

Celsius

Equipment Specification and Site Installation Report

29 September 2017



VERSION HISTORY

Version	Date	Author	Status	Comments
V0.1	19 September 2017	Damien Coyle Project manager	First draft	
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1 INTRODUCTION

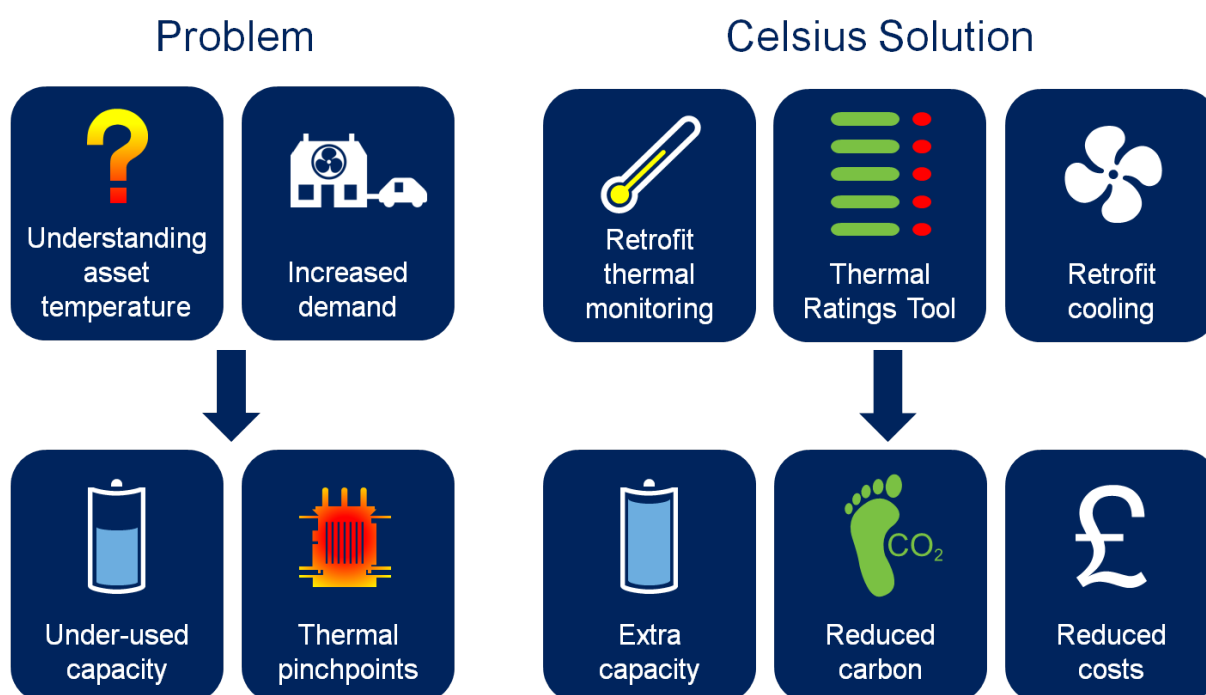
1.1 Scope

This document is evidence of Successful Delivery Reward Criteria *TW.1 Install and Commission Monitoring Equipment* as specified in the Celsius bid submission document. This document describes the monitoring equipment deployed on the Celsius project, including specifications, installation and data management.

1.2 The Celsius project background

Celsius is funded via Ofgem's Network Innovation Competition (NIC) funding mechanism. The project was authorised to commence in December 2015 and is expected to be complete by March 2020.

Celsius explores innovative, cost-effective approaches to managing potentially excessive temperatures at distribution substations, which could otherwise constrain the connection of low carbon technologies (LCTs).



Celsius first seeks to identify potential thermal issues by establishing how different distribution substations in differing environments behave thermally under a variety of load and environmental conditions. Celsius will develop the following methodologies to better understand the real thermal ratings of distribution substation assets in order to unlock capacity:

- **Retrofit thermal monitoring:** By using improved technology to measure asset and ambient temperatures, and relating these to a range of environmental, load and seasonal factors, Celsius will enable understanding of real thermal ratings of assets, rather than the nominal ratings that are used today. This will allow improved understanding of the amount of latent capacity which could be accessed without further intervention
- **Thermal ratings tool:** the learning from the retrofit thermal monitoring trials and analysis will be formalised and transferred into a simple tool that can be used by operations and planning employees at any network operator, to better understand the capacity of the existing or planned network.

Celsius will then identify, evaluate and demonstrate retrofit cooling technologies that can be used to directly manage the temperature of assets. By managing temperature in this way,

Celsius will deliver additional capacity release. Customer surveys will establish customer perception of retrofit cooling techniques and whether the application of these techniques is as acceptable to them as traditional reinforcement.

2 MONITORING EQUIPMENT

Monitoring equipment is deployed at 520 distribution substations, monitoring equipment is supplied by project partners ASH Wireless who are established experts in electronics and wireless communications. The equipment deployed on the Celsius project is described below.

2.1 Hub

The Hub KHB01 acts as a low power radio concentrator, and has a cellular modem. The Hub is battery powered, and designed to gather a data log from local sensors four times per day, log the data, and make a report to the back end via GPRS once per day. See Appendix A for the technical specification.

Figure 1: ASH Wireless Kelvin Hub



2.2 Hex

Hex sensor KHX01 & 02 units can be used to monitor six independent inputs using flying leads to measure temperature, voltage or current. Hex sensor units can also be configured for power measurement, and use paired voltage and current flying leads to measure power on three phases. See Appendix B for the technical specification.

Figure 2: ASH Wireless Kelvin Hex



2.3 Kelvin temperature sensor

Single temperature sensors KTS01 measure the temperature at a specific point, which is thermally close coupled to the mounting magnet. This can measure the surface temperature of particular assets (eg magnetically mounted onto the side of a transformer), or can be used to measure ambient conditions by reverse mounting, exposing the magnet to the air. See Appendix C for the technical specification.

Figure 3: ASH Wireless Kelvin Temperature sensor KTS01



3 CELSIUS DATA MANAGEMENT SYSTEM

Ricardo Energy & Environment provide the data communications, management and storage, through the Celsius data management system.

The data management system receives the data from each of the hubs. It then stores and processes the data, provides visualisation and enables downloading for further analysis.

When monitoring data is received by the data management system, the following processes are performed:

- Validation of the incoming data packet using hub ID and token, ignoring all other incoming data
- Verification of hub against stored sensor metadata
- Population of raw database, with all received data (ie whatever sensor data is present)
- Pass back to the hub any relevant commands from the commands queue, for example to re-send previous data or measure detailed harmonics.

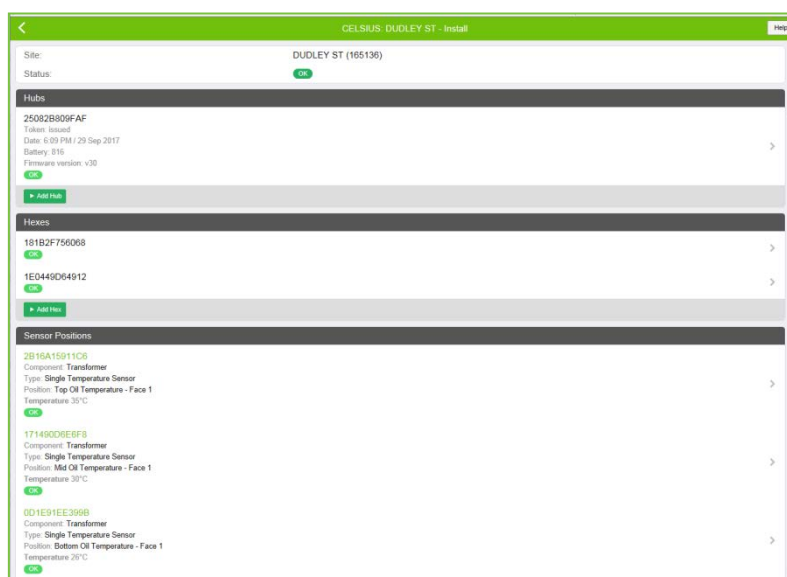
Raw data is analysed and checked for validity and processed. This includes rounding the timestamps to the nearest half-hour in order to support validation. After processing, the data is stored. Importantly, both raw and processed data are retained for diagnostic and troubleshooting purposes.

Data can be accessed, viewed and uploaded to the management system via the Celsius dashboard. The dashboard has the following functionality tools:

- Commissioning tool
- System health check
- Data dashboard.

3.1 Commissioning tool

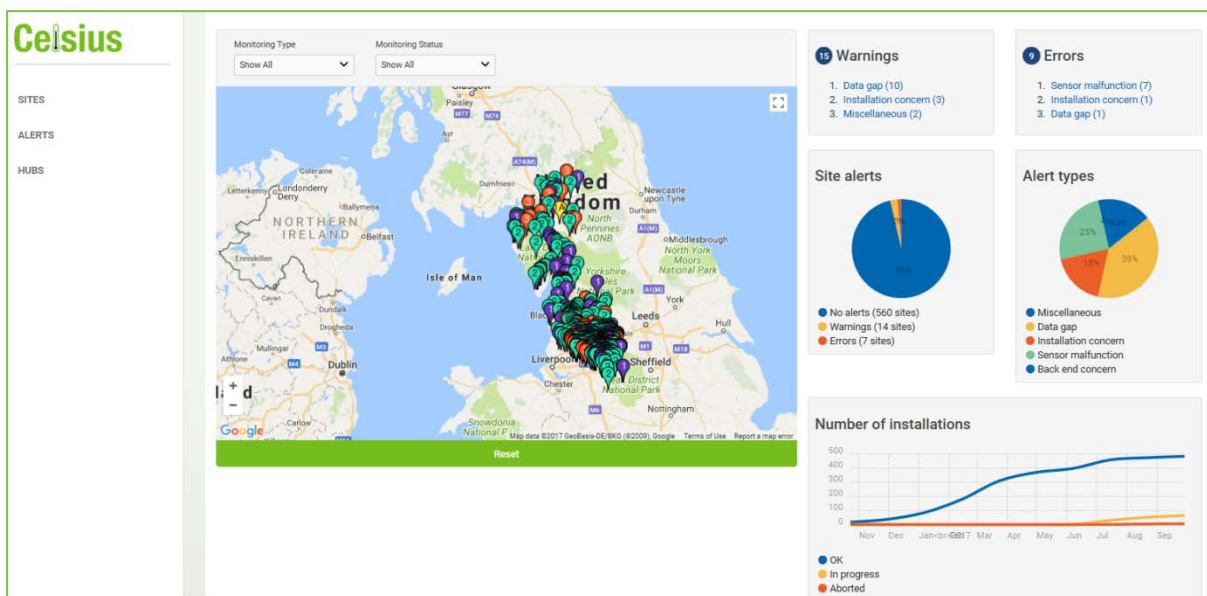
This tool provides the functionality needed for the installer in the field to register the hub and sensors that have been installed and confirm that communication is successfully occurring between the hub and the system before leaving site. It also facilitates the collection of commissioning data such as site equipment and configuration, sensor location and installation photos.



3.2 System health check

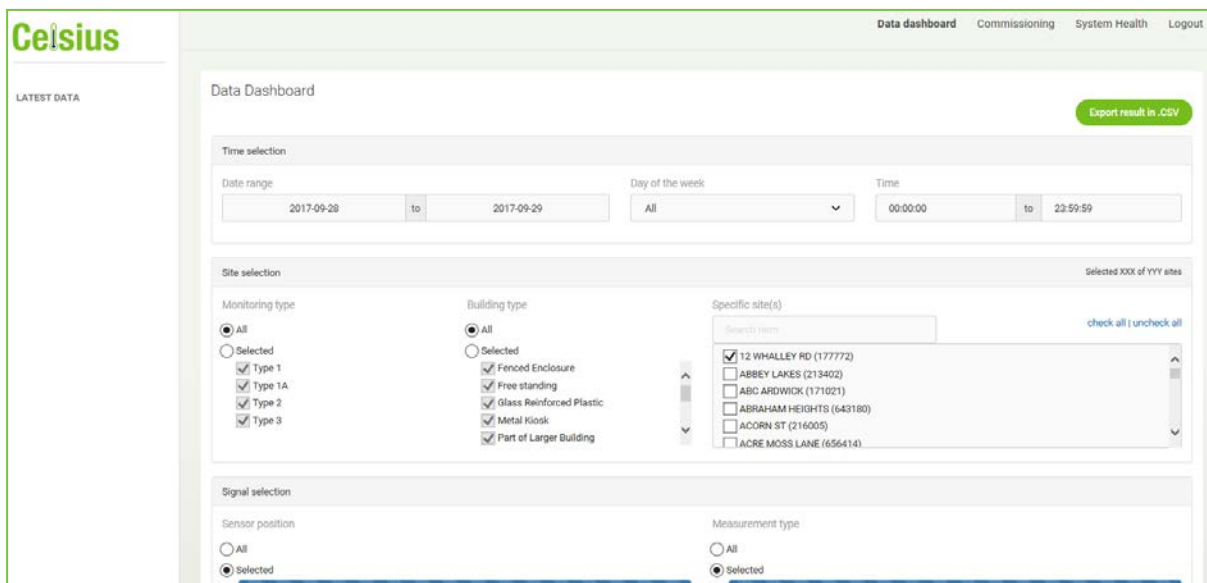
The system health check enables users to monitor all Celsius trial sites, identify any issues and assign actions to the project team, features include:

- Warnings – flag problems with data that are either issues related to installation, data processing or signal problems
- Errors – flag sensor malfunctions and issues
- Installation tracker – tracks progress of completed, aborted or in progress sites
- Alerts – this allows users to assign tasks to the relevant team member to resolve any warnings or errors.



3.3 Data dashboard

The data dashboard enables users to access all archived data. The search feature enables the user to search for sites by name, monitoring type or building type. Data sets can be customised to include different monitoring sensors which can be compiled onto graphs and viewed on the dashboard or downloaded to CSV format.



4 INSTALLATION TYPES

A Type 1a site installation is shown in our [installation video](#). Details of the number of sites and the difference between each site is defined below. See Appendix D for the full site list.

4.1 Type 1

Type 1 installation monitoring is deployed at 134 ground-mounted distribution substations, recording the following information:

- External transformer temperature: two external transformer temperatures for example in line with the top and bottom oil
- Environment and other asset temperature: 12 temperature measurements over the substation, including high and low ambient temperatures, and measurements of substation assets such as the ring main unit, the LV board and cables
- Asset loading: detailed power monitoring of the transformer load, including real and reactive power, voltage, current, unbalance and harmonics.

4.2 Type 1a

Type 1a installation monitoring is deployed at 21 of the 134 ground-mounted substations, recording the same information as Type 1 with the following additions:

- Internal transformer temperature: five sites will use existing transformers fitted with fibre optic sensors. The remaining 16 sites will have two internal temperature sensors
- External transformer temperature: 12 additional external transformer temperatures, located in various positions, for example in line with the top and bottom oil, at or close to points on cooling fins or tubes, on and near connections and bushings.

4.3 Type 2

Type 2 installation monitoring is deployed at 335 ground-mounted substations, recording the following information:

- External transformer temperature: Two external transformer temperatures for example in line with the top and bottom oil
- Environment and other asset temperature: 12 temperature measurements over the substation, including high and low ambient temperatures, and measurements of substation assets such as the ring main unit, the LV board and cables
- Asset loading: simple power monitoring of the transformer load using voltage and current measurement of one phase on the LV side of the transformer. Where this is not practical, due to access limitations, alternative approaches will be found.

4.4 Type 3

Type 3 installation monitoring is deployed at 51 pole-mounted substations, recording the following information:

- External transformer temperature: two external transformer temperatures for example in line with the top and bottom oil
- Environment temperature: the ambient temperature
- Asset loading: detailed power monitoring of the transformer load, including real and reactive power, voltage, current, unbalance and harmonics.

APPENDIX A: HUB KHB01 TECHNICAL SPECIFICATION

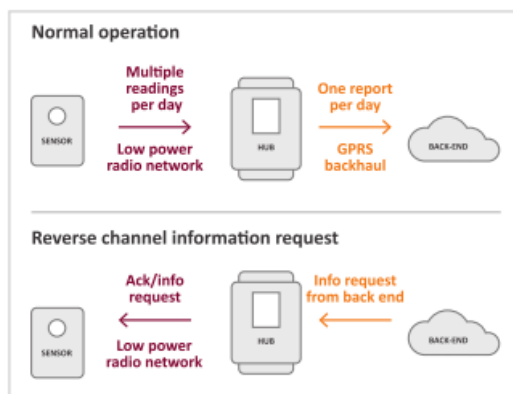
The Hub KHB01 acts as low power radio concentrator, and has a cellular modem. There may be more than one Hub used in a system to provide coverage for large areas and severe shadowing situations.

The Hub is battery powered, and designed to gather a data log from local sensors 4 times per day, log the data, and make a report to the back end via GPRS once per day.



Reported data

Message Flow (Logging + Alarms)



Standard reports

The Hub will report data from all sensors within range.

Standard reported data depends on the sensors, and can cover Temperature, Independent Voltage and Current (RMS and THD), and Power Measurement (paired Voltage and Current). Power Measurement includes Real and Reactive power.

These measurement readings are on a half hour basis (a 30 minute average of 60 x 30 second results). A day's worth of readings is then reported to the back end on a daily basis. In the event of an interruption to the backhaul, 7 days' worth of readings are stored and available for resending on request.

Further detailed measurement is available on demand for analysis of Harmonic content of the power.

Software upgradability

The Hubs can have their main processor software upgraded over the air to enable new features.

Environmental

Temperature range

The operational temperature range of the KHB01 is -20°C to +85°C.



Battery life

All units have an operating life of at least 3.5 years from initial switch on. This can be extended with the use of an external boost battery.



Weather sealing

The Hub will cope with driving rain from vertical down to horizontal, but will not cope with water jets from underneath.



Physical robustness

All units are designed to survive dropping from 1m onto concrete.



Physical dimensions

The KHB01 Hub measures 185x125x90mm.



Cellular antenna

The KHB01 comes with an external cellular antenna that plugs into the bottom of the unit.

APPENDIX B: HEX SENSOR KHX01/02 TECHNICAL SPECIFICATION

K^oLVN Hex Sensor KHX01/02



Hex Sensor KHX01 & 02 units can be used to monitor 6 independent inputs using flying leads to measure Temperature, Voltage or Current. Hex Sensor units can also be configured for Power Measurement, and use paired Voltage and Current Flying Leads to measure power on 3 phases.



Measurement Range and Accuracy

The Hex unit has six inputs. Each of these can be used to plug in a flying lead which can be a Temperature Flying Lead (TFL), Voltage Flying Lead (VFL) or Current Flying Lead. The latter can either be a Rogowski Coil (RFL) or Current Transformer (CFL) variant.

The flying leads are automatically identified when plugged in, and the relevant parameter measured on any input. When Voltage and Current Flying Leads are plugged in the appropriate pairs of input power is measured on that phase.

Temperature

Temperature readings range from -20 to +125°C (note that this is wider than the operational temperature of the Hex unit or TFL). Temperature readings have a resolution of 0.1°C, and an absolute accuracy of +/-1°C.

Voltage

Voltage readings are in RMS Volts in the range 0-300V. Voltage readings have an accuracy of +/-1V over the range 220-255V.

Current - Rogowski Coil

Current readings are in RMS Amps. The Rogowski coil measures a current directly in the range 0-2000A, with an accuracy of 1% full scale.

Current - Current Transformer Coil

The Current Transformer measurement circuit will use a standard CT, which will measure a full scale of 5A with 1% full scale accuracy. Where a CT is used, a scaling factor will need to be configured into the Hex to take account of the turns ratio of the CT measurement circuits.

Results and Readings

Each Sensor takes a sample "Result" every 30 seconds, and creates a "Reading" every 30 minutes. Each 30 seconds, the sensor transmits to the Hub the latest sample "Result" which may be used for alarm purposes, and the last 12 sample "Readings" which are used for the data logging.

Temperature

For Temperature, the sample result is the spot temperature every 30 seconds, and the "reading" is the spot temperature every 30 minutes. This is simplified as the thermal inertia of the magnet means that the results are not varying rapidly.

Voltage & Current

Every 30 seconds, a sample "Result" is calculated by taking 500 samples are taken over a 200ms window, and then computing the root mean square.

Over 30 minutes, these sample "Results" are averaged to create a sample "Reading".

THD is calculated as the square root of the distortion voltage or current divided by the total voltage or current.

Power Measurement

Where V & I sensors are paired for Power Measurement (i.e. measuring a single phase) each sample "Result" and "Reading" comprises V, I, real and reactive power.

Hex units reporting multiple phases also report the vector sum of currents (for unbalance).

Environmental

Temperature Range

The operational temperature range of the Hex is -20°C to +85°C. Temperature sensor flying leads go up to +105°C. High temperature versions of the flying leads have been developed for transformer oil temperature monitoring.

The Hex can measure higher temperatures, provided only the sensor lead is at this temperature. The operational temperature range of the Hex unit is limited by the temperature of the case (and battery within).



Battery Life

The KHX01 has an operating life of at least 3.5 years from initial switch on (this battery life can be extended by use of an external boost battery).

The KHX02 has an additional battery, and achieves a battery life of 7 years.

The battery life quoted is when using up to a max of 3 x Rogowski Flying Leads. More RFLs can be used by each Hex, especially if a Rogowski Summation box is employed, but in this case the battery life is shortened.



Weather sealing

The Hex will cope with driving rain from vertical down to horizontal, but will not cope with water jets from underneath.



Physical robustness

All units are designed to survive dropping from 1m onto concrete.



Physical Dimensions

The KHX01 & 02 Hex Sensor measures 185x125x90mm.



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APPENDIX C: TEMPERATURE SENSOR KTS01 TECHNICAL SPECIFICATION

K°LVN Temperature Sensor KTS01 ASH CREATIVE WIRELESS ELECTRONICS

Single Temperature Sensors KTS01 measure the temperature at a specific point, which is thermally close coupled to the mounting magnet. This can measure the surface temperature of particular assets (e.g. magnetically mounted onto the side of a transformer), or can be used to measure ambient conditions by reverse mounting, exposing the magnet to the air.



Measurement

The temperature sensor measures the temperature with resolution of 0.1 °C steps, with an accuracy of +/- 1°C over the range -20+85 °C. The KTS measures a spot result every 30 seconds, and provides a log of 30 minute readings.

Mounting

The temperature sensor can be mounted using the magnet, or alternatively using cable ties. A cable tie loop through one of the mounting lugs can be used by a hotstick to offer up the temperature sensor to remotely position it e.g. on a live pole mounted transformer.

<p>Environmental</p> <p>Temperature Range The operational temperature range of the KTS01 is -20°C to +85°C.</p> <p>Battery Life The KTS01 temperature sensor will achieve a lifetime of 7 years.</p>	<p>Weather sealing KTS01 is designed to meet IP67.</p> <p>Physical robustness All units are designed to survive dropping from 1m onto concrete.</p>	<p>Physical Dimensions The KTS01 Temperature Sensor measures 70x90x20mm.</p>
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APPENDIX D: SITE LIST

Site	Code	Type
12 WHALLEY RD	177772	2
ABBEY LAKES	213402	3
ABC ARDWICK	171021	1A
ABRAHAM HEIGHTS	643180	2
ACORN ST	216005	2
ACRE MOSS LANE	656414	2
ADLINGTON COMMON	414215	1
AIR MUSEUM	165991	1
AKED CL LONGSIGHT	171082	1
ALBERT MILL	314302	2
ALBRIGHTON EST	415402	2
ALBRIGHTON RD	415599	2
ALDER AVE	212304	2
ALEXANDRA RD S	171051	2
ALLITHWAITE	618166	1
ALTRINCHAM FOOTBALL CLUB	171011	2
ALTRINCHAM RD	330602	1
ANDERTON ST	211653	3
ANDREW ST	323747	2
ANGLE ST	231178	1
ANGOULEME WAY	232114	2
ASDA FARNWORTH	231871	2
ASDA STOCKPORT	338093	2
ASHLEY WALK	178381	2
ASHMOUNT ROAD B	616197	1
ASHTON 6TH FORM COLLEGE	328629	2
ASHTON CROSS	213907	3
ATE GRIMSARGH	417005	2
AUDLEY AVE	166531	2
AUDLEY HALL	450029	1
AUSTIN CT	171093	2
AVONDALE RD STRETFORD	165935	1
BACK CALEDONIA ST	231180	2
BACK DERBY ST	232985	2
BACK LN (STAVELEY)	656243	2
BAG LN	216100	2

Site	Code	Type
BAKER ST	212358	2
BANKFIELD	459032	2
BANKS CRESCENT	641855	1
BARN ST	313719	2
BASLOW RD DENTON	171151	2
BEAUFORT RD	452011	2
BEECH AVE IRLAM	165416	2
BELGRAVE NO 1	310058	1
BELLSHILL CRES	314325	2
BENTGATE ST	314740	1
BERRY LN	410073	2
BERWICK AVE	333421	2
BIRCH KIOSK	232534	2
BIRCH TREE P.M.T., HALL LANE	214301	3
BITTERN GR	336138	1
BORRON RD	216132	2
BOWER RD	171102	1
BOWLEE PMT	326774	3
BOYLE ST	165175	1
BRADFORD RD	231685	2
BRANTFELL	658014	2
BRIERLY RD	216144	2
BROAD LN	171122	2
BROADLANDS	216149	2
BROADWAY PARTINGTON	171131	1
BROMPTON RD	171262	1
BROOKFIELD INDUSTRIAL EST	325835	2
BROOKWOOD AVE	165197	2
BROUGHTON ROAD	616325	2
BROW FOOT	643032	2
BRYER STREET	641706	2
BUCKINGHAM RD	171284	1
BUCKSHAW VILL COMMERCIAL	419910	2
BURGHLEY DR, BRADLEY FOLD	232536	2
BUTTERMERE HOSTEL	620747	2
CALLANDS FOLD	214402	3
CAMBRIDGE DR	459041	1

Site	Code	Type
CARDEWLEES	636069	1
CARILOL DR	638130	2
CARNATION RD	231735	2
CARR CLOSE	642329	1
CARTFORD LN	410352	2
CARTMEL CT	165287	1
CASTLE HILL	321404	2
CATFORTH	410552	1
CAWDOR ST	166924	2
CHADDERTON HALL RD	329166	2
CHANTRY WALK	211945	2
CHAPEL HS	330109	2
CHAPEL ST	622682	2
CHEETWOOD RD	165143	1
CHELSEA RD	165304	2
CHERRY TREE RD	216242	2
CHESTER WALKS	332821	2
CHESTERHOLM	636100	2
CHETHAMS	166753	2
CHISACRE DR	211425	2
CHORLEY HOSP	415391	1
CHORLEY RD SWINTON	216107	2
CHRISTIE ST	339295	2
CHURCHTOWN ST MARYS	631191	3
CITY RD	216300	3
CLAREMONT VIEW	643287	2
CLARENDON RD WHALLEY RANGE	171422	1A
CLAUGHTON AVE	415504	2
CLUB ST (BAMBER BRIDGE)	414753	1A
COKE ST	165129	2
COMMON HEAD VILL	216263	3
CONCORDE WAY	324246	1
CONISTON DR	331311	1
CONWAY CT	416037	2
COPPICE AVE	171222	2
CORONATION DR	216270	2
COTTAM MULTISPORT	410442	2

Site	Code	Type
COW LEE'S	212854	2
CRAG BANK LANE	641595	1
CRANKWOOD RD (RR NO 250)	214605	3
CRANTOCK DR	171230	1
CROSS LANE PMT	216696	3
CROSTHWAITE CT	621856	2
CROSTON RD	414703	2
CROWN BLDG	165966	1
CUNLIFFES FARM PT	231249	3
CURTHWAITE STN COTT	630927	3
CWS BROUGHTON	165680	2
DAKOTA AVE	166512	2
DALE ST PREMIER INN	168478	2
DAM LANE RIXTON PMT	216362	3
DEAN HSG	314385	2
DEIGHTON RD	411289	2
DENBIGH PL	165603	2
DENE RD	171526	1
DEVONSHIRE ST N	171538	2
DIALSTONE LN	330134	2
DIRECT LINE	166915	2
DISLEY MAIN	331559	2
DRYDEN ST	612601	2
DUDLEY ST	165136	1A
DUKE ST	332644	2
DUNHAM HALL	171271	2
DUNKIRK AVE	410684	1
DUNSCORE RD	212301	2
DURDAR RD	636447	2
EAFIELD RD	314561	2
EDITH ST	238003	1
EGERTON	211338	2
ELLERBECK CRES	217639	2
EMMANUEL ST	410017	1
ESHER POND	410768	1
ESSEX PL	216449	1
EUSTACE ST	231757	1

Site	Code	Type
EXPRESS HOUSE	166855	1
FACTORY ST	312757	1
FAIRBANK (K.LONSDALE)	658085	2
FAR MOOR	211510	1
FARNHAM AVE	165221	1
FARRINGDON LN	410341	2
FAWLEY AVE	321389	2
FELLSIDE(BORROWDALE)	620430	2
FIR TREES	410155	2
FIRE BRIGADE HQ	410484	2
FIRS ESTATE	656241	1
FISHWICK RD	410732	2
FLIXTON RD CARRINGTON	171316	2
FORTY SPRING GDNS	167922	2
FOXWELLS	171325	2
FRYER CLOSE, FRYER CL	418202	2
GALLERIA N W	167352	2
GALLOWAY HOME	410940	2
GARDINERS BUNGALOW	621564	3
GARLAND ST	311180	2
GEORGE ST PRESTWICH	165074	2
GIDLOW CEMETRY	214103	3
GILDED HOLLINS	216534	2
GIPSY LN	315657	2
GLASSON	636036	2
GLENEAGLES RD	171350	2
GLOSSOP SHOWROOMS	320086	1
GRANGE PK RD	165266	1
GREAT CLOWES ST ADJ 140	168333	2
GREAT UNIVERSAL STORES	419655	2
GREEN LN	231207	2
GREENBANK ST	410288	2
GREENFIELD DR	414557	2
GREENSIDE LN FIVEWAYS	171747	2
GREENWAYS	410248	2
GRESSINGHAM	641072	2
GRESSINGHAM DR	641552	2

Site	Code	Type
GT HOLME MILL	458068	2
GUYWOOD LN	333782	2
HADFIELD SECONDARY SCHOOL	324126	2
HAIGHTON GRN	410261	2
HALECROFT HALE RD HALE	172225	1
HALL STREET	231248	2
HAMPSON GREEN	641174	1
HANDLEY RD	331678	2
HARDMAN LN	165337	2
HARK TO MELODY	616152	2
HASLAMS FARM PT	231293	3
HEADLANDS	620620	2
HEATHERDALE DR	165155	2
HEATON CL	414869	2
HELMSIDE DRIVE	641915	1
HELSEBY WAY	332455	1A
HEMSWORTH RD	171815	2
HEYS RD	165066	2
HIBBERT LN SCHOOL	335335	2
HIGH LEVEL RD	328480	2
HIGHFIELD AVE (RR NO 28)	216668	2
HIGHFIELD DR	231112	2
HILL FOOT (ULVERSTON)	616285	2
HILL TOP	332350	2
HOLT ST W LOCAL	232565	2
HOMEWOOD AVE	171431	1
HOOPERS	338246	1
HORSLEY SMITH	414294	2
HOSPITAL ROAD	231679	3
HOUGH LN	415142	2
HUNTING STILE K	656035	1
IBBISON CT	423897	2
JACKSON CRESCENT HULME	172500	2
JANE ST	621865	2
JENNETS LN	216735	3
JENNY LN	331782	1A
JESSEL CL	171039	1A

Site	Code	Type
JMB ACOMB ST	171090	2
JOHN HOLDEN MOSS ROSE MIL	231904	1
JORDAN ST	410671	2
JUNCTION RD W PT	231840	3
KENDAL RD W	232037	2
KESWICK SEWAGE WKS	629091	2
KESWICK ST	315108	2
KINCARDINE RD	171981	1A
KINGSHAVEN	414133	2
KINGSMERE, HASLINGDEN RD B	459786	2
KIRKANDREWS	636075	2
KIWI CT OFFICES	167591	2
KNOTT LN	320059	2
LABURNUM AVE	216801	1
LAKESIDE	337030	2
LANCASTER AVE	231078	2
LANCASTER AVE	216809	1A
LANCASTER LN	414812	2
LANGDON CL	231077	2
LANGPORT AVE	172047	2
LAWSON AVE	217117	2
LAZENBY CRES	211960	2
LEECE DRIVE	618101	2
LEICESTER AVE	212726	1A
LEITH HS_11	662882	3
LENNONS	415655	2
LEWIS RD 41	172121	2
LIGHTOWLERS LN	315233	2
LINDLEYWOOD RD	172044	1
LITTLE EDGE FM	231979	3
LLOYD ST INDOOR	171488	2
LODGE DRIVE	216839	1
LOG ST	165296	2
LONDON WAY	415922	1
LONGLEY LN 124, O/S 124	177381	2
LONGRIGG	632167	3
LONGTON RD	165007	2

Site	Code	Type
LORNE ST	450255	2
LOSTOCK LN	231794	2
LOW MOOR	455086	2
LOWER FALINGE	315097	2
LOWER KNOLL RD	327010	1
LOWTHER ROAD	643296	2
LOYNES	323789	2
LUGANO ROAD, ADJ 32	333463	2
LYONS FOLD SALE	171505	2
M & S	212209	2
M6 MAINTENANCE DEPOT	216910	3
MAGDA RD	332307	1
MAINE RD MOSS SIDE	171974	2
MANCHESTER GRAMMAR SCHOOL	172045	1
MANOR PK	167259	2
MANOR RD	455561	1
MAPLE AVE	216923	2
MAPLE RD	331867	2
MARDYKE	314775	2
MARKET CROSS	656422	2
MARSHALL ST	166140	2
MARSLAND RD	171524	1
MARTIN RD	216928	1
MATTERSONS	314705	2
MAYFIELD MILL	310482	2
MAYOR ST	231042	2
MEDLOCK DR	326707	1
MELANIE DR	333847	2
MELKINTHORPE RD ABS_11	668650	3
MELLOR ST	165912	2
MERRILL HEAD	458383	3
MIDGE HALL	414087	2
MILTON GR	211605	2
MILTON VILLA	636341	2
MOAT LANE MISSION P.M.T.	216046	3
MONKWRAY	621647	2
MOORDOWN CL	165184	1

Site	Code	Type
MOORGATE	643286	2
MOORLAND RD	211935	2
MOORVILLE DR	636429	1
MOSS LN	216962	2
MOSS LN 403 PMT	216830	3
MOSS SIDE NWK	171957	1
MOTTRAM TOWERS	333191	2
MOUNT ST	231858	2
MOUNT ST	232186	2
MOUNT ST RMU	165455	1A
MOUNTAIN VIEW	620464	2
MYRTLE GRANGE	414755	2
NELSON STREET (DALTON)	618100	2
NESSWOOD AVE	423582	1
NEW BAILEY ST	165120	2
NEW HALL RD	171560	2
NEW LN	165442	2
NEW MOSTON NWK	165310	2
NEW QUAY ST	165990	2
NEW SHED FOULRIDGE	458062	2
NEWHALL RD	330218	1
NEWTON ROAD PMT	211377	3
NIELDS BROW	171563	2
NOG TOW	410393	2
NORTH RD	217034	2
NUTHURST RD 193	165333	1
NUTTERS PLATT	414448	2
OAK AVE	312861	1
OAK RD	311176	2
OAK RD CHEADLE	171577	2
OCEAN EDGE	641859	2
OFFERTON DR	331286	1A
OLD BREWERY	636052	2
OOZEWOOD RD	313549	1
ORMSKIRK NETWORK	418061	1
ORREST HEAD FARM K	656190	2
OVERDENE CL	231644	2

Site	Code	Type
PADIHAM TOWN	458239	2
PALACE RD	338363	1
PARK RD	217102	1
PARK RD LITTLE HULTON	217101	2
PARKWAY	332559	2
PEEL MOAT ROAD, OPP NO 44	330228	2
PENNINE LN	217112	2
PENNY LN	333793	2
PENWORTHAM GOLF CLUB O/D	414695	2
PETREL AVE	334203	2
PEWFIST PMT	216226	3
PINCROFT BRIDGE	415164	1
PITT ST	458769	1
PLANETREE FM	213606	3
PLESSINGTON HS	410574	1
PLYMOUTH GR	172017	2
POOLE BANK FM	174024	3
POOLE RD	621392	1
POPE LN SCHOOL	414587	2
PORTLAND GR	332812	2
POST HS HOTEL	171621	1
PRINCESS WAY	415716	2
PRINTSHOP LN	217131	2
PRISMO PRODUCTS	419894	2
PROSPECT E	620413	3
PULL WOODS	656122	1
PUNCH BOWL	217132	1
Q COACH	415411	2
QUANTOCK DR	328589	2
QUARRY BANK MILL	335287	1
QUEENS RD	331996	1
QUEENS RD	450449	2
QUEENS RD HALE	171631	2
QUEENS RD HOSTEL	455721	2
RAILWAY RD NETWORK	168569	2
RAMILLIES AVE	171643	1
RAMSHEAD	414425	1

Site	Code	Type
RATHMELL VILLAGE	644018	1
RAVENSWOOD AVENUE	334202	1
RED TARN ROAD	658070	1
REGENT STREET	643273	2
REGINA AVE	322507	2
REGINALD ST	165431	2
RICE ST	165989	1
RICHMOND HILL APTS	168103	2
RINGWOOD AVE	327511	2
ROBIN PARK RETAIL	211235	2
ROBY ST	167475	2
ROCH VALLEY WAY	314936	1
ROF HEAPEY	414187	1
ROGERFIELD	620143	1
ROMNEY RD	612788	2
ROSCOE RD	165395	1
RUSHFORD ST	172071	2
RUSHOLME PL	172004	1
RUSSELL ST	212530	1
SADDLEWORTH SCHOOL	327652	1
SANDRINGHAM PK	328507	2
SANDY LN	211108	2
SANDY LN STRETFORD	165876	2
SAUNDERS WOOD	417305	2
SCAFELL CL	622248	2
SCHOLA GREEN LANE	641928	2
SCHOOL LN HAIGH	211745	3
SCHOOL LN STANDISH	212005	2
SEAFORD RD	165073	2
SENHOUSE ST	620572	2
SENNICAR LN	214019	3
SHACKLETON CT	165303	1A
SHAP RD LAUNDRY	659436	2
SHARD BRIDGE	423070	2
SHELMERDINE GDNS	168218	2
SHEPHERDS CL	232619	2
SHERWOOD DR	211851	2

Site	Code	Type
SHIREBROOK DR	325927	2
SHREWSBURY RD SALE	171731	2
SILCOCK ST	217301	2
SILVERWOOD AVE	171904	1
SIMONSCALES	620254	3
SIMPSONS READY FOODS	165819	2
SKERTON HOUSE	641381	1
SNIFE RETAIL PK	171056	2
SOSGILL	620942	3
SOUTH ROW	629174	2
SOUTHGATE INDUSTRIAL	641984	1
SPENDMORE LN W	414690	2
SPRING GDN ST	641609	2
SPRING MILL WALK	327533	1
ST BRIDGETS LN	622099	2
ST GEORGES PK	417252	2
ST GEORGES ST	217277	1
ST JAMES RD	165124	1
ST JOHNS RD OLD TRAFFORD	165975	1
ST JOHNS ST	621403	1
ST LEONARDS	415341	2
ST MARYS CLOSE	217279	2
ST MARYS RD	414004	1
ST MARYS SCH ASTLEY	217337	2
ST MARYS SCHOOL	415738	2
ST PETERS	213918	3
ST WILFRIDS CHURCH	417006	2
STANDISH HIGH SCH	212028	2
STANGER	620552	3
STANLEY RD CHEADLE	171758	1
STANLEY ROAD	641823	1
STONEBREAKS RD	323116	2
STRETFORD RD, CAR PK	177158	2
SUMMERVALE HS	315259	2
SWINFIELD AVE	171894	2
TAME ST	327078	2
TAYLOR ST	414287	2

Site	Code	Type
TAYLORSON ST FLATS	167975	2
TEMPLE RD N	171782	2
TENBURY	211909	2
TESCO SALE	171784	2
TGI FRIDAYS CHEADLE, WILMSLOW RD	172525	2
THE AVENUE	178220	2
THE MOORINGS	656083	2
THE PADDOCK (CLAYTON)	414281	2
THE SHEILINGS	656021	1
THICKHOLME	650168	2
THURSTONFIELD NO1	636050	2
THWAITE ST	616224	1
TILLOTSONS	166381	1
TODDINGTON LN	214412	3
TOP OF CROFT	314672	3
TOWN BRIDGE	218333	2
TRAFFORD SPORTS CTR NO 2	167028	2
TRIPPIER RD	165424	2
TULKETH MILL	410516	2
TWINE COTTAGES	232005	3
UNIT 1 LEO IND PARK	167235	2
UNIT CONTROL	320889	2
UPPER DENTON	636360	1
UPTON ST	621386	1
URBIS CENTRE	167355	2
VALE MILL	310510	2
VALLEY RD CHEADLE	171826	2
VICARAGE LN (ORMSKIRK)	414130	2
VICARS HALL LN	217461	2
VICTORIA RD ECCLES	165500	1A
VICTORIA ROAD	217465	1
VINE MILL	310504	2
WALTER ST	217502	2
WANSFELL HOLME K	656094	2
WARWICK ST	165040	2
WATER TOWER (CHORLEY)	415262	2
WELLINGTON RD	320739	2

Site	Code	Type
WENTWORTH RD	211952	2
WEST END ROAD	641975	2
WEST SHORE ROAD	618007	2
WESTBOURNE RD ECCLES	164445	2
WESTBURY DR	333800	2
WESTERN AREA SCHOOL	636118	2
WESTLINTON VILL	636160	2
WETHERAL PASTURE	631783	3
WHALLEY RD BARROW	457189	2
WHAM LN	414418	3
WHINNIE HS RD	636386	2
WHITEFRIARS	165671	1A
WHITELANDS RD IND EST	325847	2
WHITTINGHAM DR S	232113	2
WILD DUCK LANE	618116	2
WILLIAMS LN	418176	2
WILLOW LANE	641618	2
WILLOW ST	232174	2
WINDLEHURST RD FLATS	333788	2
WINDSOR RD PRESTWICH	165122	1A
WINIFRED RD NWK	331304	2
WINTERFORD RD NO2	321082	2
WITHINGTON RD I/D	178114	2
WITHINS FM	216292	3
WOODCLAY	328189	2
WOODEND LN	320618	1A
WOOLCO	171881	2
WOOLDEN RD	217539	3
WORDSWORTH RD	312968	1A
WR LEES	232170	2
WRIGHTS ARMS	231849	3
YEW TREE FM	218658	3
YEW TREE,BRIDGEWATER ROAD	216690	3
YORK STREET AUDENSHAW	172564	2

**Note: Double transformer sites are counted as two trial sites*