# Appendix C:  Hydrograph site calibration

## Hydrograph sites

### Afon Gain

Site description

A hydrograph recorder has been situated in the waterfall pool (fig.1) approximately 1km upstream from Pistyll Cain. Flow is measured at the outlet from the pool where the channel is constrained between rock outcrops. Access to the river is from the east bank, with flow measurement possible during low water and flood stages. The channel represents a bedrock reach, with isolated bed cover of cobbles and boulders of 0.5m to 1m median dimension.

Flow calculations

Theoretical water velocities have been calculated for three high-flow events:

| | 03-Feb-04 | 04-Feb-04 | 03-Jul-01 |
|---|---|---|---|
| **Manning's equation** | | | |
| Manning roughness | 0.05 | 0.05 | 0.04 |
| Cross sectional area at bankfull stage | 6.50 | 9.23 | 18.60 |
| cross sectional area / wetted perimeter | 0.70 | 0.60 | 0.90 |
| water surface downstream slope | 0.10 | 0.10 | 0.10 |
| **Discharge** | 32.41 | 41.51 | 137.09 |
| **Velocity** | 4.99 | 4.50 | 7.37 |
| **Relative Depth method** | | | |
| average water depth at bankfull | 1.23 | 1.16 | 2.41 |
| average bedload size | 0.60 | 0.60 | 1.00 |
| water surface downstream slope | 0.10 | 0.10 | 0.10 |
| channel relative depth F | 2.05 | 1.94 | 2.41 |
| roughness factor R | 1.63 | 1.58 | 1.79 |
| **Velocity** | 5.07 | 4.77 | 7.77 |

These points have been added to the river stage - flow velocity calibration graph fig.3, where they are shown outlined in red.


**Figure 1: Afon Gain hydrograph recording site. The recorder is located on the river bed at point A.**

**Figure 2: Line of section for flow velocity measurements at the outlet of the waterfall pool, Afon Gain**

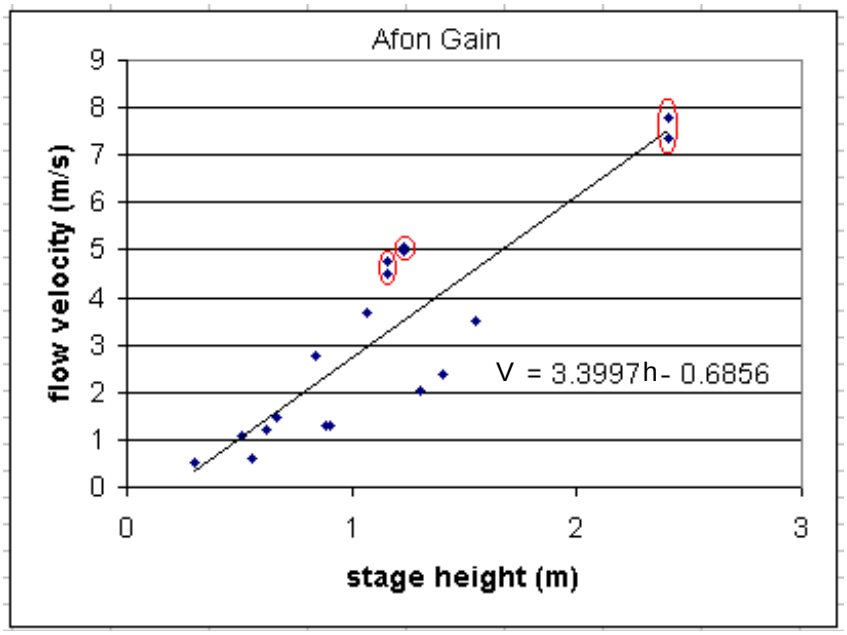


**Figure 3: Afon Gain hydrograph recording site: water depth – flow velocity calibration**

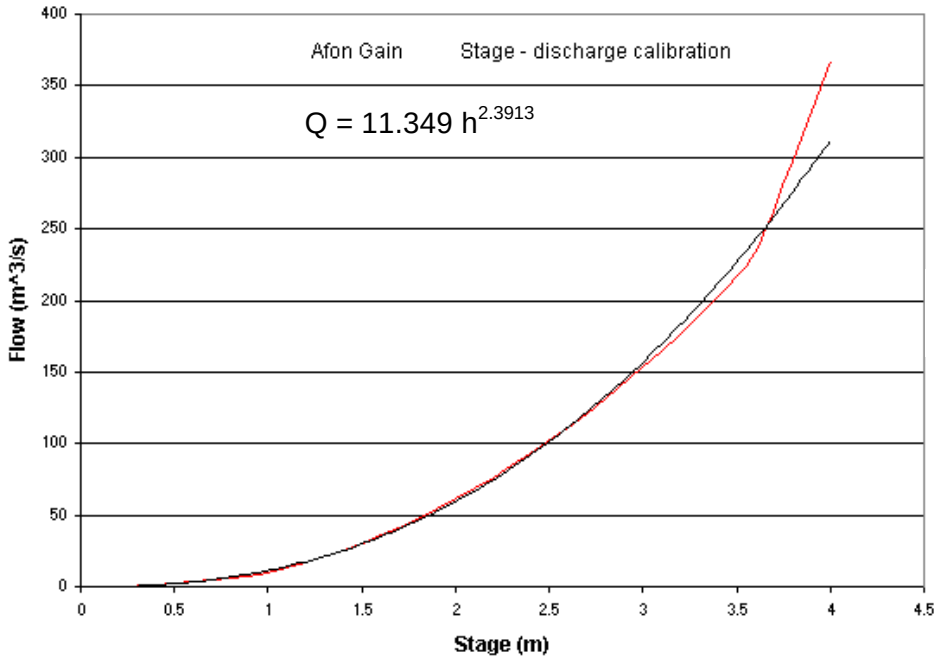


**Figure 4: Afon Gain hydrograph recording site: stage – discharge calibration.**
**Red line: determined from cross sectional area and flow velocity.**
**Black line: analytical approximation used in hydrograph plotting.**

**Pont Dolgefeiliau, Afon Eden**

Site description

A hydrograph recorder has been situated approximately 20m downstream from Pont Dolgefeiliau. Access for the measurement of flow velocities is possible from either bank, except during high flood conditions when the river extends onto the flood plain on both sides. The channel forms a plane bed reach on bedrock, with more than 90% cover of coarse gravel and cobbles in the range 0.1m to 0.5m median dimension.

Flow calculations

| | 03-Feb-04 | 03-Jul-01 |
|---|---|---|
| **Manning's equation** | | |
| Manning roughness | 0.03 | 0.02 |
| Cross sectional area at bankfull stage | 10.20 | 11.30 |
| cross sectional area / wetted perimeter | 1.00 | 1.00 |
| water surface downstream slope | 0.015 | 0.015 |
| **Discharge** | 41.65 | 69.22 |
| **Velocity** | 4.08 | 6.12 |
| **Relative Depth method** | | |
| average water depth at bankfull | 1.78 | 2.20 |
| average bedload size | 0.30 | 0.20 |
| water surface downstream slope | 0.015 | 0.015 |
| channel relative depth F | 5.93 | 11.02 |
| roughness factor R | 2.64 | 3.23 |
| **Velocity** | 3.82 | 5.20 |

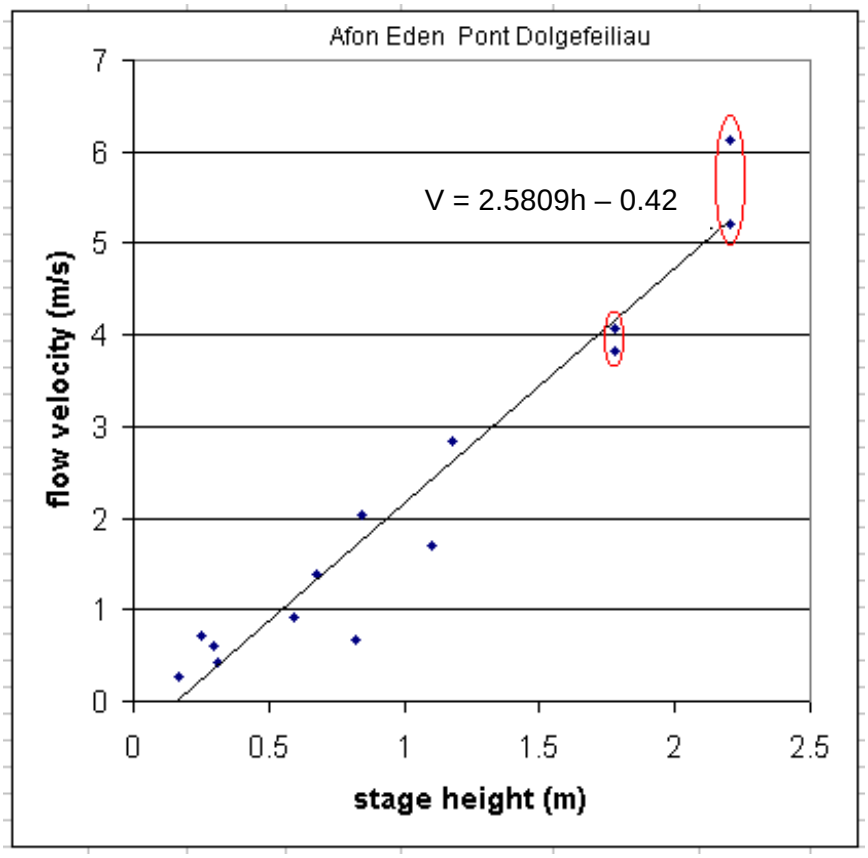


**Figure 5: Afon Eden hydrograph recording site: water depth – flow velocity calibration. Theoretical results outlined in red.**

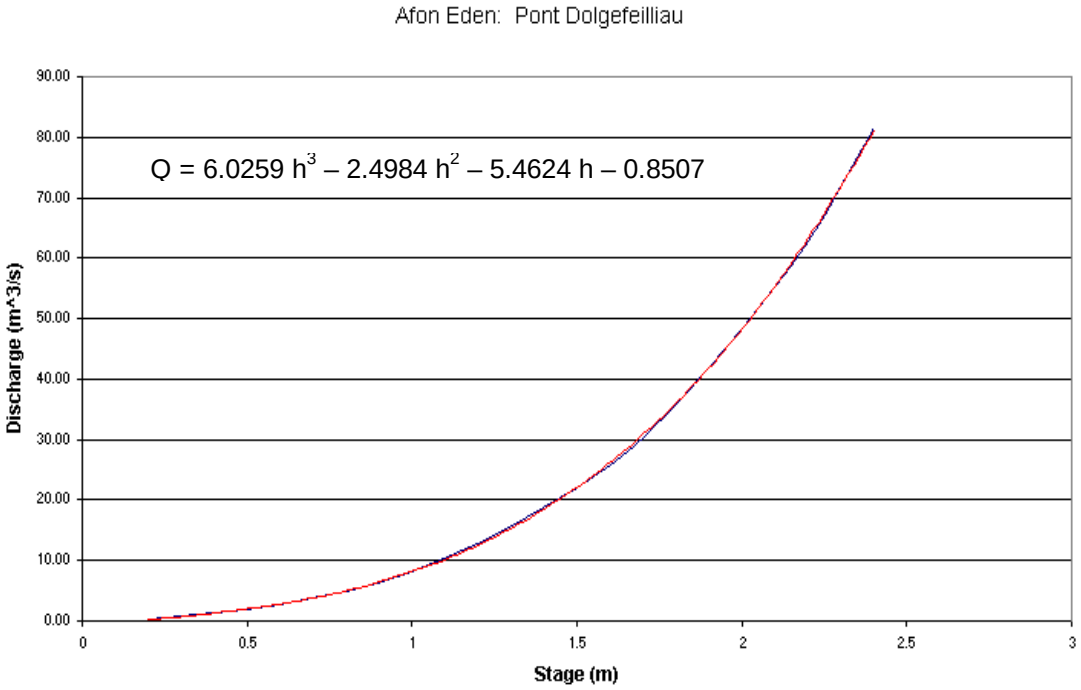


**Figure 6: Afon Eden hydrograph recording site: stage – discharge calibration.**

**Afon Wen**

Site description

A hydrograph recorder has been situated in the waterfall pool (fig.7) approximately 0.5km downstream from the village of Hermon. Flow is measured at the outlet from the pool where the channel is constrained between rock outcrops. Access to the river is from the east bank, with flow measurement possible during low water and flood stages. The channel represents a step pool reach, with bed cover of cobbles of 0.1m to 0.5m median dimension.


**Figure 7: Afon Wen hydrograph recording site. The water depth recorder is located in the pool at location A. Flow is measured at the pool outlet along the section shown in red.**

| | 03-Feb-04 | 03-Jul-01 |
|---|---|---|
| **Manning's equation** | | |
| Manning roughness | 0.03 | 0.03 |
| Cross sectional area at bankfull stage | 4.72 | 9.67 |
| cross sectional area / wetted perimeter | 0.90 | 1.20 |
| water surface downstream slope | 0.020 | 0.020 |
| **Discharge** | 20.75 | 51.49 |
| **Velocity** | 4.39 | 5.32 |
| | | |
| **Relative Depth method** | | |
| average water depth at bankfull | 1.15 | 1.94 |
| average bedload size | 0.10 | 0.20 |
| water surface downstream slope | 0.020 | 0.020 |
| channel relative depth F | 11.54 | 9.69 |
| roughness factor R | 3.27 | 3.11 |
| **Velocity** | 4.41 | 5.42 |

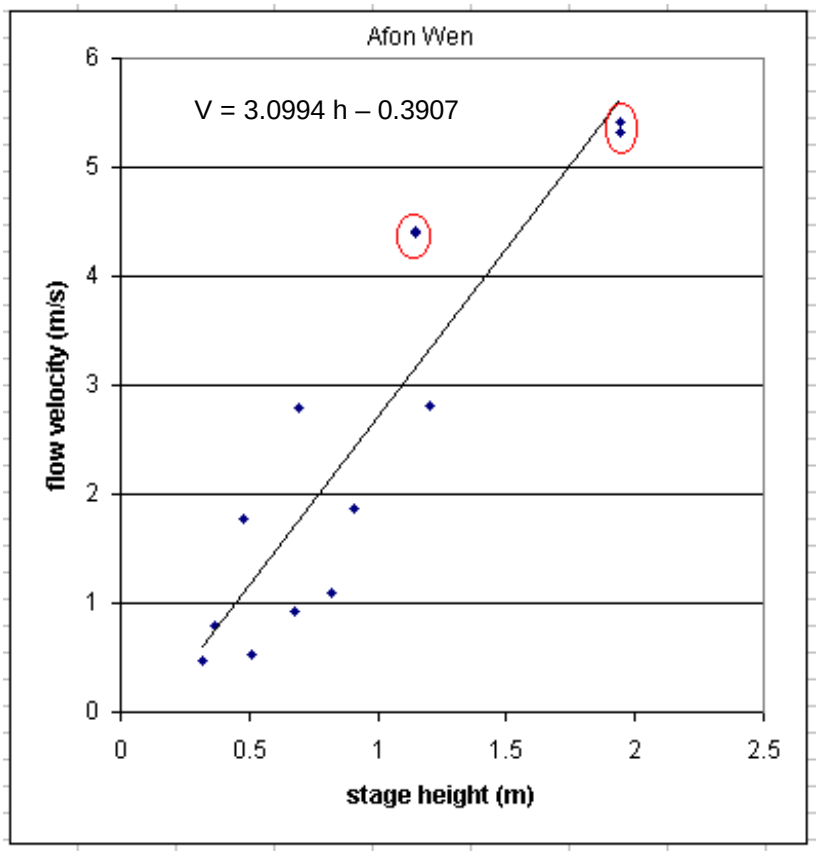


**Figure 8: Afon Wen hydrograph recording site: water depth – flow velocity calibration**

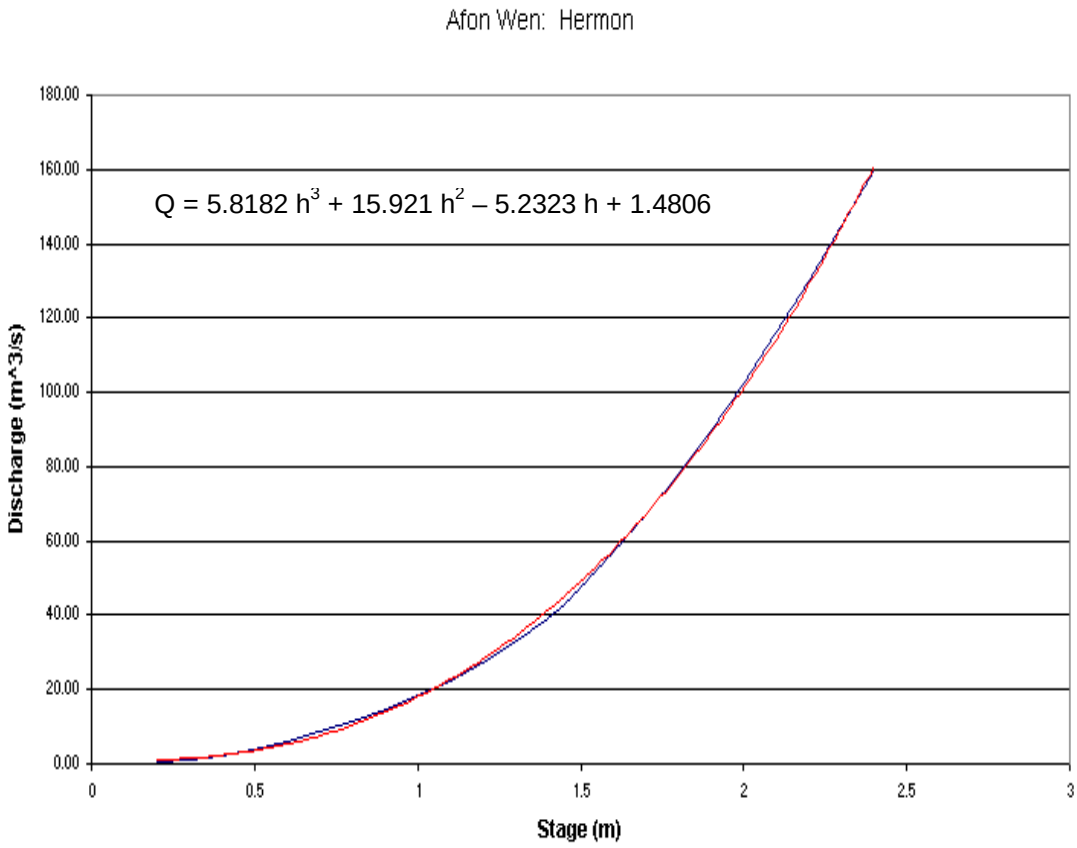


**Figure 9: Afon Wen hydrograph recording site: stage – discharge calibration**

## Afon Ty Cerrig

Site description

A hydrograph recorder has been situated in a pool on the Afon Ty Cerrig, a principal headwater stream of the Afon Wnion. This lies within a forestry plantation at Pared yr Ychain on the slopes of Aran Fawddwy. The channel is composed of cobbles and boulders of 0.5m to 1m median dimension, with a high gradient producing characteristics of a cascade reach. The channel is relatively narrow and confined within incised banks, making it accessible for flow measurement during low flow and flood conditions.

| | 03-Feb-04 | 03-Jul-01 |
|---|---|---|
| | 538 | 538 |
| **Manning's equation** | | |
| Manning roughness | 0.06 | 0.05 |
| Cross sectional area at bankfull stage | 4.69 | 5.12 |
| cross sectional area / wetted perimeter | 0.60 | 0.70 |
| water surface downstream slope | 0.10 | 0.10 |
| **Discharge** | 17.60 | 25.52 |
| **Velocity** | 3.75 | 4.99 |
| **Relative Depth method** | | |
| average water depth at bankfull | 1.10 | 1.80 |
| average bedload size | 0.80 | 1.00 |
| water surface downstream slope | 0.10 | 0.10 |
| channel relative depth F | 1.38 | 1.80 |
| roughness factor R | 1.25 | 1.51 |
| **Velocity** | 3.68 | 5.68 |

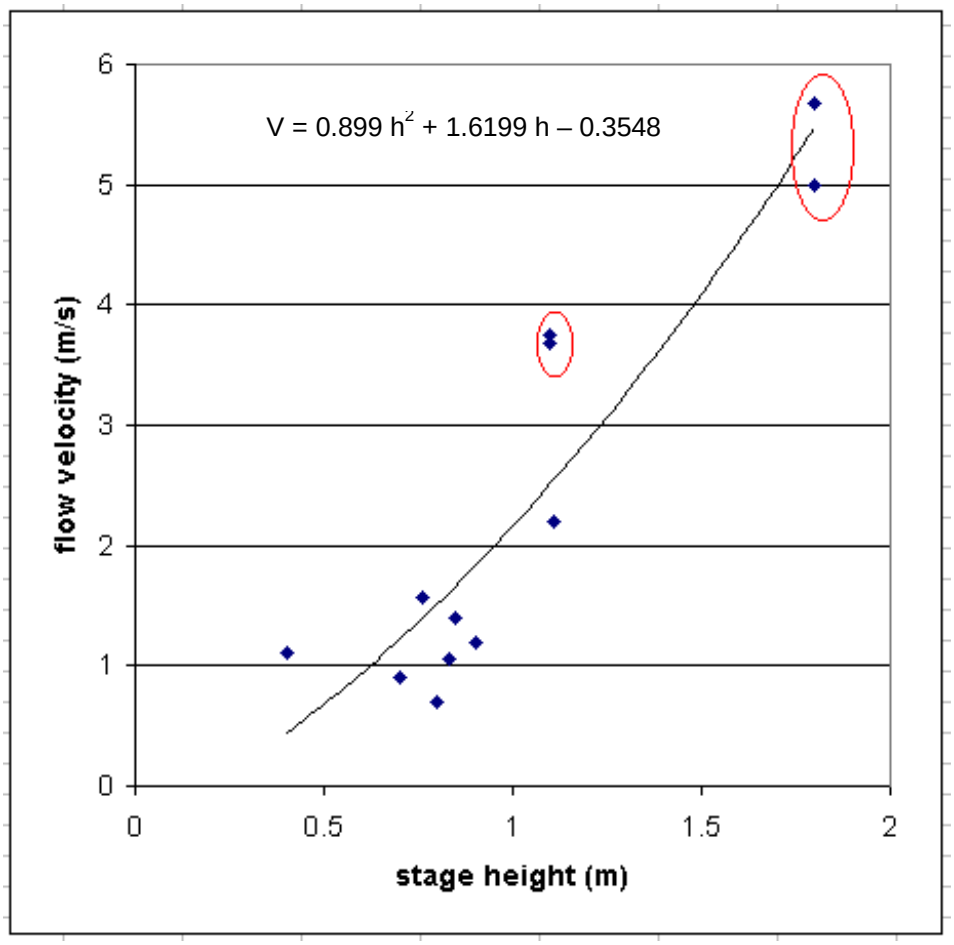


**Figure 10: Afon Ty Cerrig hydrograph recording site: water depth – flow velocity calibration**

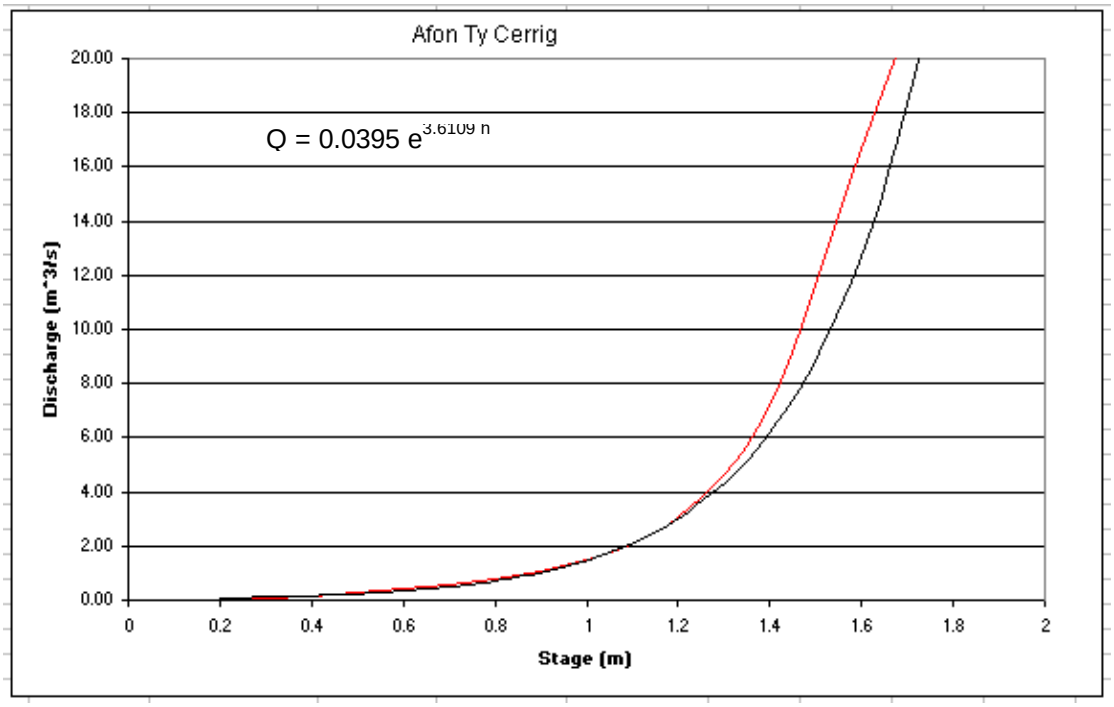


**Figure 11: Afon Ty Cerrig hydrograph recording site: stage – discharge calibration**

**Dolgellau**

Site description

River stage height data has kindly been supplied by the Environment Agency for the gauging ststion on the Afon Wnion approximately 40m upstream from Bont Fawr, Dolgellau. The gauge is situated on a plane bed reach, with coarse gravel in the size range 0.05m to 0.30m making up most of the bed load.

**Figure 12: Bont Fawr, Dolgellau, photographed from the Environment Agency river gauging station.**

| | 03-Feb-04 | 03-Jul-01 |
|---|---|---|
| **Manning's equation** | | |
| Manning roughness | 0.03 | 0.03 |
| Cross sectional area at bankfull stage | 29.55 | 51.29 |
| cross sectional area / wetted perimeter | 1.4 | 1.80 |
| water surface downstream slope | 0.02 | 0.02 |
| **Discharge** | 174.34 | 357.75 |
| **Velocity** | 5.90 | 6.98 |
| | | |
| **Relative Depth method** | | |
| average water depth at bankfull | 2.27 | 2.53 |
| average bedload size | 0.20 | 0.20 |
| water surface downstream slope | 0.02 | 0.02 |
| channel relative depth F | 11.35 | 12.65 |
| roughness factor R | 3.26 | 3.36 |
| **Velocity** | 6.15 | 6.70 |

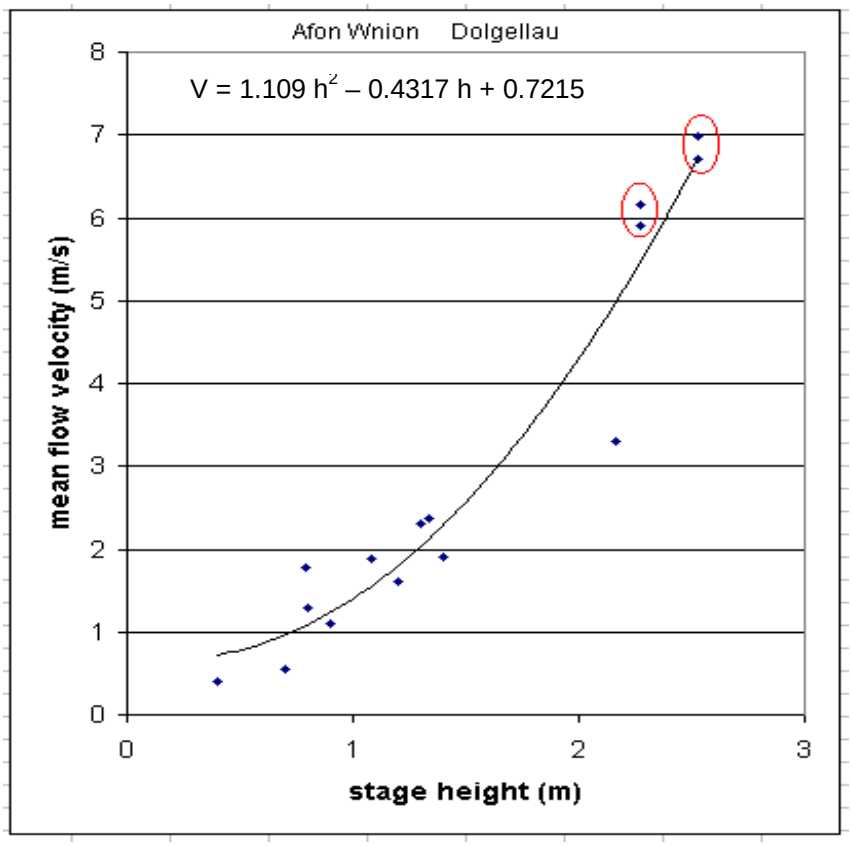


**Figure 13: Afon Wnion gauging station: water depth – flow velocity calibration**

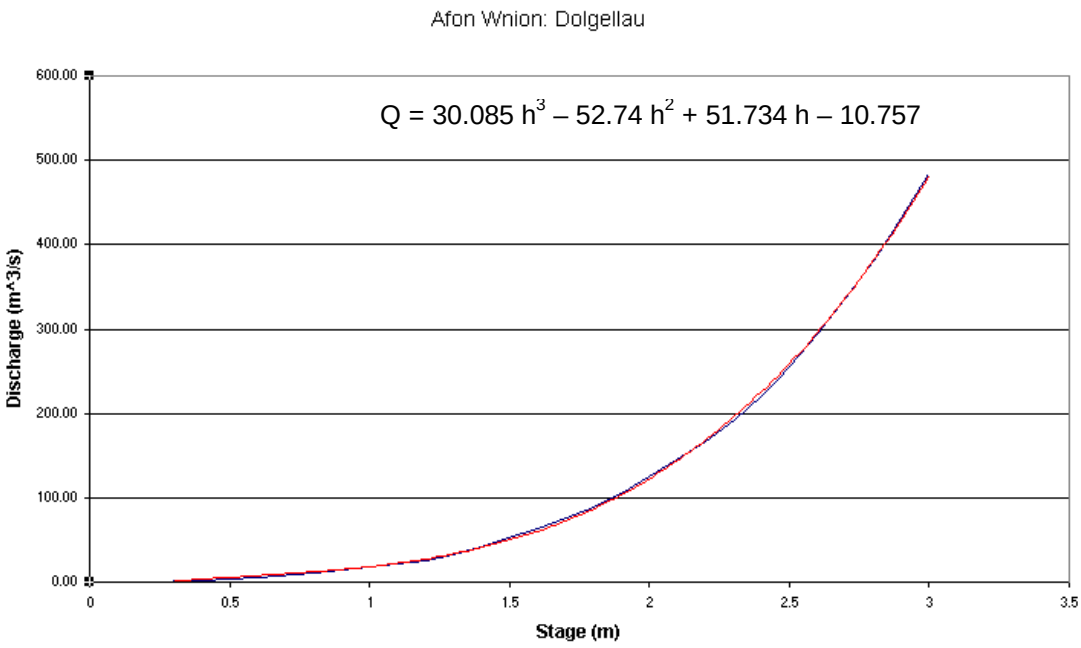


**Figure 14: Afon Wnion gauging station: stage – discharge calibration**