# Northumbria River Basin District
# Mining pollution: catchment characterisation report

## Project details

| | |
|---|---|
| **Project name:** | River |
| **Contact name:** | Peter Aldred |
| **Contact team:** | GWCL-North East Area |
| **Area Environment Manager:** | Julie Brooker |

## Water body summary information

| | |
|---|---|
| **Water body name:** | Nent from Source to South Tyne |
| **Water body id:** | GB103023075420 |
| **Water body type:** | Surface Water |
| **Catchment:** | South Tyne / River Tyne |
| **RBP Measure** | Minewater treatment and sediment management |
| **RFF database** | Zinc, Mitigation Measures, Fish |
| **Related catchments** | GB103023075531 S Tyne Black Bn to Tipalt<br>GB103023075532 S Tyne Tipalt to Allen<br>GB103023075710 S Tyne Allen to N Tyne |

## Water body classification (2009)

| | |
|---|---|
| Bad | |
| Poor | Biology |
| Moderate | Specific Pollutants, Supporting Elements |
| Good | |
| High | Phisico Chemical |
| Heavily modified water body? | Yes |
| **Comments** Priority and Priority Hazardous substances do not require assessment | |

## Summary of impacts from abandoned mines

| | | |
|---|---|---|
| NoCAM result | Impacted 16 | |
| Length of river impacted | 70 Km | |
| Groundwater body status | Poor Chemical status | |

## Mining Waste Directive

| **MWD inventory** | | | | | |
|---|---|---|---|---|---|
| **URN** | **Site name** | **Mine type** | **Reason** | **Easting** | **Northing** |
| 1005 | Nenthead Mines | Metaliferous | Water Pollution | 378420 | 543300 |
| 1137 | Hudgill Burn | Metaliferous | Water Pollution | 375180 | 545660 |

## Review of data and conceptual model

Background.
The Nent valley is one of the most intensively mined waterbodies in the country with extensive spoil heaps throughout the valley and a number of significant discharges from adits. A number of studies have been carried out over the years to try and get a picture of the extent of the metal pollution from the abandoned mines.

- Feasibility of the amelioration of the metalliferous discharges in the Nent, East and West Allen catchments by Entec in 1997. Confirmed the very wide spread nature of the problem.
- Aquatic zinc pollution from abandoned mines. Assessment and passive treatment in the Nent valley. Charlotte Nuttall 1997 PhD.
- North Pennines metal mine monitoring report – R Nent Atkins 2010 this conformed the importance of the pollution from 3 main mine adits in the Nent valley.
- Tyne catchment characterisation study P Aldred 2012

| Site Name | Flow | Pb Diss | Pb Load | | Cd Diss | Cd Load | | Zn Diss | Zn Load | |
|---|---|---|---|---|---|---|---|---|---|---|
| | L/s | µg/L | mg/s | % of Bywell | µg/L | mg/s | % of Bywell | µg/L | mg/s | % of Bywell |
| Average | | | | | | | | | | |
| S Tyne at Alston GS | 2317 | 7.97 | 18.4665 | 28 | 0.17 | 0.39389 | 14 | 57.4 | 133 | 10 |
| R Nent at Alston | 440 | 16.6 | 7.304 | 11 | 3.14 | 1.3816 | 47 | 1483 | 652.52 | 47 |
| S Tyne at Featherstone G.S | 6333 | 4.57 | 28.9418 | 44 | 0.33 | 2.08989 | 72 | 132 | 835.96 | 60 |
| E Allen u/s Allendale STW | 870 | 6.64 | 5.7768 | 9 | 0.19 | 0.1653 | 6 | 76.8 | 66.816 | 5 |
| W Allen at Hindley Wrae Fd | 1078 | 4.48 | 4.82944 | 7 | 0.86 | 0.92708 | 32 | 323 | 348.19 | 25 |
| S Tyne at Haydon Br | 11688 | 3.14 | 36.7003 | 55 | 0.21 | 2.45448 | 84 | 79.9 | 933.87 | 67 |
| R Tyne at Bywell | 41656 | 1.59 | 66.233 | 100 | 0.07 | 2.91592 | 100 | 33.5 | 1395.5 | 100 |

The above table is a summary of the loadings of metals into the R Tyne catchment and confirms the importance of the contribution from the Nent waterbody of 47% of the total load of Zinc and Cadmium.

Following a review of these studies the EA and CA started to look at the possibility of treating the mine discharges in the waterbody and installed flow loggers in 2 adits, Rampgill and Caplecleugh. This study was started at the same time to confirm the loading of metals and inform the design of treatment schemes.

Background information, history of mining, results of preliminary investigative monitoring etc.

## Geology

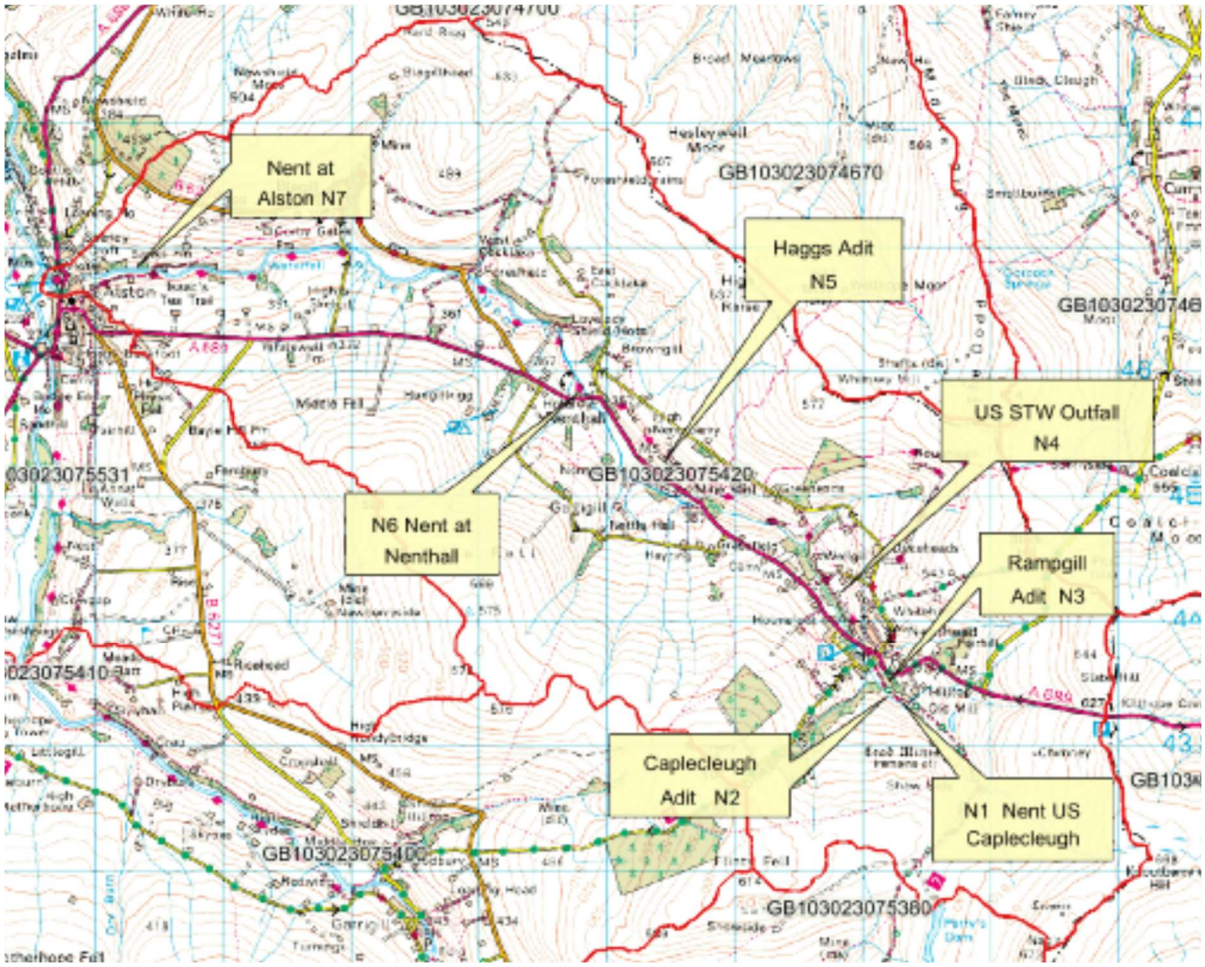
The Nent valley drains the Western side of the Alston Block mining area. This consists of a dome of 'Weardale' Granite overlain with thick limestone capped with sedimentary sandstones and mudstones. The limestone has fractured in multiple directions allowing hot mineral rich water to flow and leave ore deposits in many veins as it cooled. The ore body has a number of zones radiating out from the central source of mineralisation with zinc and lead more prominent towards the centre and Barium and Flourite further out. Nenthead is almost at the centre of the area and therefore has a particularly high zinc content, which is reflected in the high zinc concentration in the mine drainage. The limestone geology buffers acid produced when sulphide minerals oxidise, resulting in the minewaters discharging being close to neutral pH. The main river and tributaries are deeply incised into the rock exposing some of the veins and enabling historical mines to access the minerals.

## Biology

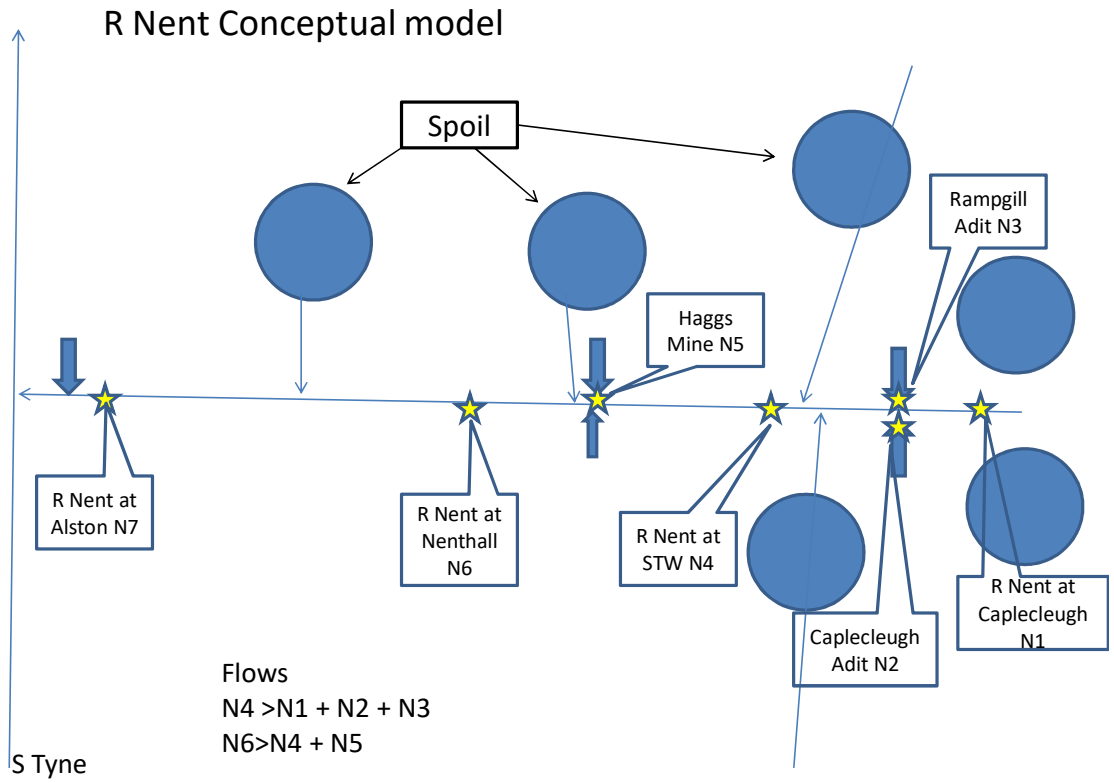
Brief summary of any historical biology data – fish, inverts, diatoms??

## Monitoring program

A monitoring program was set up to measure the metal load (flow and quality) with all points being sampled within one day to enable the same conditions to be assessed. Information from the Atkins 2010 report indicated that 3 point sources Caplecleugh Adit, Rampgill Adit and Haggs Adit, were significant and could lead to significant benefits to the river if treated so were targeted for sampling. Other discharges were of very low flow and could potentially be included in larger treatment schemes. The Nentforce level although a major source of metals was thought to be too difficult to monitor and with no space to treat and was left out of this survey, although further investigations are to be undertaken to look at the source of the flow and whether it could be prevented or diverted to alternative sites.

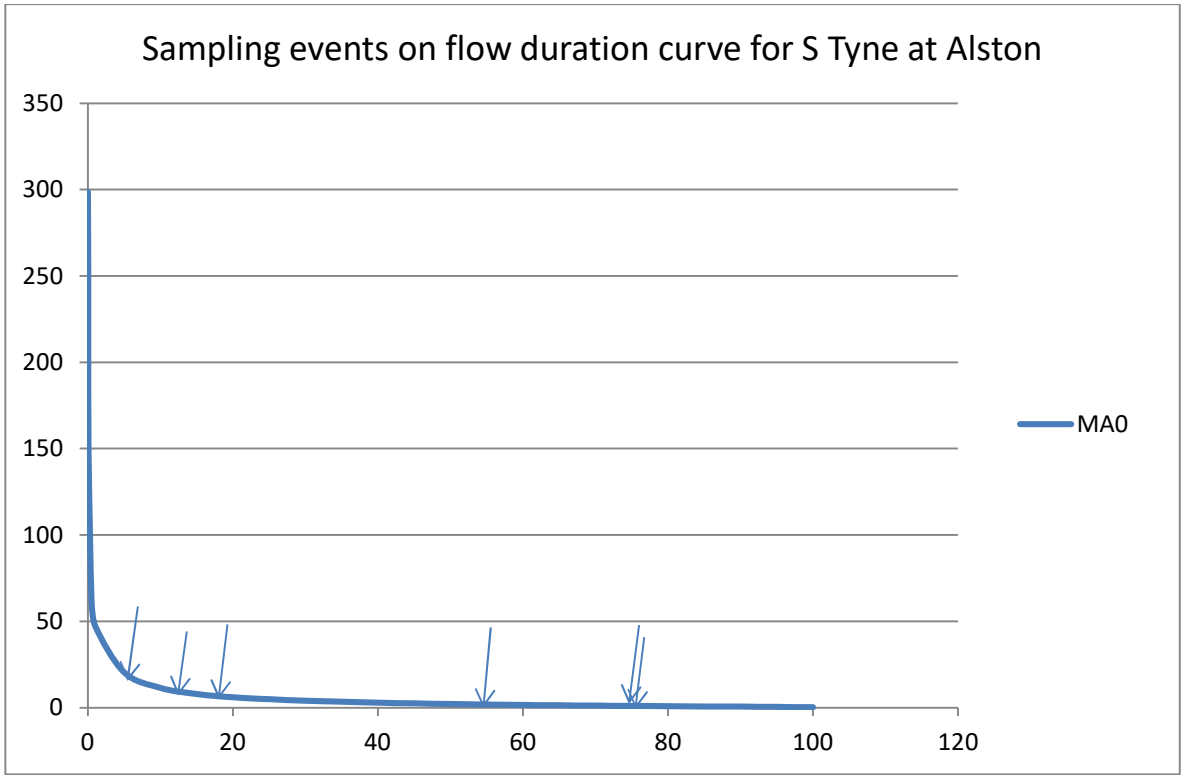


## Conceptual Model




## Flow

S Tyne at Alston Gauging station flow duration curve with sampling events marked



A reasonable wide range of flow events have been sampled but we are still awaiting samples from the lowest flow conditions. In very high flows gauging in the R Nent can be dangerous due to algae on the bed and the high speed of the flows, so no flows have been obtained with Q at Alston <19 which limits the interpretation of the data for these conditions.

Flow balances

| **Date** | N1 | N2 | N3 | N1+N2+N3 | N4 |
|---|---|---|---|---|---|
| 11/12/2013 | 206 | 8.5 | 7.6 | 222.1 | 285 |
| 16/01/2014 | 308 | 19.8 | 7.2 | 335 | 474 |
| 19/02/2014 | 669 | 23.2 | 6.5 | 698.7 | 971 |
| 17/03/2014 | 109 | 9.5 | 3.5 | 122 | 121 |
| 15/04/2014 | 114 | 12.0 | 4.1 | 130.1 | 164 |
| 08/05/2014 | 345 | 13.0 | 3.0 | 361 | 602 |

| **Date** | N4 | N5 | N4+N5 | N6 |
|---|---|---|---|---|
| 11/12/2013 | 285 | 11 | 296 | 428 |
| 16/01/2014 | 474 | 10 | 484 | 696 |
| 19/02/2014 | 971 | 15 | 986 | Hi Flow |
| 17/03/2014 | 121 | 12 | 133 | 239 |
| 15/04/2014 | 164 | 4.0 | 168 | 284 |
| 08/05/2014 | 602 | 4.3 | 606.3 | 870 |

In both of the above situations it is known there are tributaries adding to the flow in the main river between monitoring points so I would expect the downstream point flows to exceed the calculated flows which they do apart from one occasion.
It is noted that the only point where calculated flows don't agree with measured flows is on the lowest flow conditions when we could expect less accurate data due to water flowing amongst gravels on the bed.
Between March 2014 and April 2014 the flow monitoring at Haggs mine N5 changed from a spot flow/area gauging to an in pipe flow logger. It is noted there appears to have been a step change in flow results here, it would be of benefit to check the calibration of the 2 methods to confirm the results.

## Results

**Should include all dets of significance**

**Table 1**

| River Nent Average Data (µg/l) (min-max) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Site Name** | **Flow L/s** | **pH** | **Hard** | **Tot Pb** | **Diss Pb (EQS 7.2)** | **Tot Cd** | **Diss Cd (EQS 0.08)** | **Tot Zn (EQS 8,50,75)** | **Diss Zn** |
| Nent at Caplecleugh | 292<br>109-669 | 7.14<br>6.7-7.6 | 23.1<br>13.7-40 | 26.9<br>18.6-44 | 19.3<br>10.5-35 | 0.72<br>0.6-0.8 | 0.67<br>0.57-0.74 | 270<br>246-295 | 266<br>239-297 |
| Caplecleugh at Nent | 14.5<br>9.5-23 | 8.04<br>7.7-8.2 | 274<br>172-325 | 39.8<br>29-69 | 28.9<br>25-37 | 12.7<br>9.6-15 | 12.6<br>9.5-14.8 | 7427<br>5730-8690 | 7473<br>5710-8920 |
| Rampgill Adit | 5.3<br>2.9-7.5 | 8.28<br>8.1-8.4 | 259<br>196-310 | 398<br>13-1790 | 8.39<br>4.4-13.2 | 5.07<br>3.2-11.5 | 3.19<br>2.9-3.4 | 2938<br>1790-6870 | 1825<br>1580-1980 |
| Nent just US Nenthead STW outfall | 436<br>121-971 | 7.94<br>7.6-8.2 | 53.3<br>28-90 | 37.1<br>23-51 | 21.1<br>13-37 | 1.94<br>1.5-2.8 | 1.77<br>1.4-2.3 | 888<br>617-1280 | 845<br>607-1150 |
| Haggs at Nent | 9.4<br>3.9-15 | 7.83<br>6.3-8.2 | 527<br>493-553 | 4.54<br>2.5-10 | 0.6<br><2-3.5 | 11.6<br>10.3-13.7 | 11.4<br>10.2-13 | 11900<br>10700-13700 | 11700<br>10800-13300 |
| Nent at Nenthall | 503<br>239-< | 8.35<br>8.1-8.5 | 94.3<br>37-186 | 36.7<br>18.6-78 | 19.2<br>8.9-36 | 2.86<br>1.5-4.8 | 2.7<br>1.5-4.6 | 1322<br>709-2140 | 1301<br>672-2170 |
| R Nent at Alston | 652<br>223-< | 8.31<br>8.1-8.6 | 89.3<br>42-158 | 46.6<br>21-91 | 21<br>11.2-33 | 2.97<br>1.5-4.8 | 2.66<br>1.5-3.7 | 1156<br>701-1820 | 1083<br>672-1450 |

The upstream point chosen for this investigation has a significant failure for Cadmium, Lead and Zinc, however this is expected due to this point being downstream of the mine site but upstream of the point source discharges so gives a useful indication of the diffuse pollution.
Comparing the current results with Atkins 2010 data the Caplecleugh and Rampgill adits are similar concentrations but the Haggs mine has almost doubled its concentration of Cadmium and Zinc over this period. It is unclear what may have caused this although it is known that mine explorers have removed roof collapse blockages within the mine and this may have altered underground water flows.

## Water quality – adits

| Name | Flow (l/s) | pH | µg/l (dissolved) | | | | | Mn | $SO_4$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Pb | Cd | Zn | Cu | Fe | | |
| | Mean (Min – Max) | Mean (Min – Max) | Mean (Min – Max) | Mean (Min – Max) | Mean (Min – Max) | Mean (Min – Max) | Mean (Min – Max) | Mean (Min – Max) | Mean (Min – Max) |
| Caplecleugh MW | 14.5 9.5-23 | 8.02 7.4-8.2 | 22.4 12-36 | 12.9 9.5-15 | 7825 5710-9890 | 1.13 <1-2.4 | 20.2 <30-79 | 188 126-208 | 175 99-209 |
| Rampgill MW | 5.3 2.9-7.5 | 8.13 7.8-8.3 | 5.09 <2-13.2 | 3.19 2.8-3.5 | 1917 1690-2240 | 0.16 <1-1.4 | 28 <30-108 | 127 96-159 | 124 84-141 |
| Haggs MW | 9.4 3.9-15 | 7.89 7.6-8.1 | 0.4 <2-3.6 | 11.8 10.2-13.6 | 12844 10800-16600 | 1.57 <1-3.47 | <30 | 398 344-605 | 432 401-462 |
| Croft MW (2010) | | 7.69 7.6-7.7 | <2 | 3.72 3.6-3.9 | 1607 1510-1700 | 0.85 <1-1.5 | 27 <30-37 | 66 64-67 | 90 89-91 |
| Nent Force Level (2010) | | 7.57 7.5-7.58 | <2 | 2.46 2.4-2.52 | 1526 1450-1580 | 0.24 <1-1.2 | <30 | 15 14-16 | 130 125-134 |

## Metal loading  Preferred units for all loads should be ug/s

| Site Name | Flow L/s | Pb Diss µg/L | Pb Load ug/s | Pb Load % of Alston | Cd Diss µg/L | Cd Load ug/s | Cd Load % of Alston | Zn Diss µg/L | Zn Load ug/s | Zn Load % of Alston |
|---|---|---|---|---|---|---|---|---|---|---|
| 11/12/2013 Q 54 | | | | | | | | | | |
| Nent at Caplecleugh | 206 | 10.5 | 2163 | 14 | 0.584 | 120 | 5 | 239 | 49234 | 4 |
| Caplecleugh at Nent | 8.5 | 27.7 | 237 | 1.5 | 9.98 | 85 | 3 | 5850 | 49977 | 4 |
| Rampgill Adit | 7.5 | 6.26 | 47 | 0.3 | 3.42 | 26 | 1 | 1980 | 14947 | 1 |
| Nent just US Nenthead STW | 285 | 12.9 | 3677 | 24 | 1.61 | 459 | 18 | 777 | 221445 | 20 |
| Haggs at Nent | 11 | 0 | 0 | 0 | 13 | 143 | 6 | 13300 | 146300 | 13 |
| Nent at Nenthall | 428 | 18.5 | 7918 | 53 | 2.65 | 1134 | 44 | 1350 | 577800 | 52 |
| R Nent at Alston | 825 | 18.2 | 15015 | 100 | 3.09 | 2549 | 100 | 1350 | 1113750 | 100 |
| 16/01/2014 Q 19 | | | | | | | | | | |
| Nent at Caplecleugh | 308 | 17.3 | 5328 | 28 | 0.703 | 217 | 7 | 274 | 84392 | 8 |
| Caplecleugh at Nent | 20 | 26.8 | 532 | 3 | 14.8 | 294 | 10 | 8920 | 176982 | 16 |
| Rampgill Adit | 7 | 8.08 | 58 | 0.3 | 3.34 | 24 | 1 | 1830 | 13171 | 1 |
| Nent just US Nenthead STW | 474 | 19.2 | 9101 | 48 | 1.74 | 825 | 28 | 836 | 396264 | 36 |
| Haggs at Nent | 10 | 3.57 | 36 | 0.2 | 10.6 | 106 | 4 | 10900 | 109000 | 10 |
| Nent at Nenthall | 696 | 17.5 | 12180 | 64 | 1.87 | 1302 | 44 | 929 | 646584 | 59 |
| R Nent at Alston | 1220 | 15.7 | 19154 | 100 | 2.4 | 2928 | 100 | 904 | 1102880 | 100 |
| 19/02/2014 Q 9 | | | | | | | | | | |
| Nent at Caplecleugh | 669 | 25.1 | 16792 | ###### | 0.765 | 512 | ###### | 297 | 198693 | ###### |
| Caplecleugh at Nent | 23 | 37 | 859 | ###### | 9.51 | 221 | ###### | 5710 | 132546 | ###### |
| Rampgill Adit | 6.4 | 13.2 | 85 | ###### | 3.32 | 21 | ###### | 1690 | 10924 | ###### |
| Nent just US Nenthead STW | 971 | 28.6 | 27771 | ###### | 1.47 | 1427 | ###### | 629 | 610759 | ###### |
| Haggs at Nent | 15 | 0 | 0 | ###### | 10.2 | 153 | ###### | 10800 | 162000 | ###### |
| Nent at Nenthall | Hi Flow | 22 | ##### # | ###### | 1.45 | ##### | ###### | 672 | #VALUE ! | ###### |
| R Nent at Alston | Hi Flow | 18.9 | ##### # | ###### | 1.53 | ##### | ###### | 672 | #VALUE ! | ###### |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 17/03/2014 Q 73 | | | | | | | | | | |
| Nent at Caplecleugh | 109 | 14.4 | 1570 | 25 | 0.571 | 62 | 7 | 246 | 26814 | 8 |
| Caplecleugh at Nent | 9.5 | 25 | 237 | 4 | 14.5 | 137 | 16 | 8270 | 78358 | 24 |
| Rampgill Adit | 3.5 | 4.36 | 15 | 0.2 | 2.99 | 10 | 1 | 1910 | 6683 | 2 |
| Nent just US Nenthead STW | 121 | 14.4 | 1742 | 28 | 2.29 | 277 | 33 | 1150 | 139150 | 43 |
| Haggs at Nent | 12 | 0 | 0 | 0 | 11.2 | 134 | 16 | 11300 | 135600 | 42 |
| Nent at Nenthall | 239 | 8.9 | 2127 | 34 | 4.57 | 1092 | 131 | 2170 | 518630 | 160 |
| R Nent at Alston | 223 | 28.3 | 6311 | 100 | 3.74 | 834 | 100 | 1450 | 323350 | 100 |
| 15/04/2014 Q 73 | | | | | | | | | | |
| Nent at Caplecleugh | 114 | 13.2 | 1505 | 40 | 0.669 | 76 | 7 | 269 | 30666 | 7 |
| Caplecleugh at Nent | 12 | 30.7 | 368 | 10 | 13.2 | 158 | 14 | 8320 | 99682 | 22 |
| Rampgill Adit | 4.1 | 7.14 | 29 | 1 | 3.09 | 13 | 1 | 1960 | 8063 | 2 |
| Nent just US Nenthead STW | 164 | 15.1 | 2476 | 65 | 2.1 | 344 | 31 | 1070 | 175480 | 39 |
| Haggs at Nent | 4 | 0 | 0 | 0 | 10.8 | 43 | 4 | 11500 | 45897 | 10 |
| Nent at Nenthall | 284 | 12.1 | 3436 | 90 | 4 | 1136 | 103 | 1970 | 559480 | 125 |
| R Nent at Alston | 340 | 11.2 | 3808 | 100 | 3.25 | 1105 | 100 | 1320 | 448800 | 100 |
| 08/05/2014 Q 16 | | | | | | | | | | |
| Nent at Caplecleugh | 345 | 35 | 12075 | ###### | 0.736 | 253 | ###### | 268 | 92460 | ###### |
| Caplecleugh at Nent | 14 | 26.4 | 369 | ###### | 13.6 | 190 | ###### | 7770 | 108640 | ###### |
| Rampgill Adit | 3 | 11.3 | 34 | ###### | 2.95 | 9 | ###### | 1580 | 4705 | ###### |
| Nent just US Nenthead STW | 602 | 36.5 | 21973 | ###### | 1.42 | 855 | ###### | 607 | 365414 | ###### |
| Haggs at Nent | 4.2 | 0 | 0 | ###### | 12.6 | 54 | ###### | 12400 | 52725 | ###### |
| Nent at Nenthall | 870 | 36.1 | 31407 | ###### | 1.67 | 1453 | ###### | 717 | 623790 | ###### |
| R Nent at Alston | Hi Flow | 33.4 | ##### # | ###### | 1.94 | ##### | ###### | 799 | #VALUE ! | ###### |
| Atkins report 2010 mean values | | | | | | | | | | |
| Nent at Caplecleugh | | 19.5 | | | 2.49 | | | 995 | | |
| Caplecleugh at Nent | 13.8 | 23.08 | | 0.7 | 11.87 | | 11 | 6950 | | 17 |
| Rampgill Adit | 13.1 | 4.81 | | 0.4 | 3.39 | | 3 | 1889 | | 4 |
| Nent just US Nenthead STW | 275 | 17.57 | | 17 | 3.31 | | 23 | 1573 | | 27 |
| Haggs at Nent | 12.7 | <2 | | 0.2 | 4.22 | | 3 | 5911 | | 11 |
| Nent at Nenthall | | 15.85 | | | 3.13 | | | 1536 | | |
| R Nent at Alston | | 14.62 | | | 2.83 | | | 1266 | | |

## Bioavailable Zinc

All sites exceed the Zinc, Cadmium and Lead EQS by a large margin including the chosen upstream point

## Potential water quality improvements from treating point sources (use MINDAR s/s)

Currently due to the data available it is difficult to evaluate the impacts of the mines. Caplecleugh and Haggs adits appear to be the major point sources into the river Nent.
It is difficult to flow gauge the lower reaches of the Nent in high flows for Health and safety reasons so we cannot calculate the contributions to the river in these conditions. However this should not be too much of a problem as point sources are usually a larger contribution in low flows when we could expect greater benefits from a treatment scheme but we are likely to need to monitor for a longer period to get enough useful data.

The flow from the Haggs mine needs to be confirmed as this looks like the major contributor to the pollution load. Also if there has been a significant change in concentration is this going to stay high or could it reduce over time, longer term monitoring is required to confirm this.

## Constraints

### Land owners and occupiers

If known, please state land owners and occupiers. Do not include contact details that may be covered by the Data Protection Act.

### Conservation and heritage designations

Nenthead mine site is a Scheduled ancient monument
Smallcleugh mine, (Nenthead mine site) is a SSSI predominantly for mineral interest and Haggs mine is a SSSI.

### Stakeholders

Natural England, English Heritage, North Pennines AONB, Nenthead mines Conservation society, Cumbria County Council (landowner of Nenthead site)

Peter Aldred July 2014