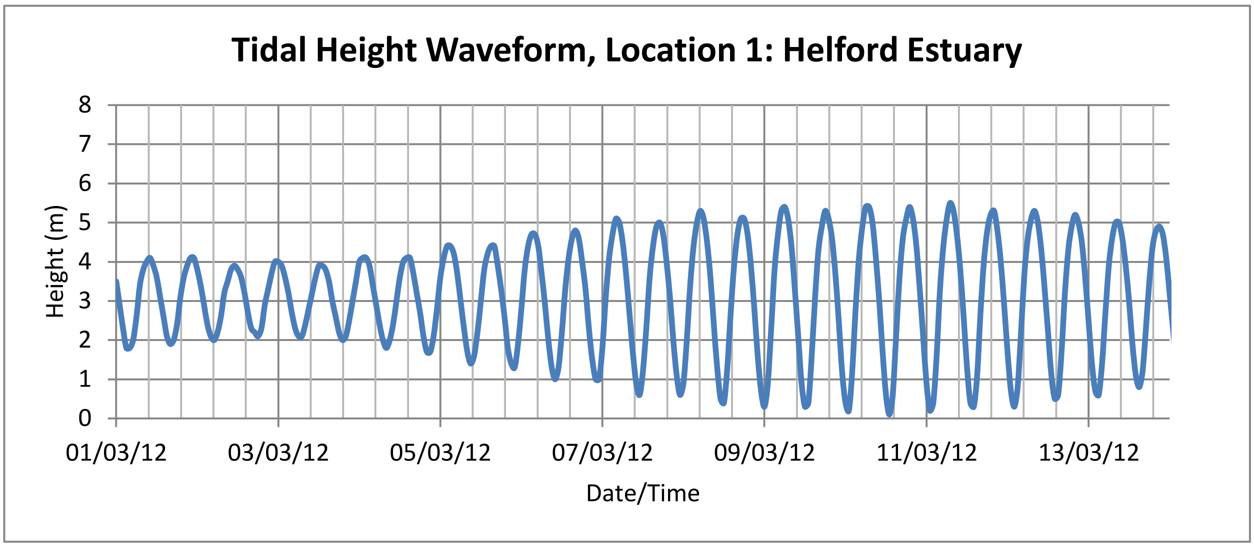
SS: Do you have the tidal height data available that was looked at for the Verderg assessment? I would be interested in looking at it to relate to my assessment project.

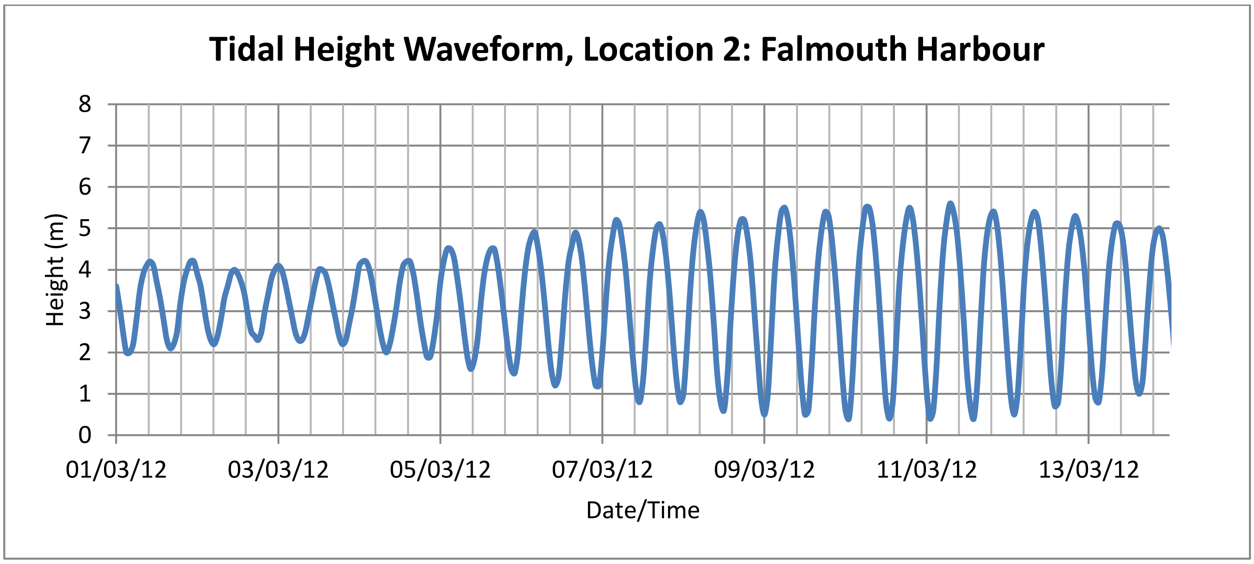
JC: Paul Bird is the one who will be able to help you there as he did the initial assessment report. We can forward you that too.

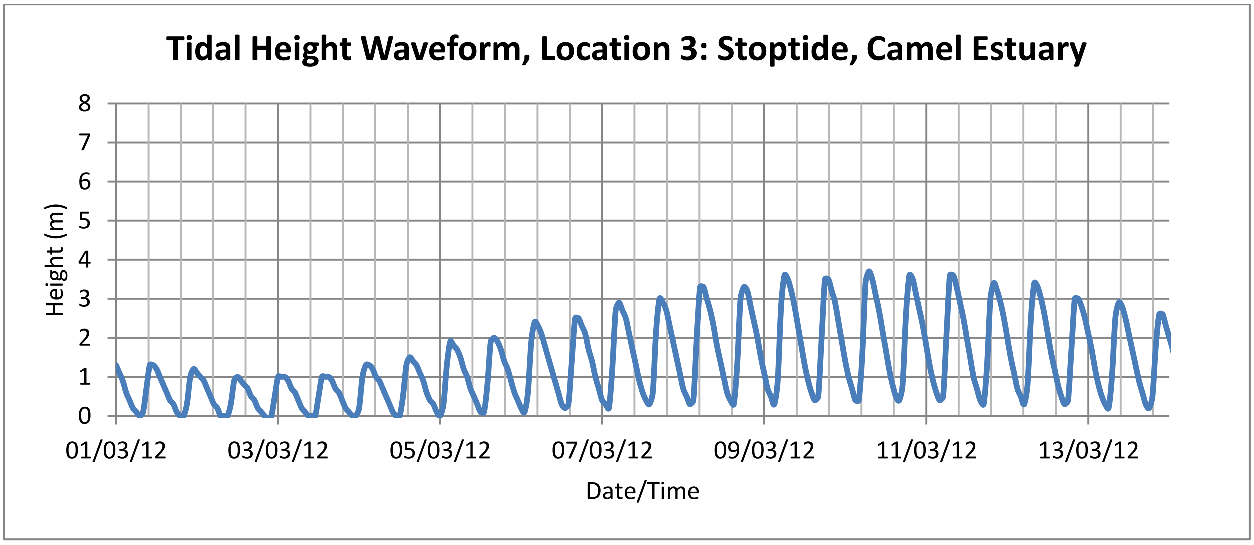
DA: Right I will email you the files you need. Is there anything else?

SS: There's plenty of information there for me to consider. Thank you very much.

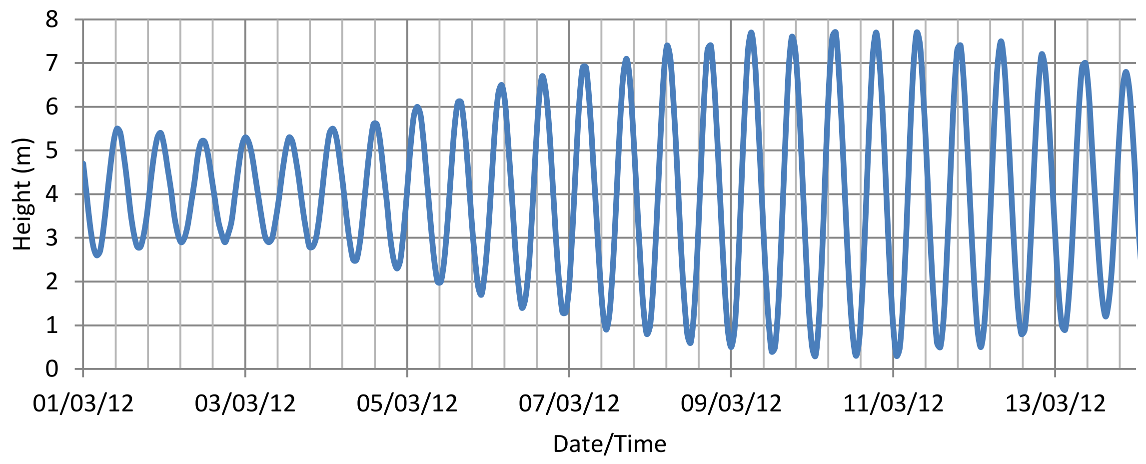
Appendix 2 - Tidal Height Waveforms



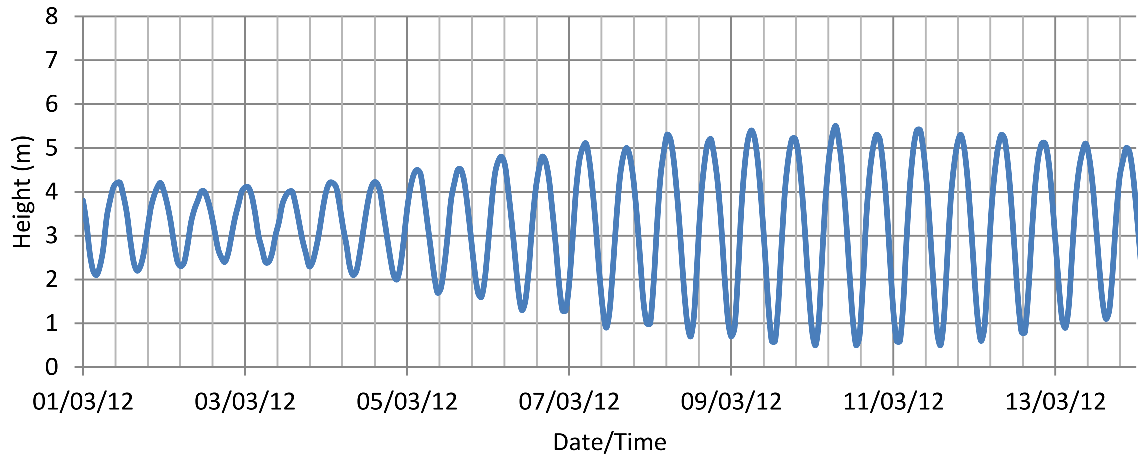




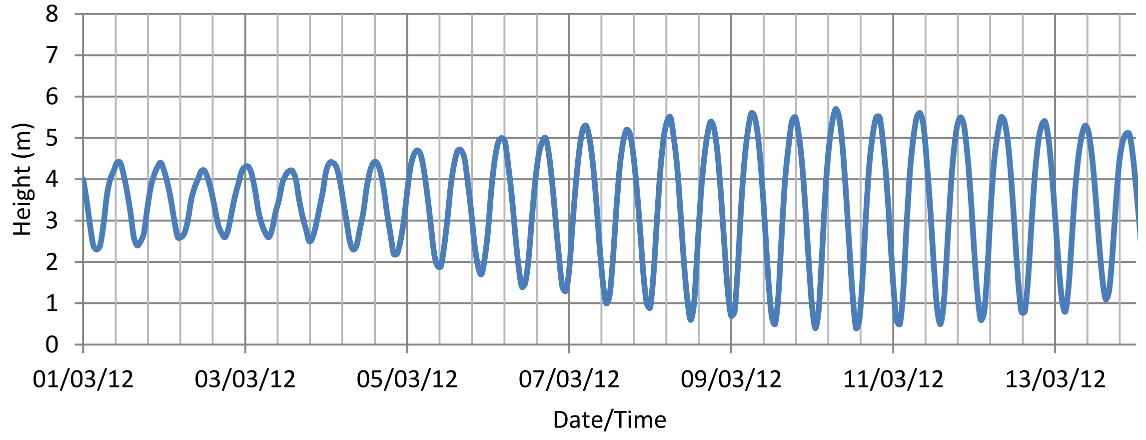
Tidal Height Waveform, Location 4: Padstow, Camel Estuary

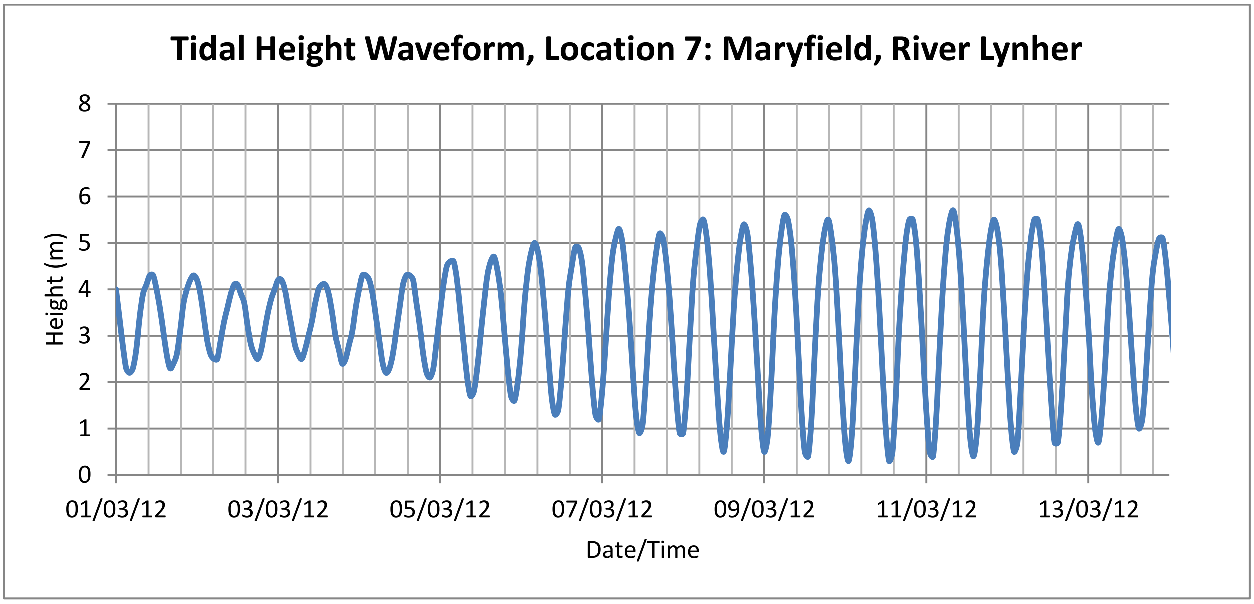


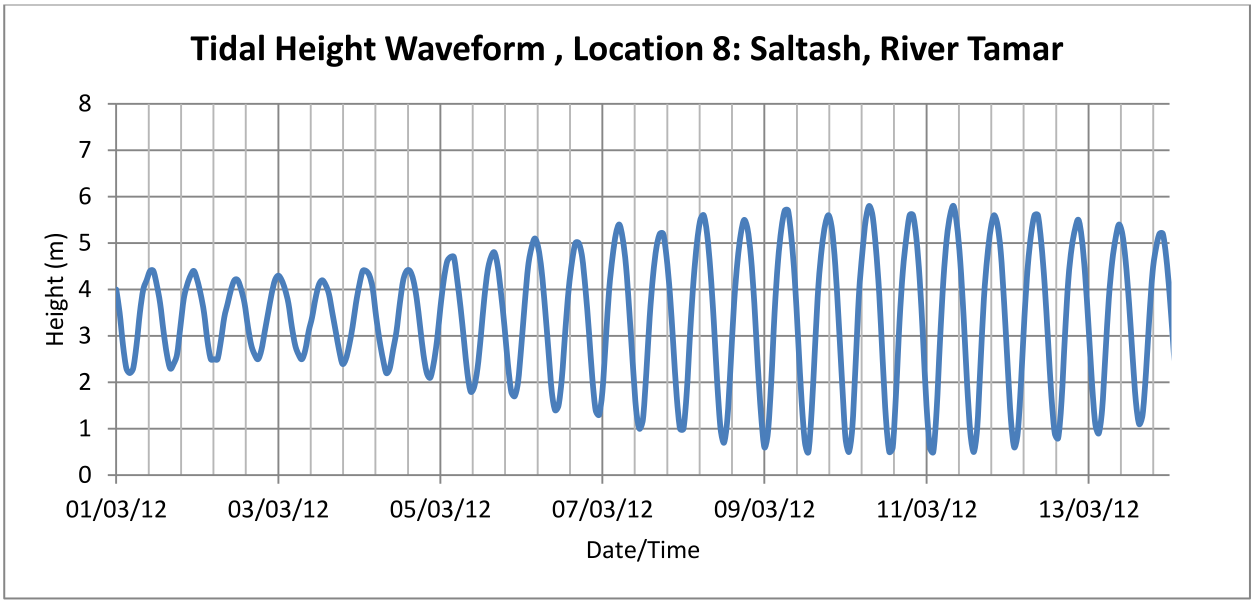
Tidal Height Waveform, Location 5: Plymouth Sound

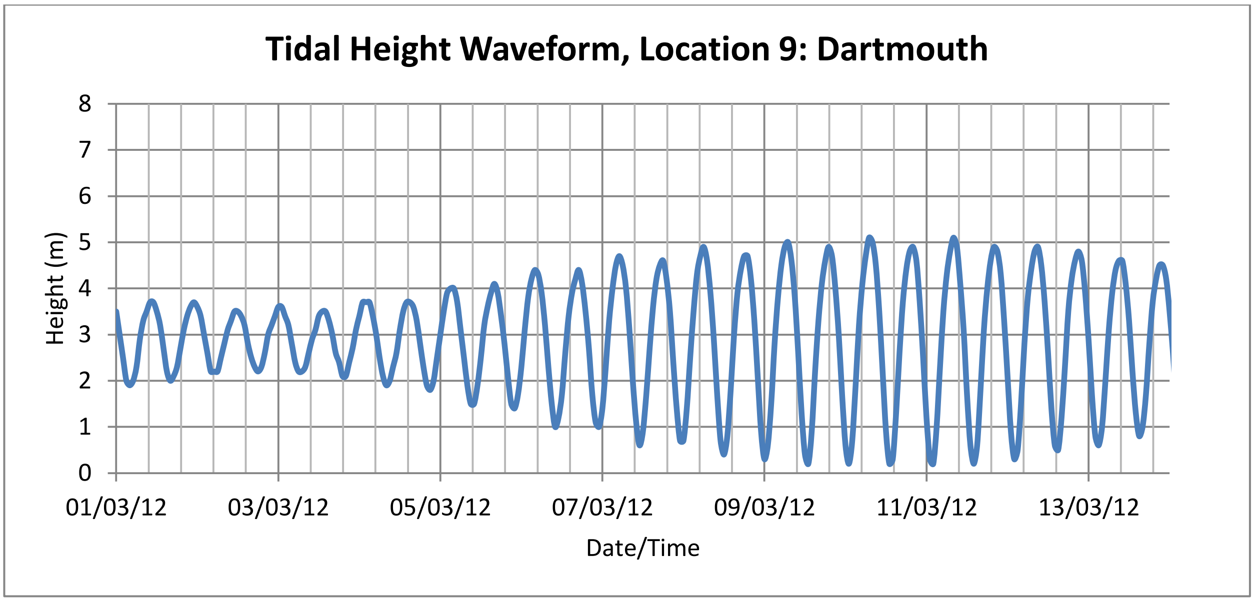


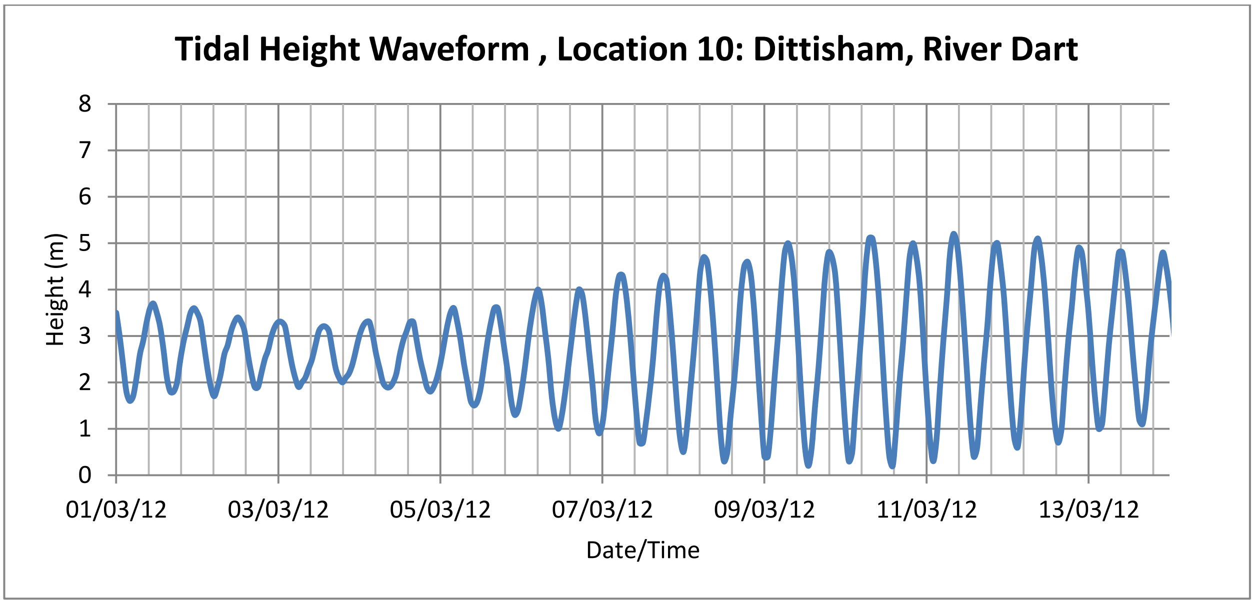
Tidal Height Waveform, Location 6: Plym Estuary

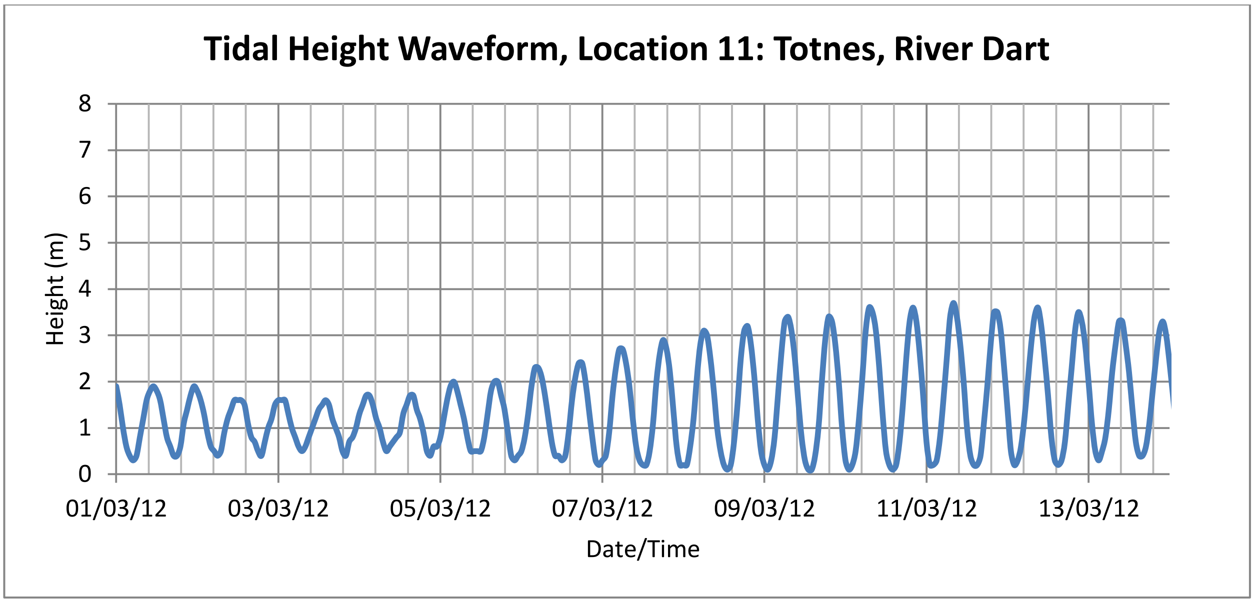



Tidal Height Waveform, Location 7: Maryfield, River Lynher
Height (m)
0
1
2
3
4
5
6
7
8
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
Date/Time


Tidal Height Waveform , Location 8: Saltash, River Tamar
Height (m)
0
1
2
3
4
5
6
7
8
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
Date/Time

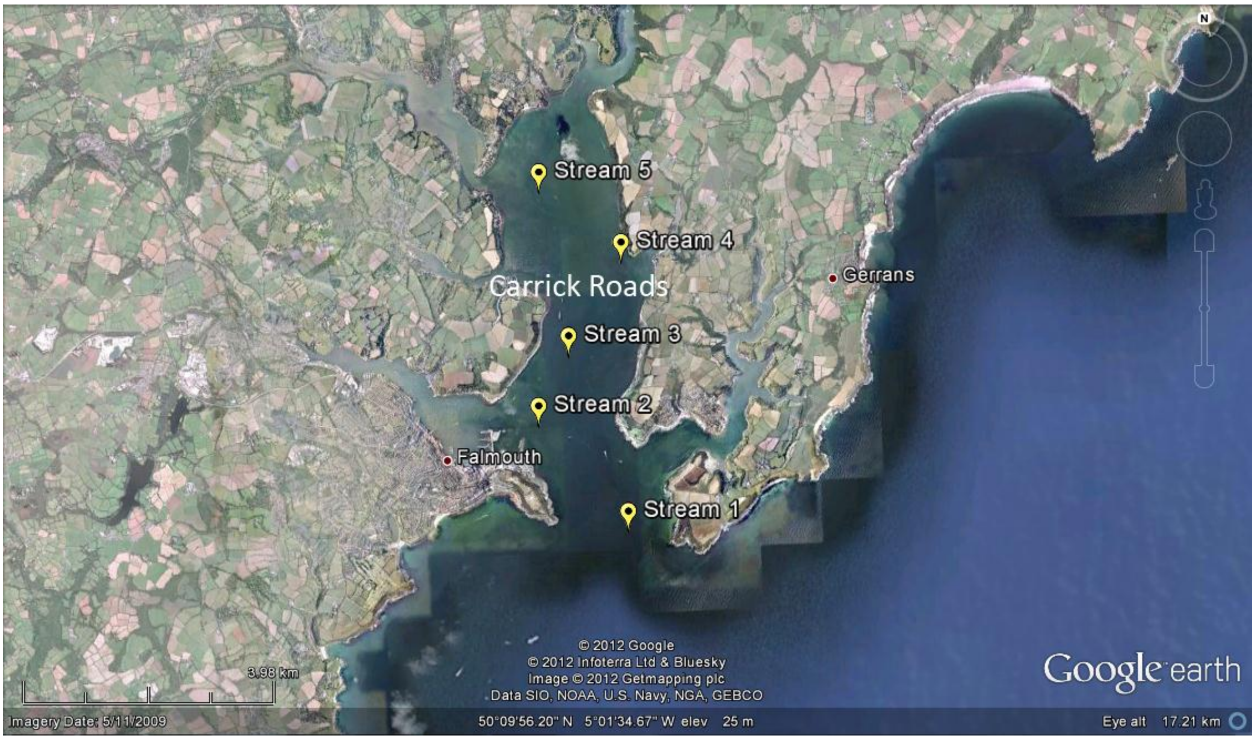

Tidal Height Waveform, Location 9: Dartmouth
Height (m)
0
1
2
3
4
5
6
7
8
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
Date/Time


Tidal Height Waveform , Location 10: Dittisham, River Dart
8
7
6
5
4
3
2
1
0
Height (m)
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
Date/Time


Tidal Height Waveform, Location 11: Totnes, River Dart
8
7
6
5
4
3
2
1
0
Height (m)
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
Date/Time

Appendix 3 - Tidal Velocity Location Maps

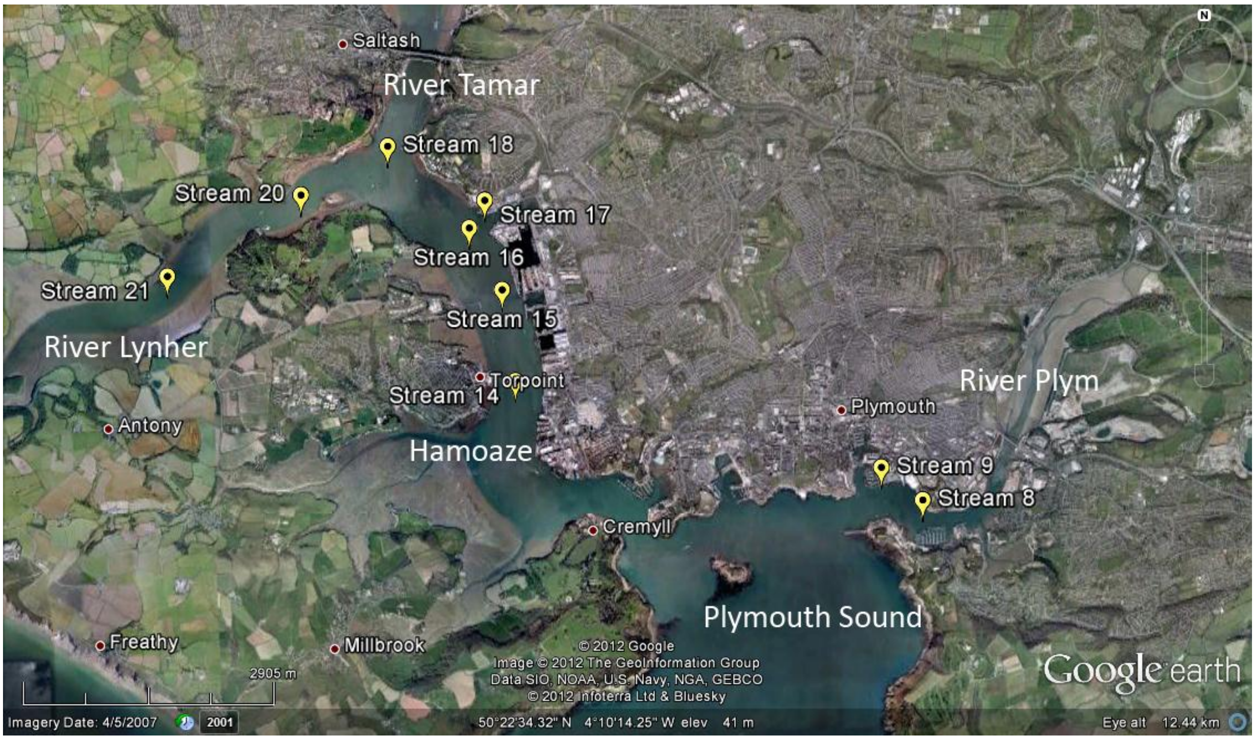
Falmouth



Padstow

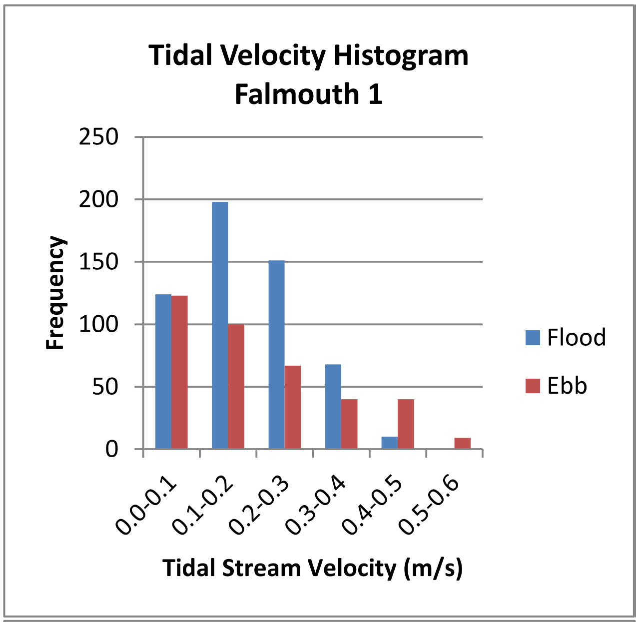
Dartmouth

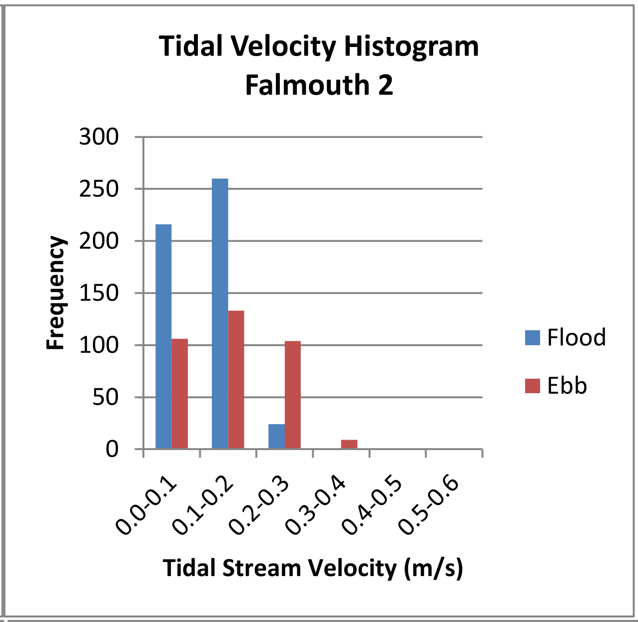
Plymouth and Saltash

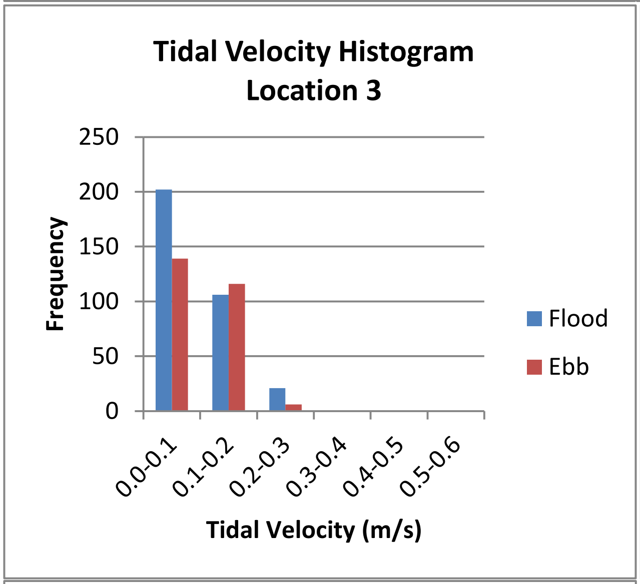


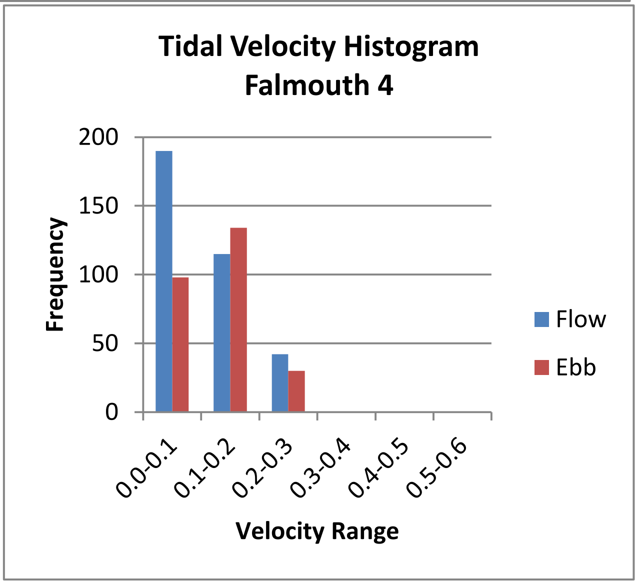
Appendix 4 - Tidal Velocity Histograms

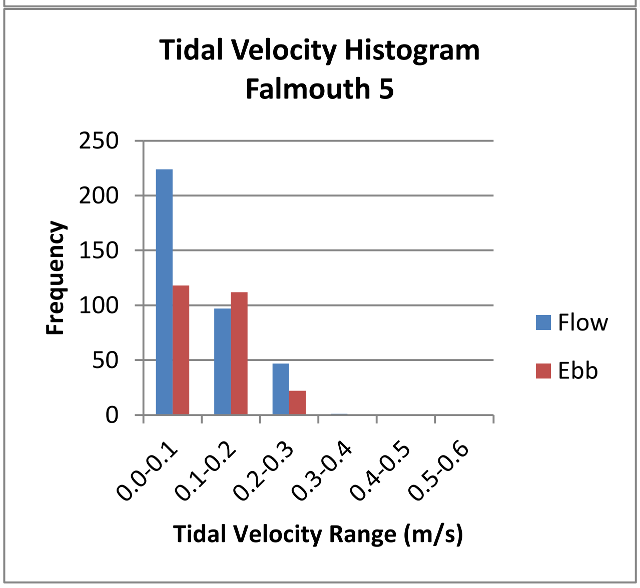
Falmouth



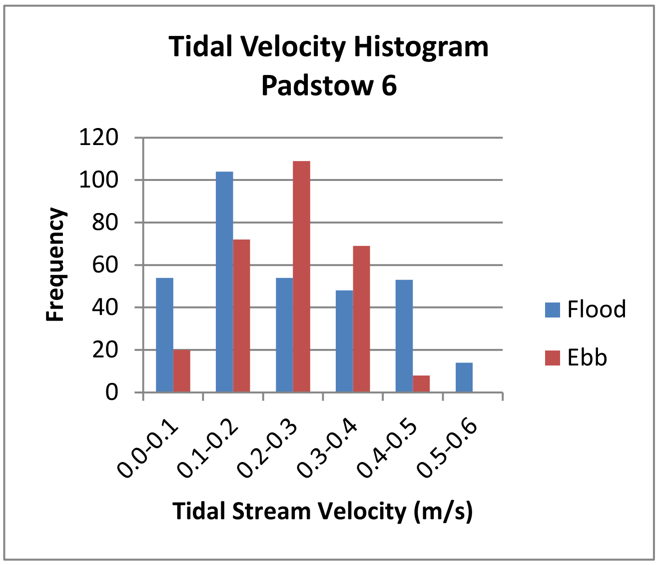




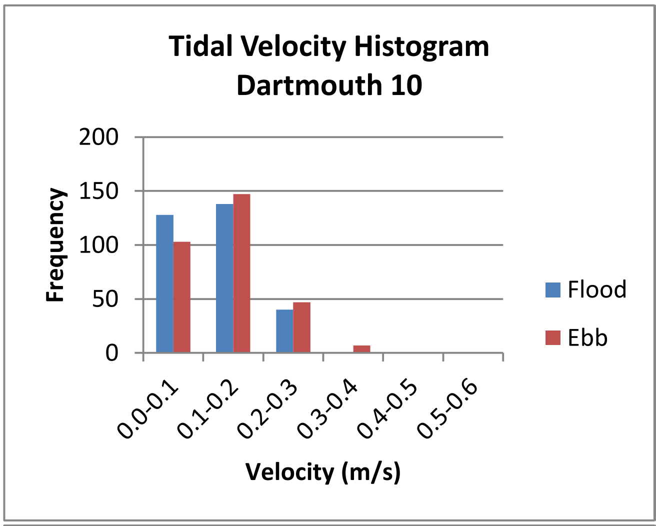


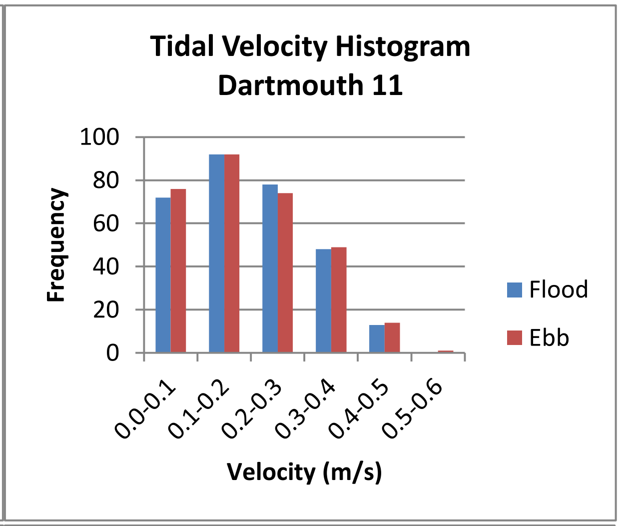


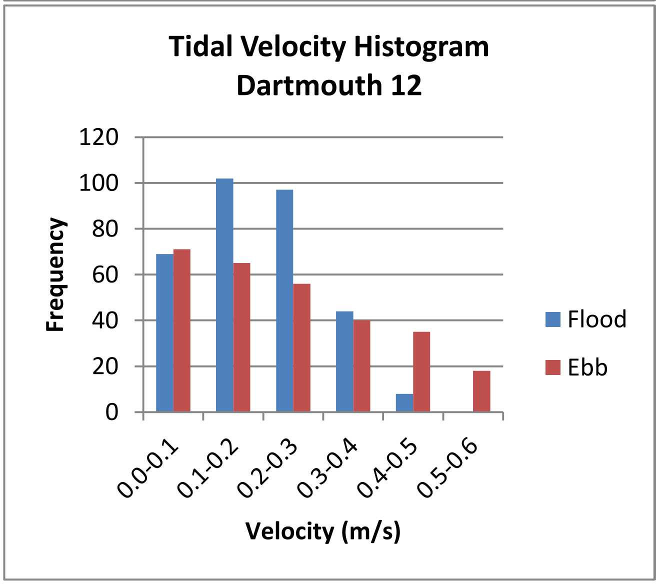
Padstow

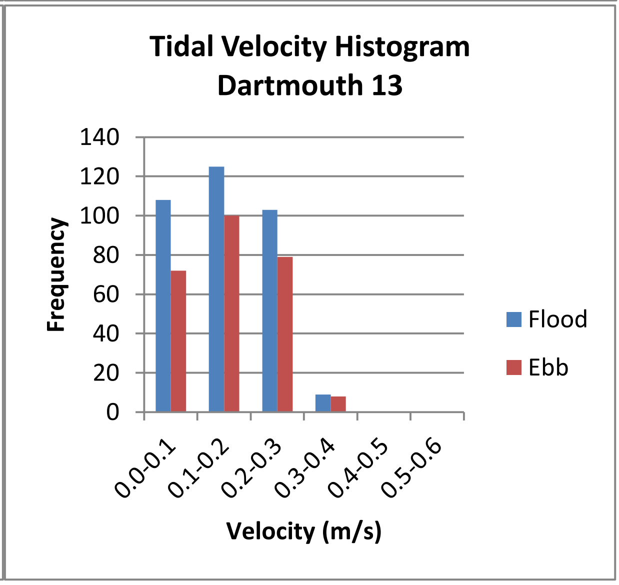


Dartmouth

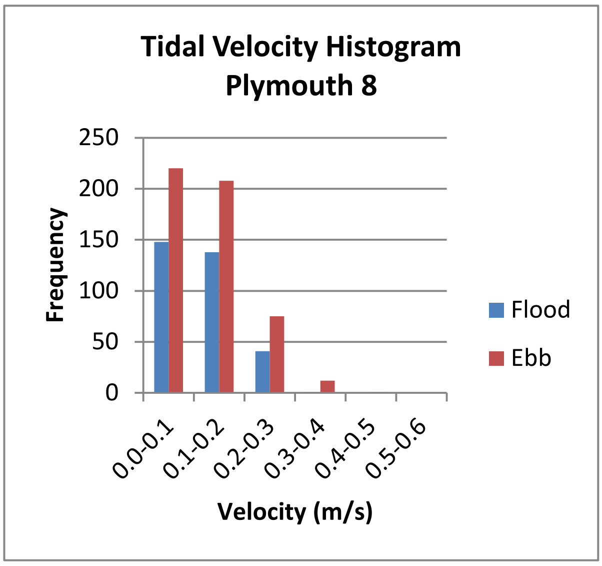


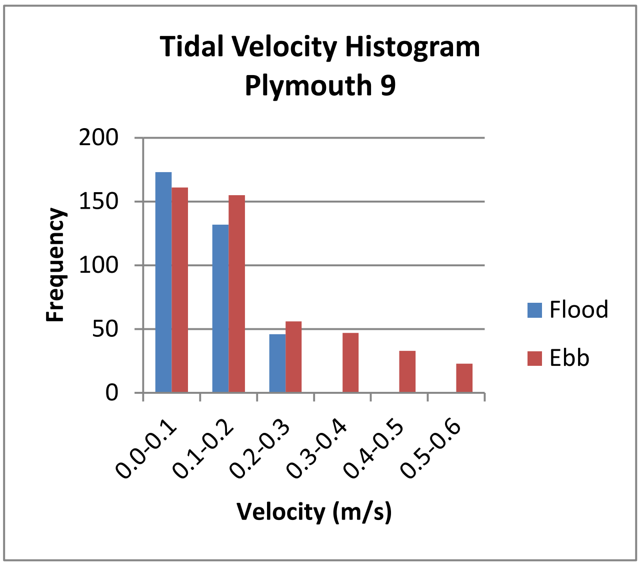


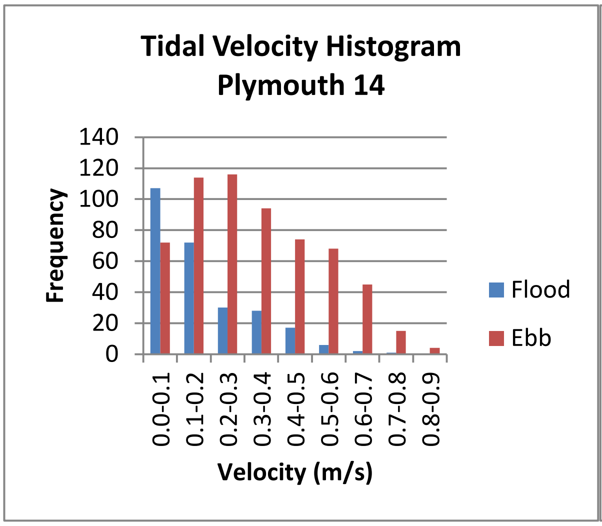


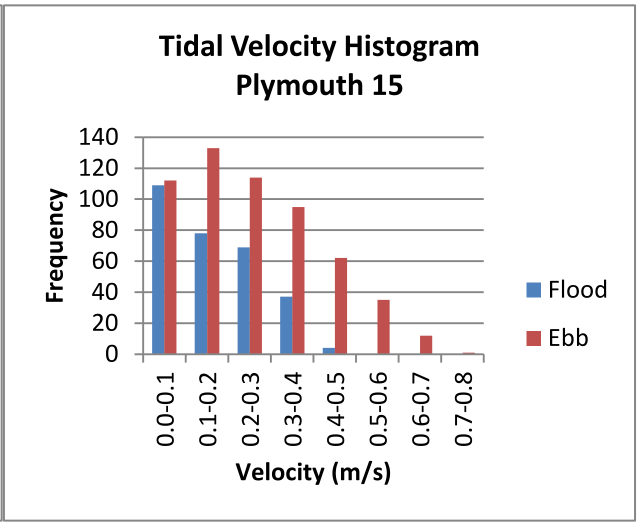


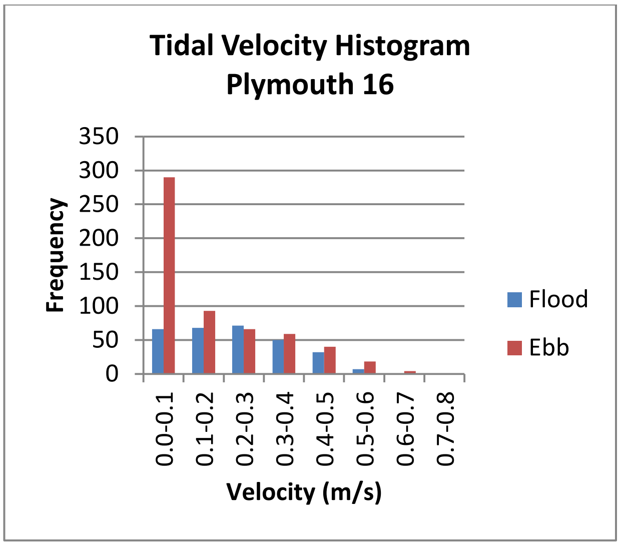
Plymouth

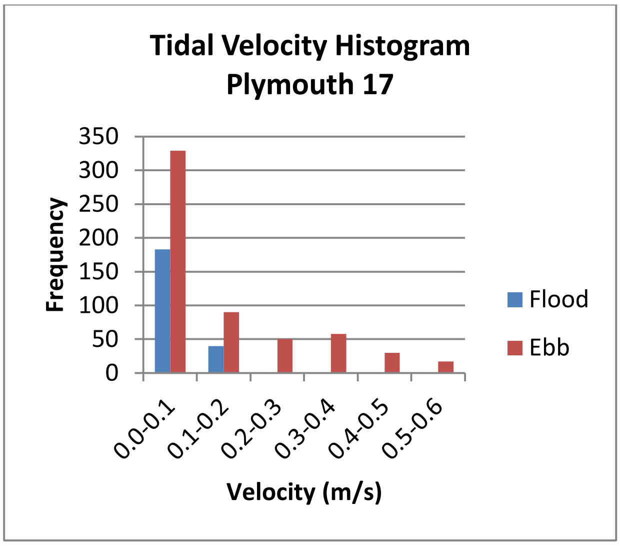

Tidal Velocity Histogram
Plymouth 8
Frequency
250
200
150
100
50
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Velocity (m/s)
Flood
Ebb

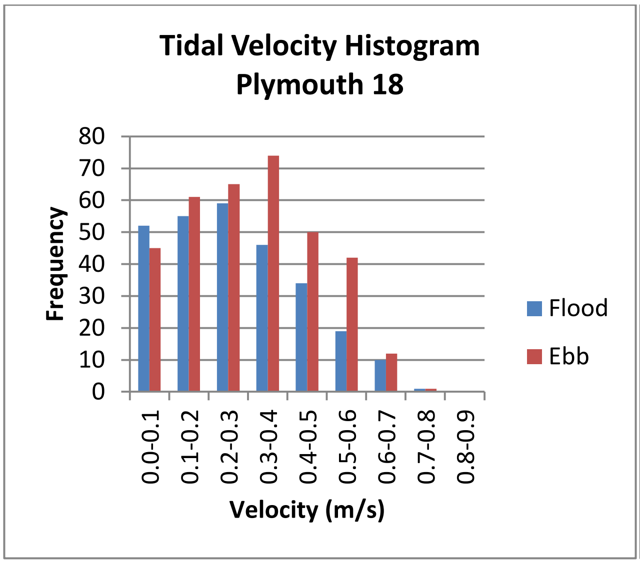

Tidal Velocity Histogram
Plymouth 9
Frequency
200
150
100
50
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Velocity (m/s)
Flood
Ebb

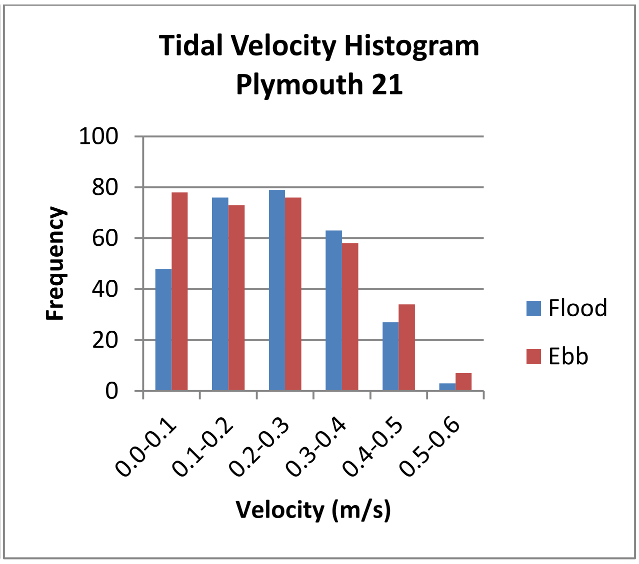

Tidal Velocity Histogram
Plymouth 14
Frequency
140
120
100
80
60
40
20
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
0.6-0.7
0.7-0.8
0.8-0.9
Velocity (m/s)
Flood
Ebb


Tidal Velocity Histogram
Plymouth 15
Frequency
140
120
100
80
60
40
20
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
0.6-0.7
0.7-0.8
Velocity (m/s)
Flood
Ebb


Tidal Velocity Histogram
Plymouth 16
Frequency
350
300
250
200
150
100
50
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
0.6-0.7
0.7-0.8
Velocity (m/s)
Flood
Ebb

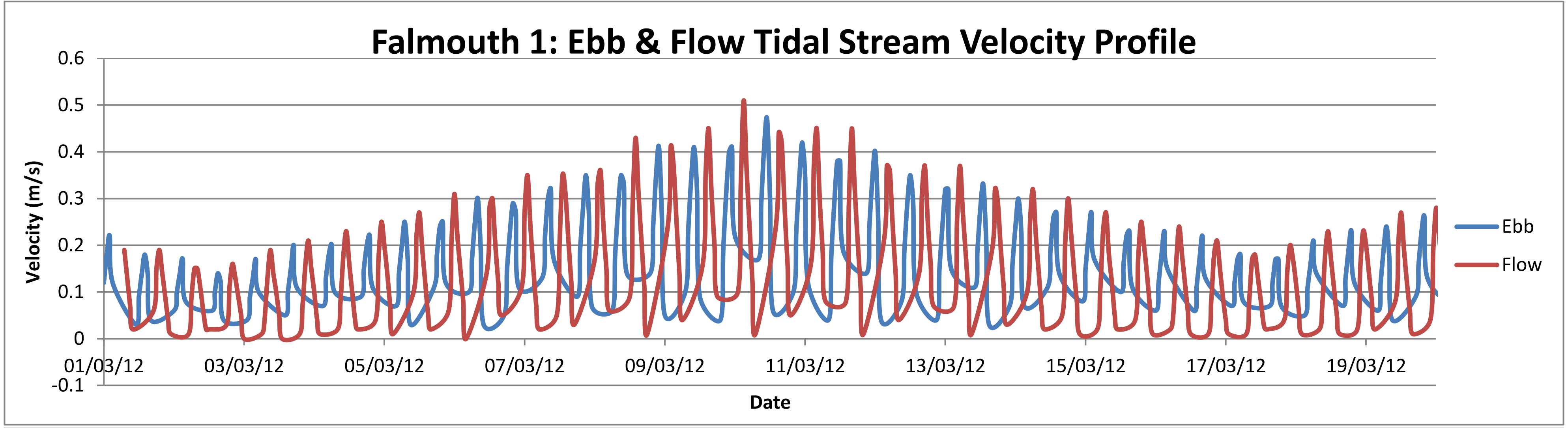

Tidal Velocity Histogram
Plymouth 17
Frequency
350
300
250
200
150
100
50
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Velocity (m/s)
Flood
Ebb

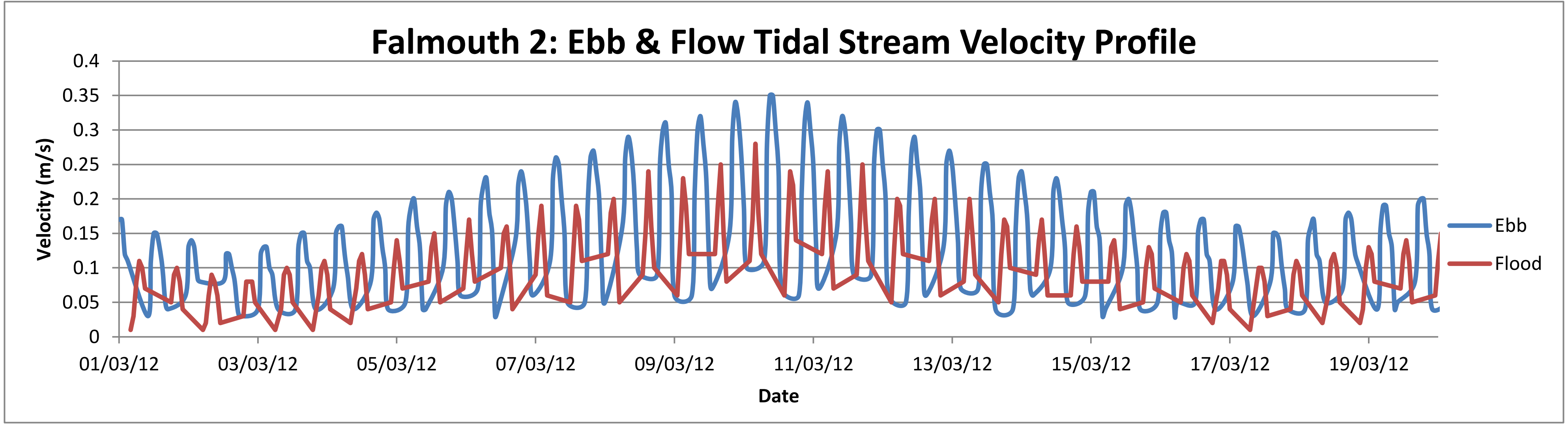

Tidal Velocity Histogram
Plymouth 18
Frequency
80
70
60
50
40
30
20
10
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
0.6-0.7
0.7-0.8
0.8-0.9
Velocity (m/s)
Flood
Ebb

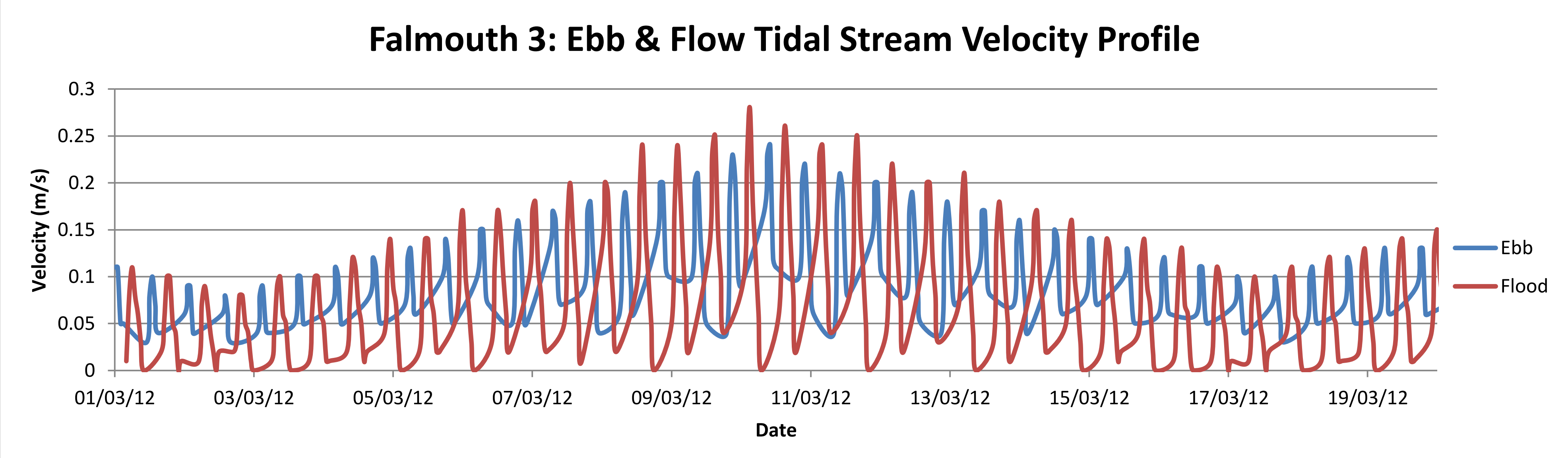

Tidal Velocity Histogram
Plymouth 21
Frequency
100
80
60
40
20
0
0.0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Velocity (m/s)
Flood
Ebb

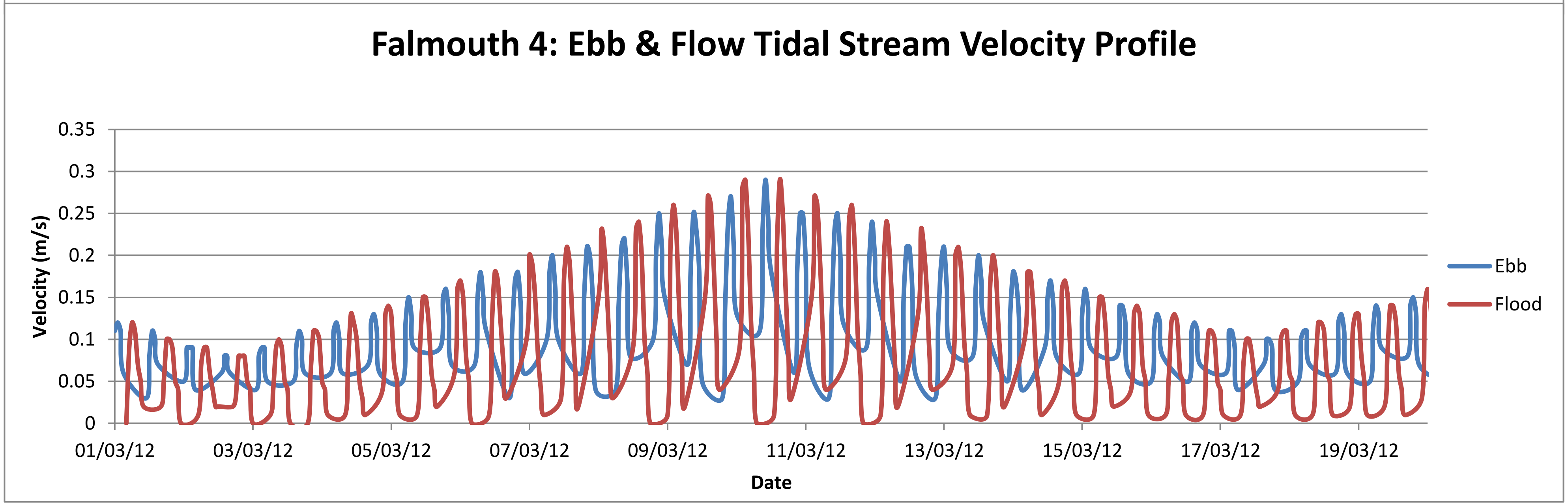
Appendix 5 - Tidal Stream Velocity Profiles

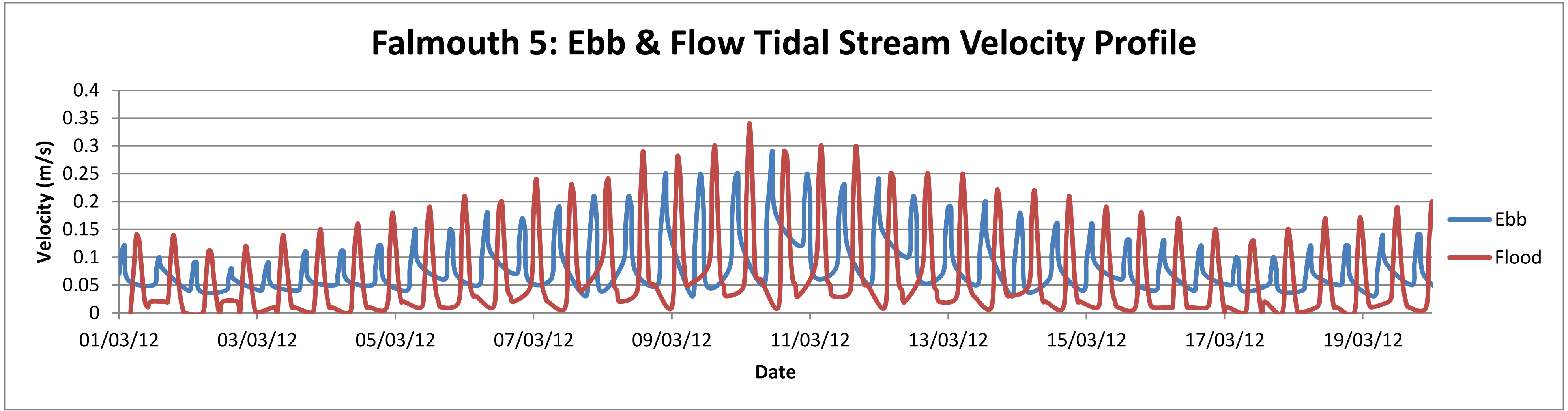
Falmouth



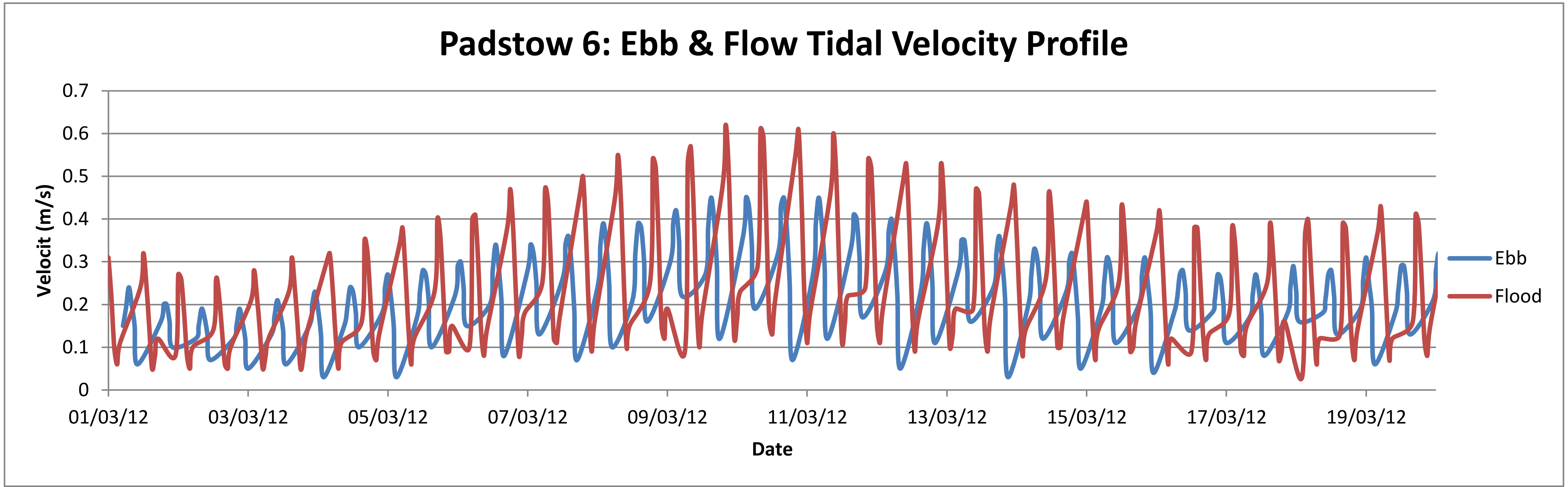



Falmouth 3: Ebb & Flow Tidal Stream Velocity Profile
Velocity (m/s)
0.3
0.25
0.2
0.15
0.1
0.05
0
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date
Ebb
Flood

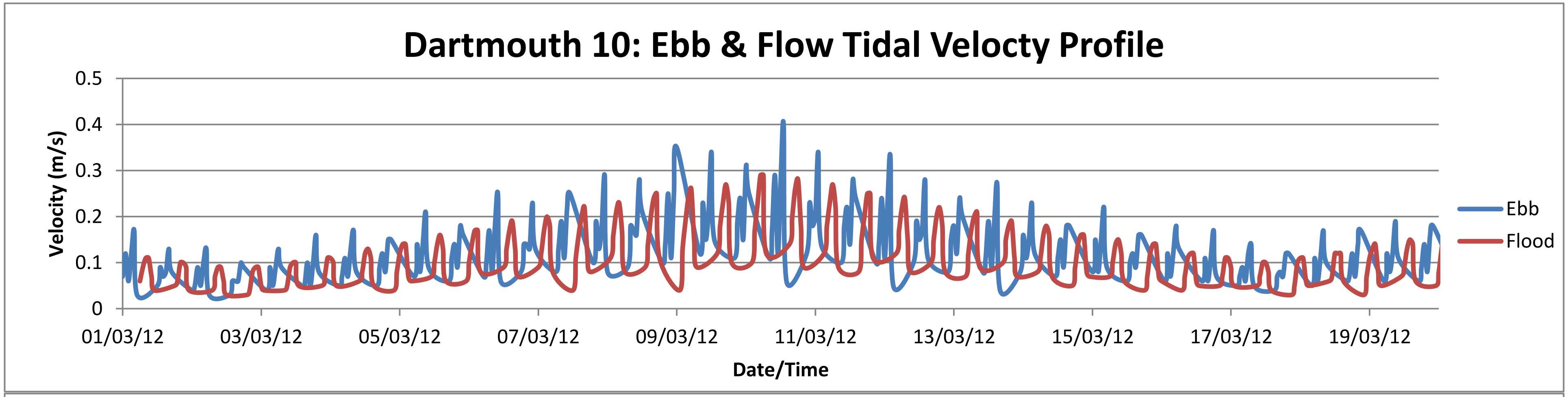

Falmouth 4: Ebb & Flow Tidal Stream Velocity Profile
Velocity (m/s)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date
Ebb
Flood

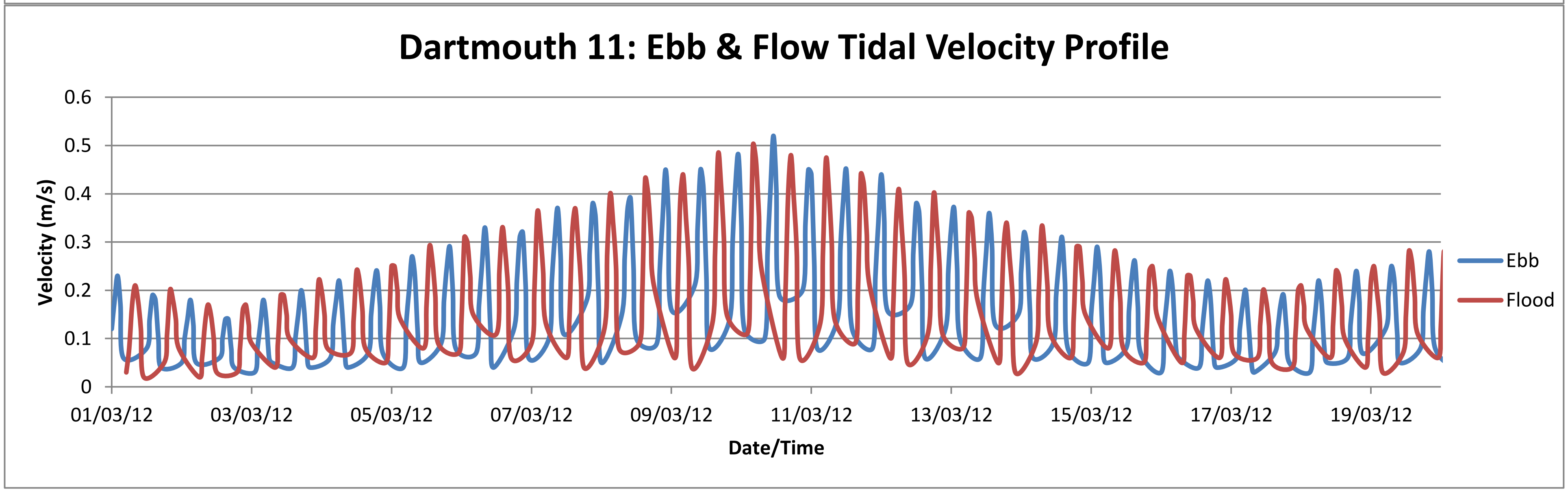

Falmouth 5: Ebb & Flow Tidal Stream Velocity Profile
Velocity (m/s)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date
Ebb
Flood

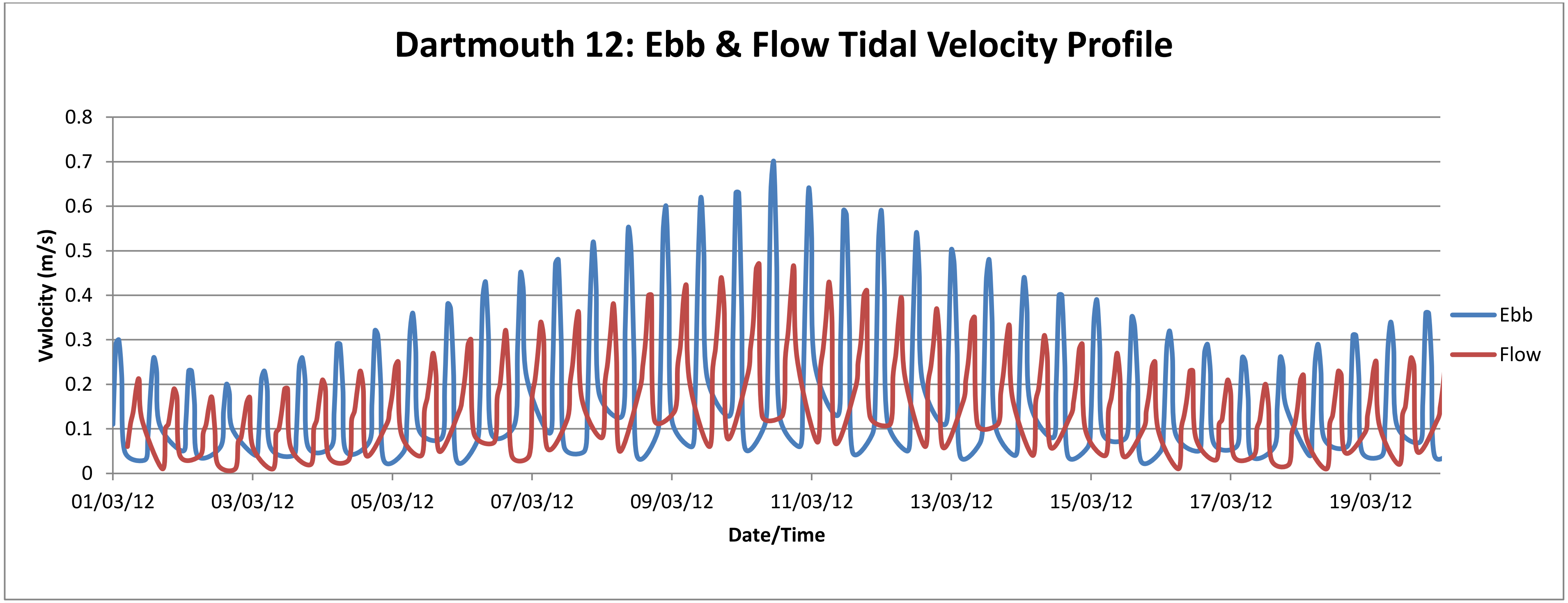
Padstow

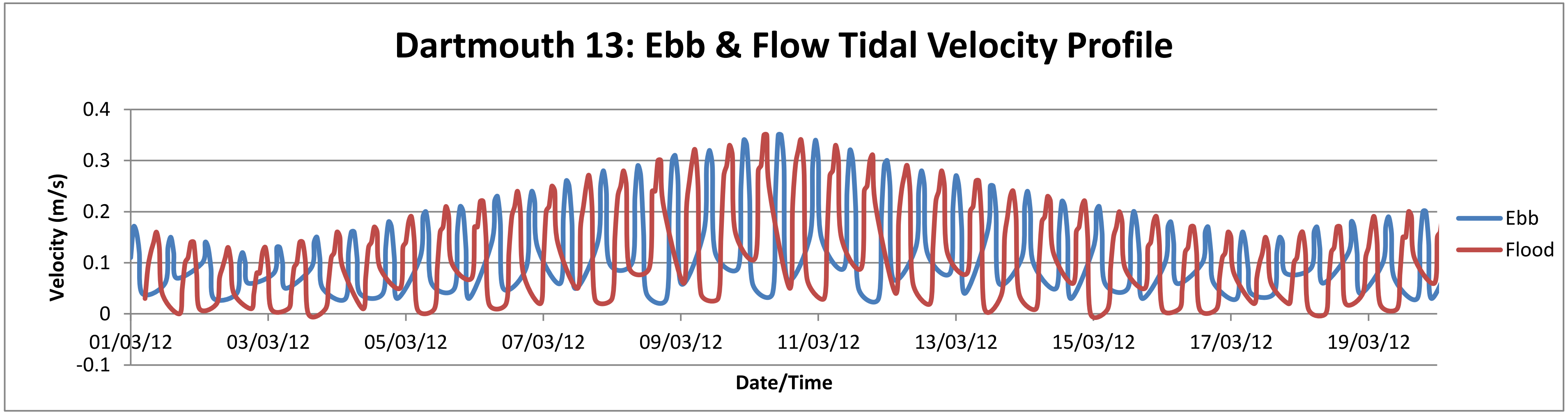

Padstow 6: Ebb & Flow Tidal Velocity Profile
Velocit (m/s)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date
Ebb
Flood

Dartmouth

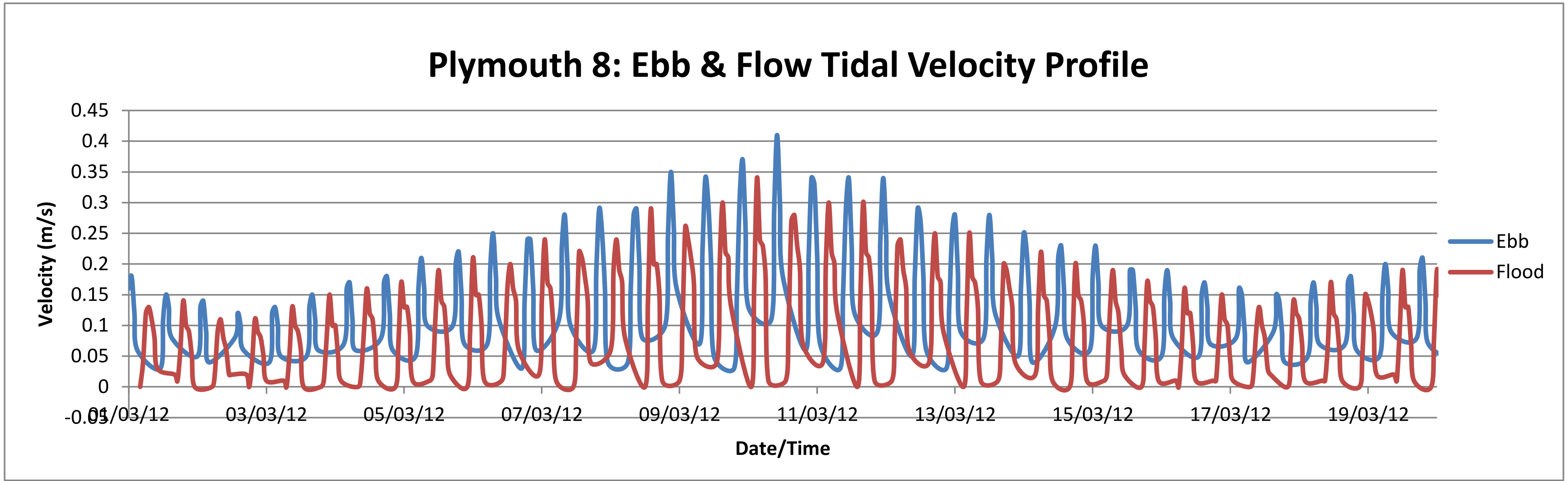

Dartmouth 10: Ebb & Flow Tidal Velocty Profile
Velocity (m/s)
0
0.1
0.2
0.3
0.4
0.5
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flood

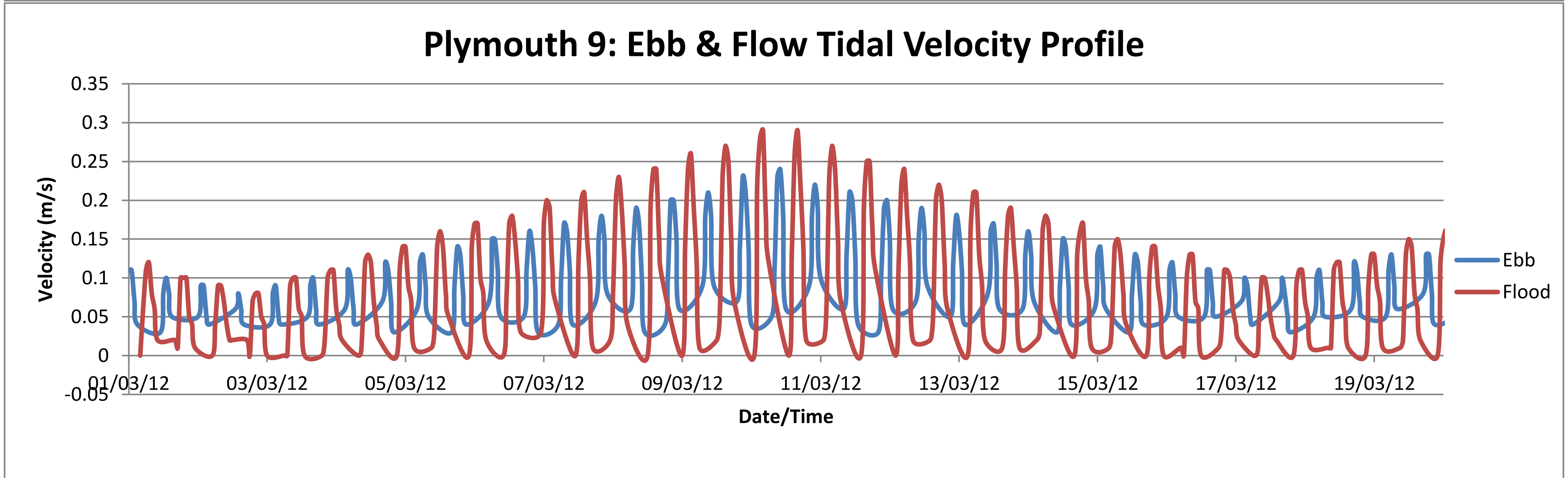

Dartmouth 11: Ebb & Flow Tidal Velocity Profile
Velocity (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flood

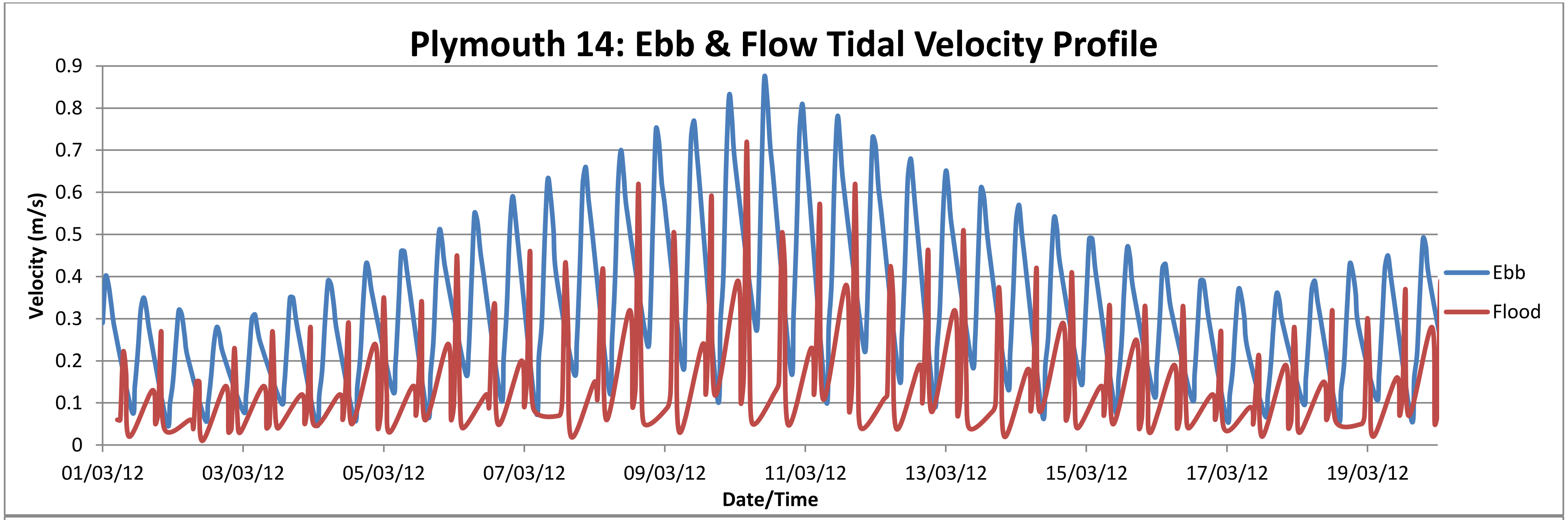

Dartmouth 12: Ebb & Flow Tidal Velocity Profile
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Vwlocity (m/s)
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flow

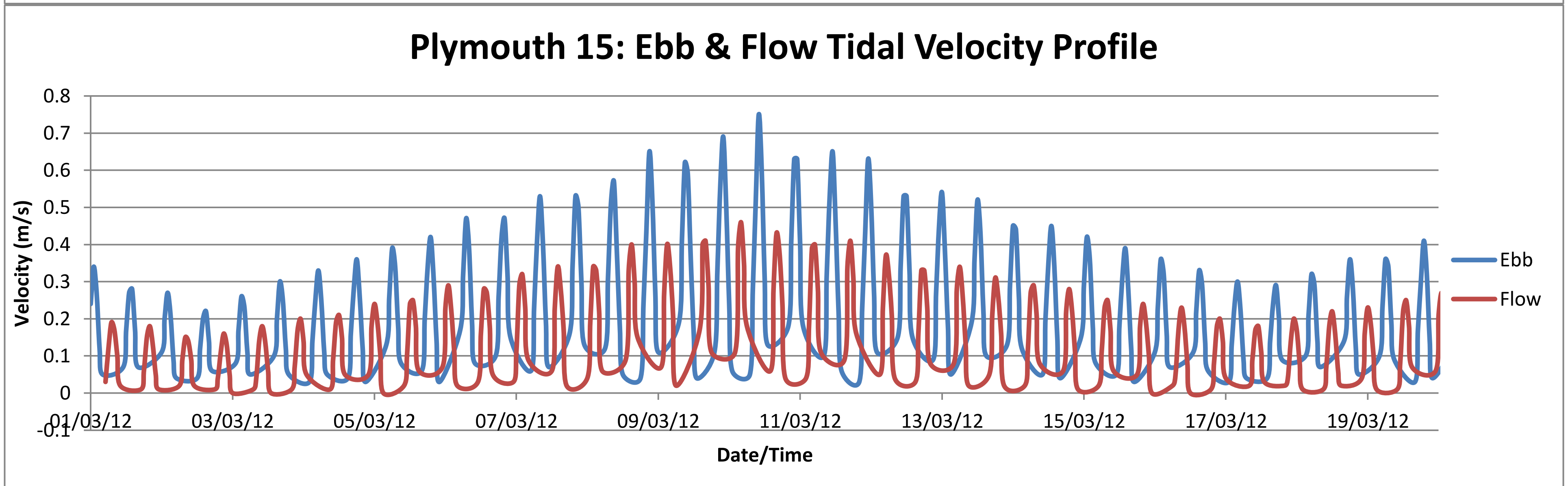

Dartmouth 13: Ebb & Flow Tidal Velocity Profile
0.4
0.3
0.2
0.1
0
-0.1
Velocity (m/s)
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flood

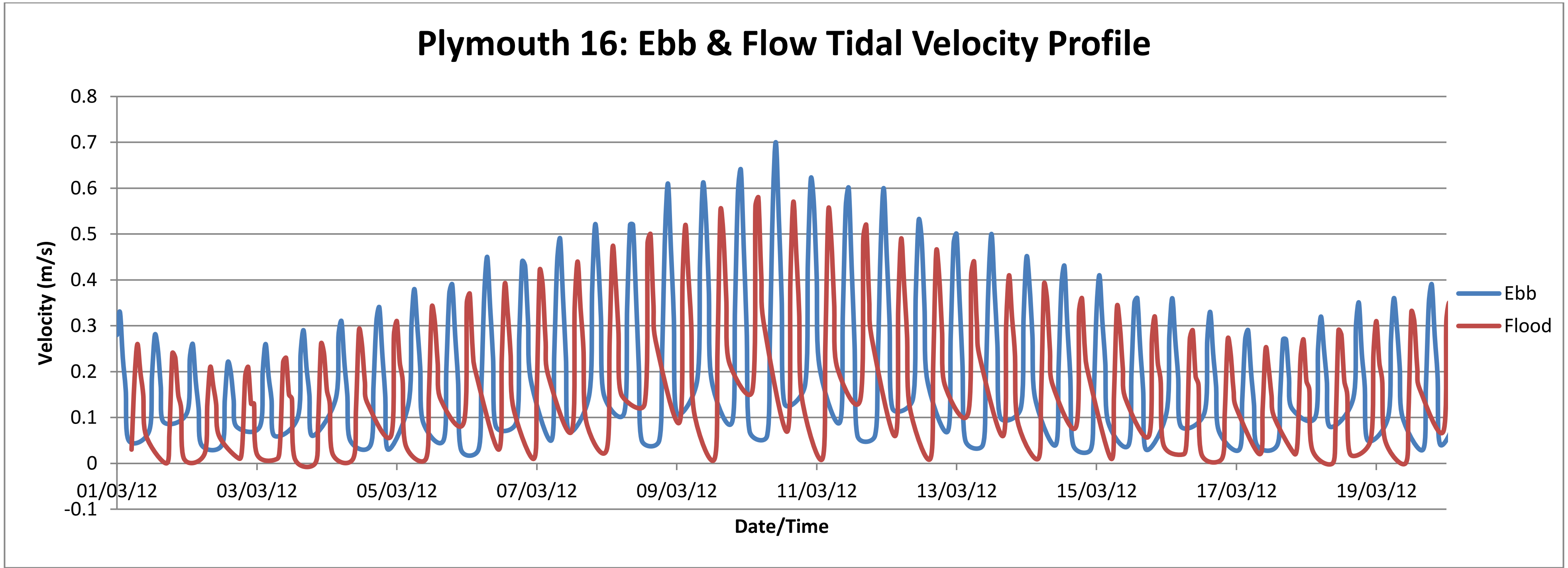
Plymouth

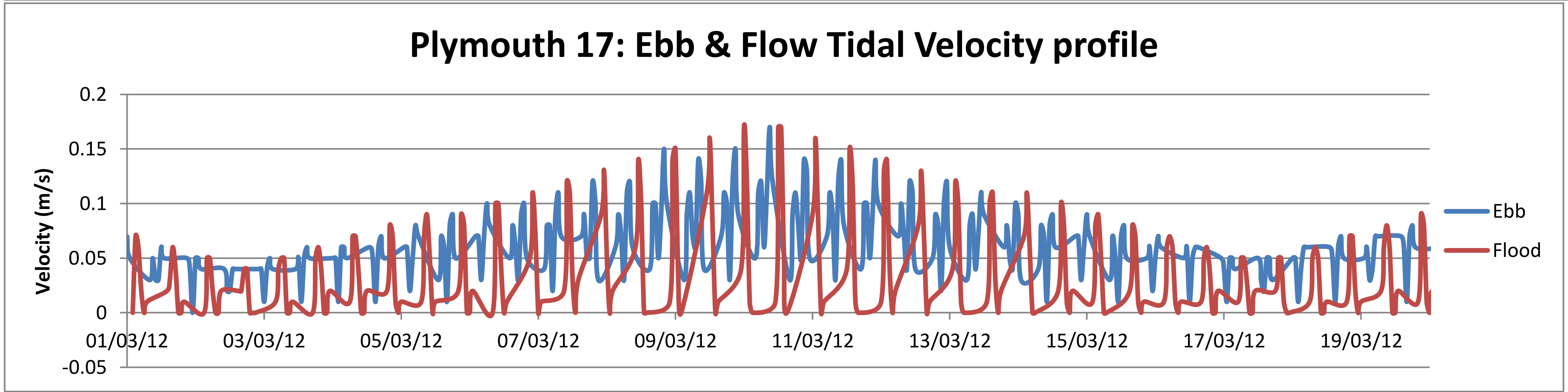

Plymouth 8: Ebb & Flow Tidal Velocity Profile
Velocity (m/s)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flood

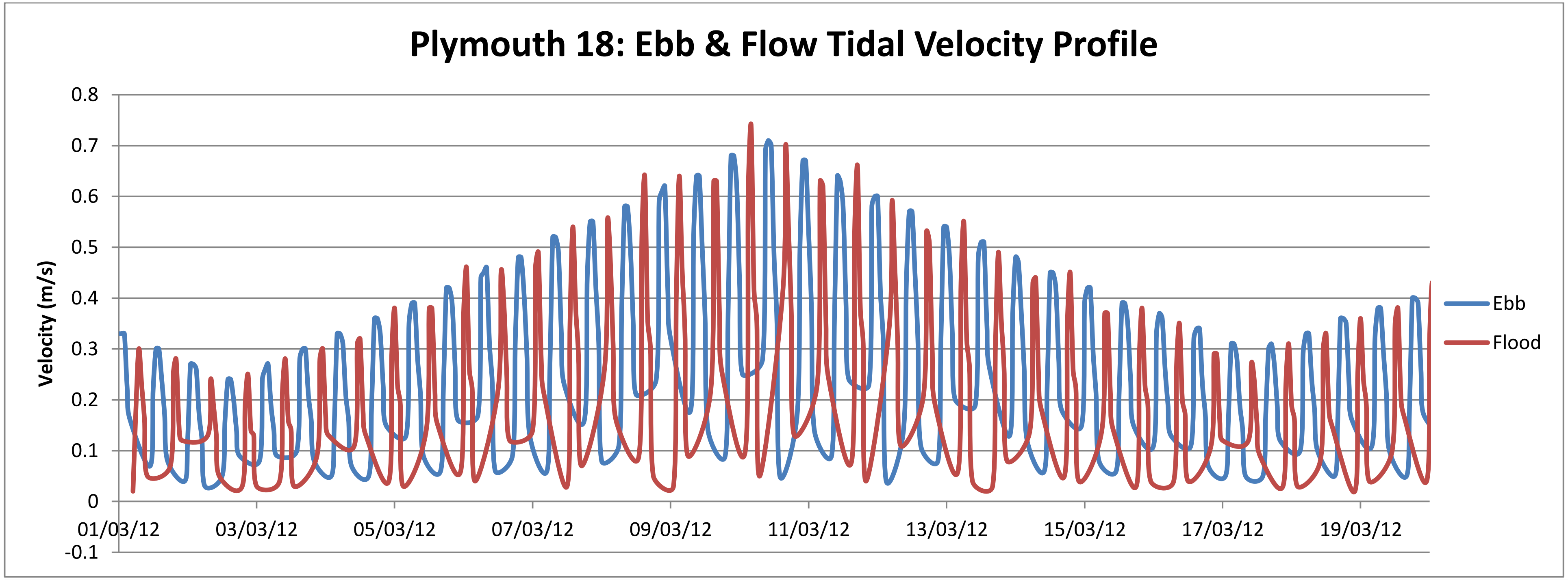

Plymouth 9: Ebb & Flow Tidal Velocity Profile
Velocity (m/s)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flood

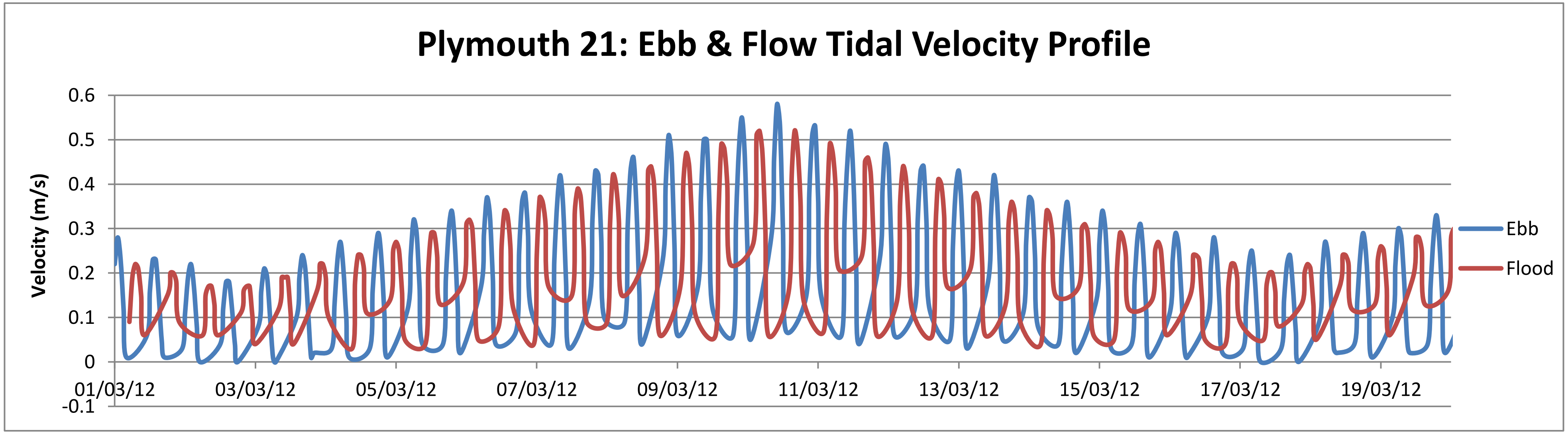

Plymouth 14: Ebb & Flow Tidal Velocity Profile
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Velocity (m/s)
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flood


Plymouth 15: Ebb & Flow Tidal Velocity Profile
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
Velocity (m/s)
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flow


Plymouth 16: Ebb & Flow Tidal Velocity Profile
Velocity (m/s)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Date/Time
Ebb
Flood


Plymouth 17: Ebb & Flow Tidal Velocity profile
Velocity (m/s)
0.2
0.15
0.1
0.05
0
-0.05
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Ebb
Flood


Plymouth 18: Ebb & Flow Tidal Velocity Profile
Velocity (m/s)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Ebb
Flood


Plymouth 21: Ebb & Flow Tidal Velocity Profile
Velocity (m/s)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
01/03/12
03/03/12
05/03/12
07/03/12
09/03/12
11/03/12
13/03/12
15/03/12
17/03/12
19/03/12
Ebb
Flood

Appendix 6 - WREN Fundamental Questions

Medium/format: **Email correspondence**

Date: **Thursday 3rd May 2012**

Present: **Sophie Stevens = SS**

Stephen Frankel = SF

SS: Who were the main initiators of the project - had they done anything like it before?

SF: Mainly me – I had run major initiatives before, including university departments, and national programmes, such as the NHS R&D programme - and Jerry Clark who is a major contributor to Green Building Magazine.

SS: What were the main reasons you started the project (ideally looking for things that are SPECIFIC to Wadebridge)?

SF: To show how the barriers to low carbon solutions in energy and otherwise are largely confected and sustained by the incumbents who benefit from them. There is nothing promising about Wadebridge in this respect, so if these changes can be readily accepted here, then rapid change elsewhere will become the norm. The local motivation was to create local economic resilience, common purpose, and enhance the quality of life.

SS: What has been you biggest issue with moving things forward? (both generally and in the case of the tidal side of things)

A lack of resources. We will become a self-sustaining organisation, but until the commercial returns from the energy economy are available, it is difficult to function at the right scale within the tidal area as any other.

SS: How many volunteers are currently working for WREN and how many do you think might get paid employment in the future?

There are some 10 very active volunteers, and some 10 also contributing practically. There are now almost 600 members. WREN itself will employ some 4-6 people, but the parallel employment in the low carbon sector, and research activity, will be considerable. For example we are developing the WREN EcoPark that will provide some 500 jobs.

Appendix 7 - Tidal Power: Understanding the Potential

What causes the tides?

Tides are the rise and fall of sea levels caused by many different components called ‘tidal constituents’. There are over 128 tidal constituents taking various factors into consideration. Tidal variation exists primarily due to the effect of the Moon’s gravitational field acting on the Earth but there are other factors too, which include the gravitational effect of the Sun, the rotation of the Earth and the local bathymetry.

In order to explain how the tides behave, the two most dominant tidal constituents are described below:

The Principle Lunar Semi-Diurnal Constituent, M_2

The association between the tides and the moon was first recorded at around 300BC by the Greek geographer Pytheas. In more recent times Newton derived his Law of Universal Gravitation which states that “*The force of gravitational attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them”.*

$$F \propto \frac{m_1 m_2}{d^2}$$

Using the above equation it is possible to calculate the gravitational force incident at a specified (non-dimensional) point on the Earth’s surface from the centre of another astronomical body.

If two points on the Earth’s surface A and B are taken to be the furthest and closest points from the Moons centre of gravity (see Figure 1a) if the Earth is said to have radius ‘r’ then point A, the point on the Earth’s surface closest to the Moon, will feel the force:

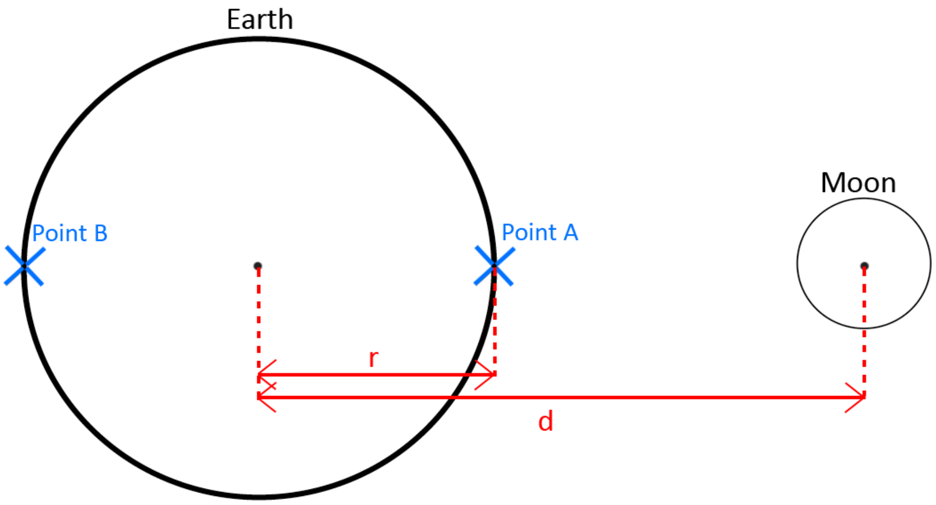
$$F \propto \frac{m_1 m_2}{(d-r)^2}$$

And at point B the gravitational force will be:

$$F \propto \frac{m_1 m_2}{(d+r)^2}$$

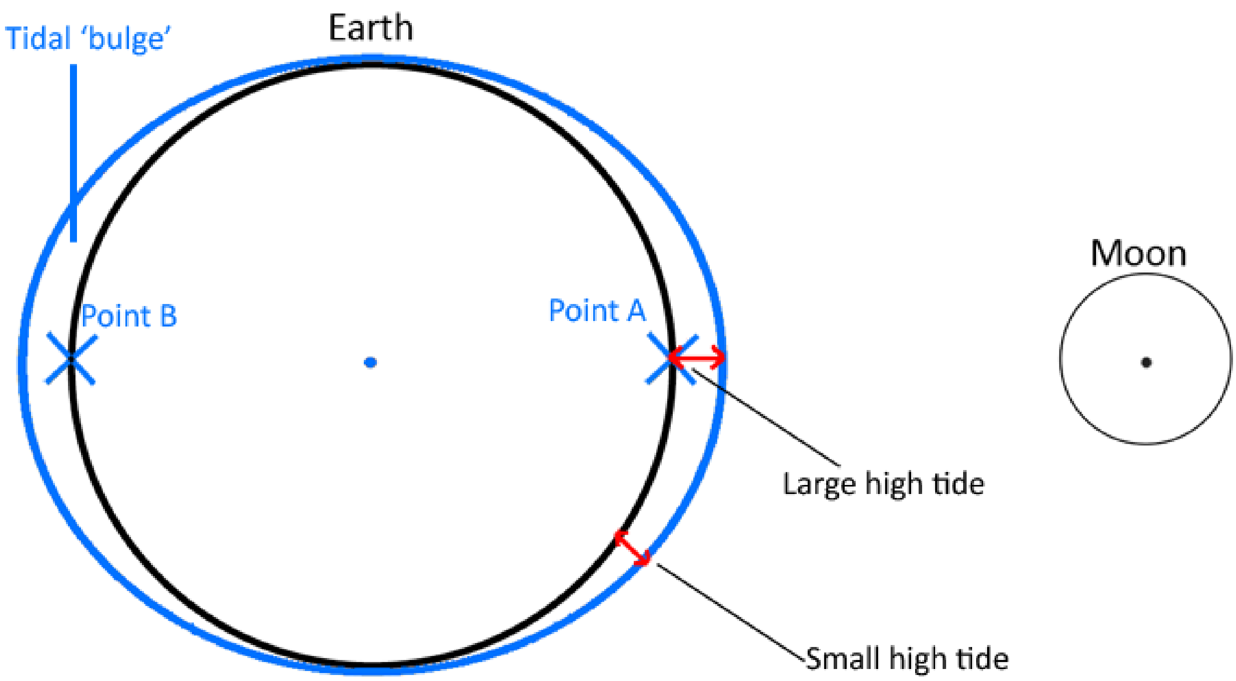
This proves that the side of the Earth closest to the Moon experiences a higher gravitational field than the side furthest away.

<u>Figure 1a - Gravitational Force Felt on Earth by the Moon</u>



The tidal force is therefore a differential force; the gravitational effect is felt most strong when closer to the moon and least strong when furthest from the moon. This difference in gravitational effect creates 'bulges' of water on either side of the Earth (see Figure 2a). The gravitational effect felt at Point A is 1.068 times that felt at Point B (Nave, 2000).

<u>Figure 2a - The Effect of the Gravitational Force on the Sea</u>

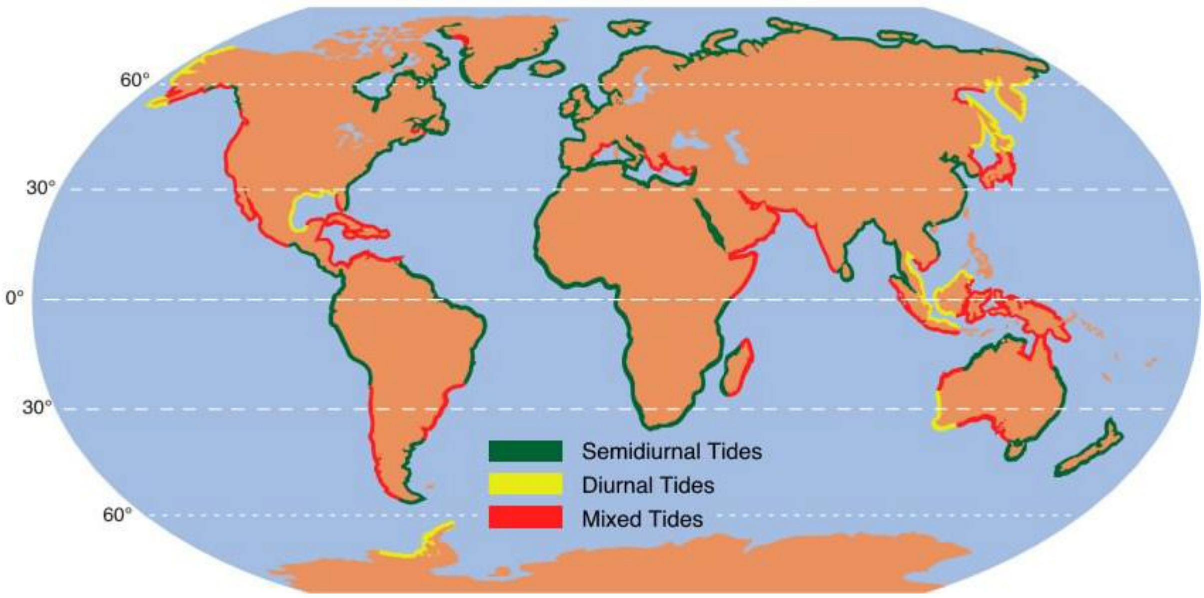


The Earth effectively rotates beneath these tidal 'bulges' so in the majority of locations, tides are semi diurnal (two high tides and two low tides every lunar day). A lunar day lasts 24 hours and 50 minutes.

Diurnal Tide

However since the Moon orbits the Earth at an angle to the equator, the tidal 'bulges' will sometimes be either side of the equator (one South and one North). This means as the Earth rotates there will be some points at which only one high tide and one low tide occur per day, called a diurnal tide (Schwartz, 2005). These areas are shown in Figure 3a.

Figure 3a - Geographic Distribution of Tidal type



Source: (Pidwirny, 2009).

Principle Solar Semidiurnal Constituent, S_2

The gravitational force of the Sun also affects the tides but although the Sun's mass is over 25 million times that of the Moon, the effect of the Sun is around 0.46 times that of the Moon. This is due to the astronomical difference in distance (Tomczak, 2005) between the two bodies. The principle solar semidiurnal constituent represents the rotation of the Earth with respect to the Sun and is based on a cycle of 12 hours.

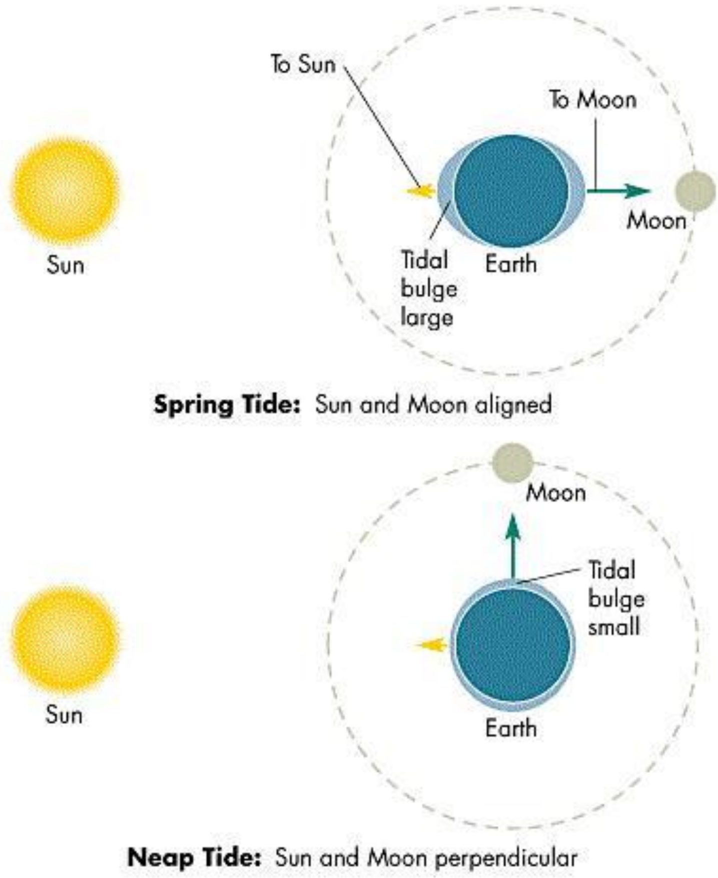
Bathymetry

Of course the Earth is not a perfect sphere, it has varying masses of land distributed over its surface and thus creating huge variances in the shape of sea and river beds, called bathymetry. Location specific tides and tidal waveforms are affected greatly by the local bathymetry of a particular site; in some locations bathymetry is the cause for deviation from a semidiurnal tide. Extreme examples of this exist such as in the South China Sea and the Gulf of Mexico, where they experience a diurnal tide due to bathymetry (MacKay, 2009).

Spring Tides and Neap Tides

When the Sun and the Moon are aligned with each other their combined forces create more extreme tides called ‘spring’ tides. This happens at both the new and full moon stages. Conversely, when the Moon and the Sun are at right angles to each other the gravitational effect of the Sun partly ‘cancels out’ the effect of the Moon, causing smaller tides called ‘neap’ tides (see Figure 4a).

Figure 4a - Spring Tides and Neap Tides



Source: (MHHE, 2012).