Kinver Nitrate Investigation Summary

Report details

This document is a summary of the detailed information provided in the main nitrate investigation report for the site (ref. 63684K R7), completed by ESI. It aims to provide an overview of the nitrate modelling work and catchment assessment for the site, for internal use by South Staffordshire Water (SSW) and as a communication tool with relevant stakeholders. Referenced acronyms are described in the glossary section and figures are included at the end of the summary report.

Site details

NGR:	SO 8483 8337	Average monthly abstraction (1970 – present):	11.3 Ml/d
Number active of boreholes:	2 (KV1 and KV2)	Average monthly abstraction (2011 – present):	1.8 Ml/d
Catchment area (modelled):	16.2 km^2		

Water quality details

Average nitrate concentration:	KV1: 48 mg NO_3/l KV2: 50 mg NO_3/l	Observed nitrate range (as monthly average across site):	KV1: 36 - 51 mg NO_3/l KV2: 46 - 53 mg NO_3/l
Overall observed nitrate trend:	Generally flat	Nature of peaks:	Lack of data

Site background

Kinver PWS is located in the village of Kinver approximately 5.5 km west of the centre of Stourbridge. The two boreholes (KV1 and KV2) are 11 m apart and completed in the Bridgnorth Sandstone Formations of the Triassic Sherwood Sandstone Group at about 237 mbd and 220 mbd respectively. Nearby abstraction sites include Cookley (2.7 km south), Churchill (3.9 km south east), Prestwood (2.6 km north east) and Tack Lane (4.6 km north east).

The average abstraction rates from KV1 and KV2 over the period 2008 to 2012 are 6.1 Ml/d and 5.5 Ml/d (53% and 47% of the combined abstraction) respectively.

The groundwater catchment was delineated using historical groundwater flow patterns from the Environment Agency's West Midlands Worfe model and then input to the FlowSource model. The catchment is 16.2 km^2 in size and extends north east from the abstraction. The predominant flow direction is from the area in the immediate vicinity of the abstraction, from the centre of the catchment and from the area that the River Stour passes through in the northeast of the catchment

The Kinver boreholes are close to the River Stour where there are alluvium deposits comprising clay, silt, sands and gravel around the boreholes and further sand and gravel deposits following the course of the river. The main soil type across the groundwater catchment is sand and loam to sand, except beneath the watercourses, where it is clay to loam (Figure 1). The unsaturated zone is thickest in the vicinity of the north-western and south-eastern corner of the catchment, up to about 70 m thick (Figure 1).

Observed nitrate at the site

Measured nitrate concentrations were fairly stable at around 13-14 mg/l until 1961. The main periods of rising nitrate concentrations were 1961-1966 (by approximately 15 mg/l), 1970-1975 (by over 10 mg/l), 1975-2015 (a gradual rise of approximately 10 mg/l). Peak concentrations have exceeded the PCV intermittently since 1987. Since 2008, the average nitrate concentration for KV2 has been marginally higher than for KV1 (50 and 49 mg NO_3/l respectively).

Due to the high nitrates from both boreholes, Kinver must blend with Cookley so if Cookley goes out of supply, Kinver does too.

A very small area (4 ha or about 0.04 km^2) of the Kinver catchment is located within a Nitrate Sensitive Area (NSA), which was designated in 1998.

Land use and sources of nitrate

59% of the catchment is used for arable farming and 3% as pasture for raising livestock. 34% of the catchment is urban, including the land around the Kinver source and Stourbridge to the east (Figure 1).

Agricultural nitrate: Nitrate concentrations from the NEAP-N model (Figure 1) are highest in the rural areas around the borehole (between approximately 30 and 60 mg/l) whereas in the urban areas they are much lower (between approximately 20 and 30 mg/l). Between 1980 and 2010 there has been an average decrease of 0.3 to 0.9 mg NO_3/l per year across the catchment (Figure 3). Most (about 60%) of the nitrate is from fertilised arable land, about 17% is from animals grazing on pasture and about 13% is expected to be from urban land.

Surface water infiltration: About 30% of the yield from the boreholes is estimated to come from the River Stour and the Staffordshire and Worcestershire Canal. The nitrate concentration in the River Stour in 2009 (latest available data) was approximately 40 mg NO_3/l.

Point sources: Roundhill Sewage Treatment Works (about 2.3 km east of the Kinver boreholes) has been in operation since 1930. Treated water is returned to the River Stour. The STW is not believed to contribute inputs of nitrate directly to the groundwater system but only via the River Stour, which is accounted for in the surface water infiltration above.

Summary of model results

Hydrogeological parameters:

Hydraulic conductivity of the aquifer (K) of 5 m/d	Hydraulic gradient (i) of 0.015
Porosity (n) of 15 %	
Unsaturated zone thickness ranging between 5 and 70 m (Figure 1)	Hydraulic conductivity of the unsaturated zone (K_{usz}) of 0.015 m/d

Observed nitrate data and the modelled trends are illustrated in Figure 2. With the information currently available for the site, regarding potential sources of nitrate within the catchment, the following parameters were used:

- 4 % of borehole yield comprises fresh groundwater (3.3 mg/l as NO_3 (Tyler-Whittle et al., 2002)).
- 30 % of borehole yield comprises surface water (40 mg/l as NO_3).
- 0 % of borehole yield comprises point source NO_3.

The model simulates expected concentrations at the boreholes assuming that the only sources of nitrate in the catchment are agriculture (operating according to good agricultural practice) and diffuse urban sources of N. Residence times of nitrate in the sub-surface are calculated according to expected hydrogeological parameters. No additional source of nitrate is required for the modelled concentrations to fit the observed concentration reasonably well.

The counterfactual (or 'do nothing'/'business as usual') scenario (the 'Source Model' line in Figure 2) predicts that average and peak concentrations (Source+2SD) of nitrate will remain relatively over the next 70 years and will fluctuate both above and below the PCV.

Catchment management

Catchment management mitigation measures (for nitrate) considered suitable for this groundwater catchment are listed below. Further information on these measures including reduction rates and costing estimates (on an individual farm basis) is provided in a separate technical note (63684K TN1). The timing and magnitude of an estimated impact of such measures (mainly light touch catchment measures) to the concentration of nitrate at the PWS is shown on Figure 2 ('Future Model' trend line).

Measures for Severn Valley, arable farms, free-draining soils	Measures for Severn Valley, livestock farms, free-draining soils
Use plants with improved nitrogen use efficiency	Establish cover crops in the autumn
Use a fertiliser recommendation system	Use plants with improved nitrogen use efficiency
Use manufactured fertiliser placement technologies	Use a fertiliser recommendation system
Fertiliser spreader calibration	Integrate fertiliser and manure nutrient supply
Unfertilised cereal headlands	Use clover in place of fertiliser nitrogen

Measures such as these are likely to have an effect on nitrate concentrations at the Kinver site within approximately 10 years, and after about 20 years are predicted to have reduced peak nitrate concentrations by about 2.5 mg/l from the 'do nothing' scenario. If this rate of reduction can be achieved, the impact on nitrate concentrations at the site are summarised below.

Predicted impact of catchment management:

Maximum reduction of peak counterfactual concentration	3 mg/l as NO_3 (5%)
Impact to average concentration	Average concentration at the site should remain below the PCV (from around 2026 onwards).
Impact to peak concentration	Peaks (Future Model+2SD) predicted to remain above the PCV over the modelled period (up to 2085)

Spatial outputs from the model (Figure 3) can be used to inform implementation of catchment management options. Travel times of nitrate are lowest (1-5 years) immediately to the north and east of the Kinver site where the land use is typically agricultural. So catchment management should be targeted in this area but its effects need to be carefully monitored because NEAP-N nitrate loadings have already decreased in this area (1980-2010).

Key outcome and recommendations

The model indicates that agricultural mitigation measures should improve the nitrate concentration at the Kinver boreholes within about 10 years by targeting the area immediately to the north and east of the boreholes.

Further investigation into the contribution of nitrate to the boreholes from the River Stour, the Staffordshire and Worcestershire Canal and the Roundhill STW discharge is recommended prior to any implementation of catchment management measures.

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Glossary	
mbd	Metres below datum
KV	Kinver borehole
NEAP-N	The National Environment and Agriculture Pollution Nitrate model
PCV	Prescribed concentration or value*
PS	Pumping station
PWS	Public water supply
SPZ	Source protection zone
SSW	South Staffordshire Water Ltd

*Note that in this case, PCV is interchangeable with drinking water standard (DWS), which is also 50 mg NO_3/l.

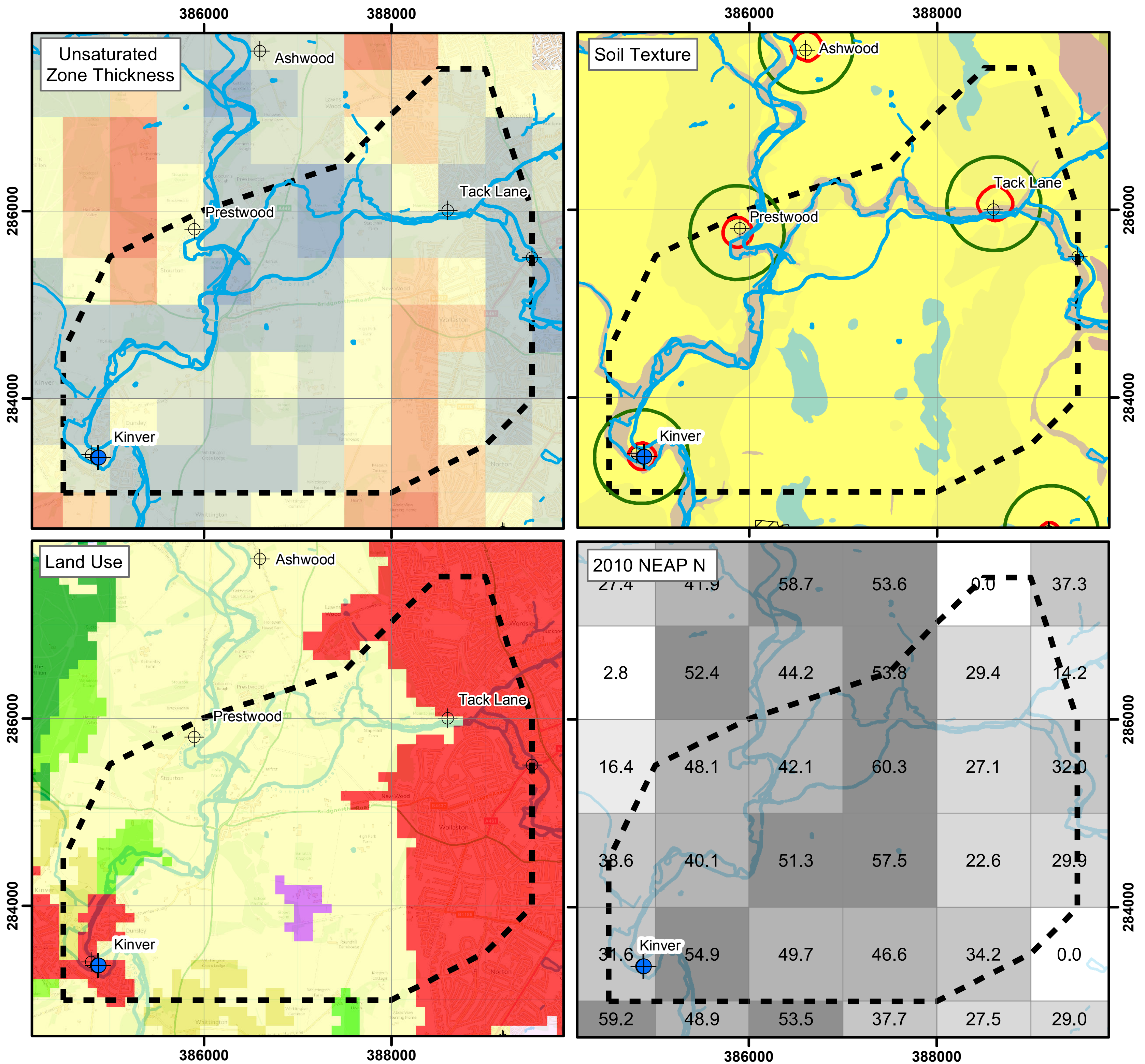

Figure 1
Kinver catchment

Legend

- Abstractions
- Other PWS groundwater abstractions
- Historical catchment
- SPZ 1
- SPZ 2

Unsaturated zone thickness (m)

- < 0
- 0.1 - 5
- 5.1 - 10
- 10.1 - 20
- 20.1 - 30
- 30.1 - 40
- 40.1 - 50
- 50.1 - 60
- 60.1 - 70
- 70.1 - 80
- 80.1 - 90

Soil Texture

- Clay to Loam
- Silt to Sand
- Sand
- Loam to Sand

Land Use

- Discontinuous Urban Fabric
- Industrial or Commerical Units
- Sport and Leisure Facilities
- Non-irrigated Arable Land
- Pastures
- Broad Leaved Forests
- Coniferous Forest
- Mixed Forest

NO3 Concentration (mg/l)

- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 50
- 51 - 75
- 76 - 100
- 101 - 200

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Date	Mar 2017	Drawn	EJC
Scale	1:55,000	Checked	RFF
Original	A3	Revision	V1

File Reference
O:\63684K SSW AMP6 NO3 modelling\GIS\Map documents\Site summary

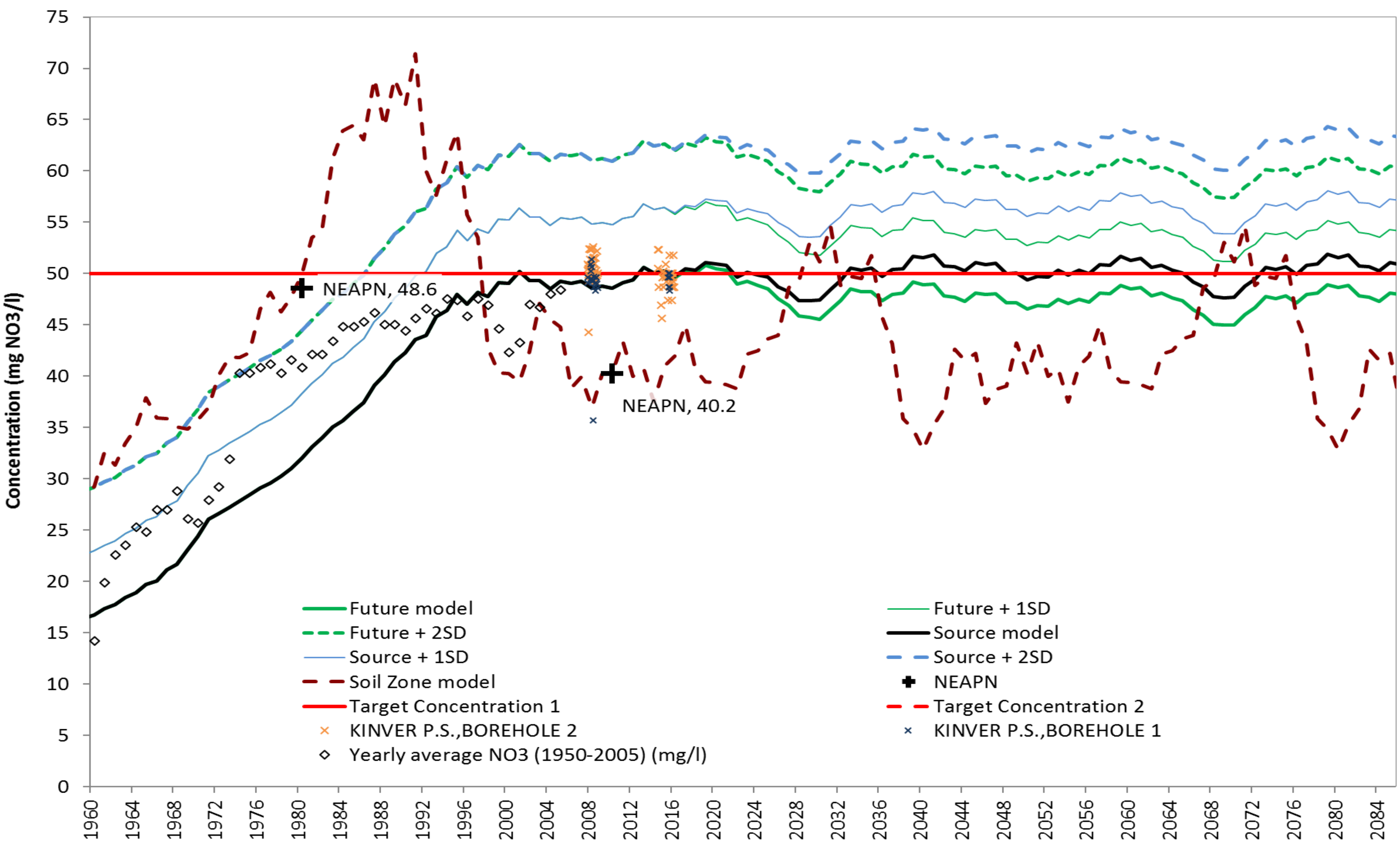

Figure 2

Observed nitrate concentration and modelled trends (using justified parameter values)

The 'future model' trend shows the estimated impact if catchment management measures targeting agriculture were carried out (equivalent to ~8% reduction in N loading in arable and pasture fields from 2016 onwards).

Date Mar-17	Drawn EJC
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Original A4	Revision 1
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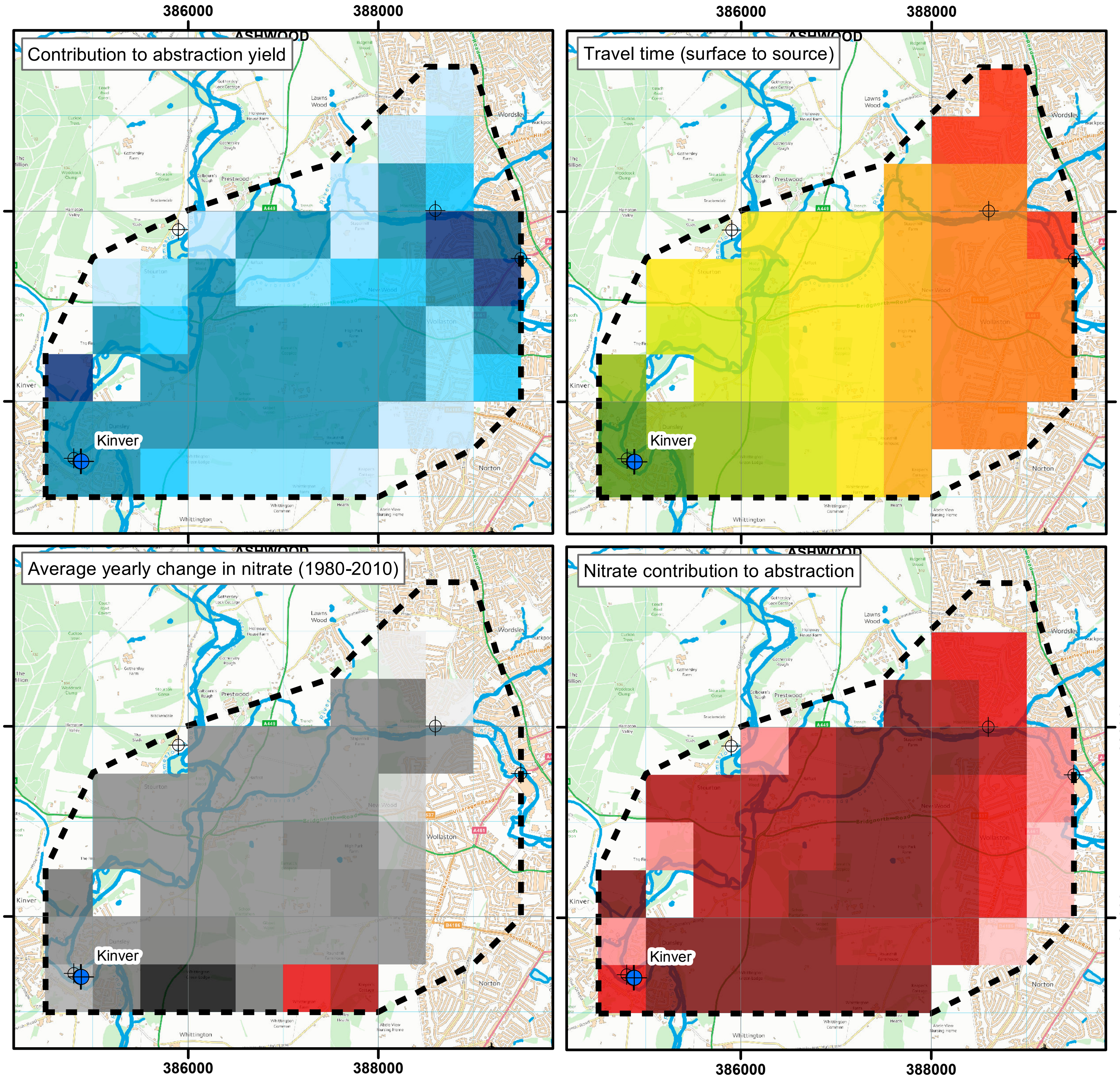

Figure 3
Kinver spatial outputs

Legend

- Abstractions
- Other PWS groundwater abstractions
- Historical catchment
- Surface Water

Abstraction Yield (%)

- 0
- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 3
- 3 - 5
- 5 - 10

Travel time (years)

- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 40

Change in N loading per year (kg/ha)

- <-20
- -20 - -10
- -10 - -2.5
- -2.5 - -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - 0
- 0
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 10
- 10 - 20

N contribution (%)

- 0
- < 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 - 5

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File Reference
O:\63684K SSW AMP6 NO3 modelling\GIS\Map documents\Spatial Outputs\Kinver Spatial Outputs.mxd