Technical history of the town gas plants of the British Isles

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Abstract: All of Europe contributed in some way to the discovery of manufactured gas, but it was in Birmingham, England that this great industrial process first emerged commercially to light the world in 1805.

British gas plants constituted a world model for design, layout and operational technology. Their manner of establishment was unique to Britain, where only a few large gas companies were established under royal charter while a greater number emerged under individual Statutory Acts of Parliament, but most were simply self-incorporated. Because of these variable conditions of origin, this paper presents the first attempt at a freely accessible, comprehensive listing of UK gas works.

Due to the patchwork of gas works origins, including steady acquisition of commercial gas works by towns and cities, many older and smaller works were abandoned and no longer appear in the firmament of plants scheduled for remediation prior to new land uses. Some of this obscurity came after the 1947 nationalization of the gas industry, which was entirely manufactured in nature. Nationalization created twelve regional gas boards and the remaining smaller plants were erased from active memory through improvements in higher-pressure gas distribution from centrally located urban stations.

As there is no single list of historic UK gas works, the senior author has spent 12 years searching and codifying the UK record. The new database has been assessed to compile this paper and to display (via four GIS plots) more than 2180 Former Manufactured Gas Plants (FMGPs) and other coal-tar sites that have been discovered, most of which are former gas manufacturing undertakings. Based on our work in the United States to predict the relative percentages of accessory coal-tar sites, we present our estimates of British coal-tar sites, which we now suggest range from 12,920 to 20,355 in number. These are the locations at which we believe various coal carbonization and other manufactured gas residuals and wastes are to be expected. We believe that each site merits attention toward remedial characterization and whatever remedial engineering attention is thereby indicated.

Résumé: Toute l'Europe contribuée d'une manière que découverte du l'essence manufacturé, mais c'était en Angleterre que ce grand processus industriel a émergé pour commerce pour le premier temp et allumer le monde en 1805, à Birmingham. Les usines britanniques de gaz ont constitué un modèle pour la conception, la disposition et la technologie opérationnelle pour le monde. Leur établissement était unique en Grande-Bretagne, où seulement quelques grandes compagnies de gaz ont été établies sous la charte royale. Plusiers les autres compagnies émergeait sous différentes lois statutaires, mais plus que les autres etait l'auto-portrait-incorporated. Au cause de ces origine different, cet article présente la première tentative de liste libre-accessible et complète des gaz usines BRITANNIQUE.

En raison du rapiéçage des origins du gaz usine, y compris l'acquisition régulière du gaz usine commercial à côté des villes, beaucoup des usines plus anciens et plus petits ont oublie. Ces usines n'apparaissent plus dans le firmament des usines programmées pour la remédiation avant de nouvelles utilisations de la terre. Une partie de cette obscurité est le concequence de la nationalisation en 1947 de l'industrie de gaz, qui a été entièrement fabriquée en nature. La nationalisation a créé douze panneaux régionaux de gaz et les usines plus petites ont oublie par des améliorations de distribution de gaz de haut-pression des stations urbaines centralement localisées.

Car il n'y a aucune liste d'usines à gaz BRITANNIQUES historiques, l'auteur aîné a passé 12 ans recherchant et codifiant les enregistres du UK, et maintenant nous avons évalué que base de données de propriété industrielle pour compiler cet article et pour montrer (par l'intermédiaire de quatre traces de terrain de GIS) plus de les 2180 FMGPs et d'autres emplacements de goudron de houille qui ont été découverts dans notre processus. La plupart de ces derniers sont d'anciennes entreprises de fabrication de gaz. A cause de notre travail dans les Etats-Unis, pour le relatif pourcentage des sites de goudron de houille accessible, nous presente notre estimer le "univers" des sites de goudron de houille des île britannique. Maintenant nous pensons que les sites gamme 12.920 de 20.355 endroits, selon notre protocole pour le collection et cotisation de donnée. Ce sont les endroits auxquels nous croyons que la diverse carbonisation de charbon et d'autres résiduels et pertes manufacturés de gaz doivent être prévus. Nous croyons que chaque emplacement mérite l'attention vers la caractérisation réparatrice et quelqu'attention réparatrice de technologie est de ce fait indiquée.

Keywords: Contaminated land, engineering geology, environmental geology, environmental protection geoenvironmental engineering, pollution

INTRODUCTION

All of Europe contributed in some way to the discovery of manufactured gas, but it was in England that this great industrial process first emerged to light the world in 1805, at Birmingham. From a humble beginning, the technologies of manufactured gas grew grandly in scope and in location of application. The world continued to look to Britain for

guidance and it was not until 1873 that a significant contribution (carburetted water gas) came from elsewhere, mainly America.

British gas plants generally constituted the world model for design, layout and operational technology. These details were covered quite nicely in The Journal of Gas Lighting, which originated in 1849 and survived beyond the era of manufactured gas. Contemporaneous with development of manufactured gas technology came the spread of Britain's canal and rail network and gas works were rapidly established both in towns and factories as a source of light, and later for heating and various fuel uses. The manner of establishment was unique to Britain in that some large gas companies came to be under royal charter while a greater number emerged under individual Parliamentary Acts, and many were simply self-incorporated. Because of this variable condition of origin, this paper presents the first attempt at a freely accessible, comprehensive listing. All of this was very much different to North America, where literally all town gas plants had to have a franchise granted by the city or town, and most of these were exclusive in the sense of monopolies. Also unique to the British experience were a large and growing percentage of "corporate" gas works belonging to towns and later (after about 1870) to district councils. Over time, there was a trend away from commercial gas works in most cities, so that at the end of the era of manufactured gas, a considerable percentage of UK gas works were in municipal hands.

As a consequence of British Gas PLC holding its list of gas works at a confidential level of privacy, the authors have spent the past ten years searching and codifying the record of gas works of the UK. Our results, presented in this paper, list and display (via GIS plots) nearly 1700 FMGPs and other environmentally prominent locations, which should receive remedial characterization and engineering attention.

The authors believe that sound site and waste characterization (classification) is absolutely essential to public health and safety considerations surrounding the presence and possible re-use of grounds affected by historic gas manufacturing activities and disposal of their residuals and wastes. We strongly advocate that such remedial characterization be led by geologists or that a geologist be involved in key participation for such work (Hatheway, 2002) and we understand that there is a statutory requirement for the UK environmental agencies to employ sufficient chartered geologists and chartered civil engineers for attachment to each local authority, to ensure that subsurface conditions and details of environmental significance are discovered and dealt with properly.

Along this line of geological reasoning, we present just one technical illustration, provided in 1890 by the Bristol United Gaslight Company. This view brings the reader to focus on the high degree of plant interface with the ground, especially around the then prevalent subsurface masonry gas-holder tanks, as well as the tar wells, the water-quench aprons in front of the retort beds, and around and below such other components as the condensers, washers and purifiers.

DEVELOPMENT AND GROWTH OF MANUFACTURED GAS IN THE BRITISH ISLES

Perhaps the first obstacle in locating or otherwise detecting the presence of a former town gas plant, as a potential environmental and public health threat, is to sort out the overlapping nature of plant versus "undertaking".

Manufactured gas in the UK was a dynamic industry, geared to serving consumers, who were wooed by the company into subscribing to the service, literally block-by-block in developed municipalities. By the late Victorian era, consumers were added by expansions of towns served by "extension" of service. In the course of this history, the industry was buffeted by various financial crises, labour unrest and the contingencies caused by war. Gas undertakings were under constant pressure to improve the quality of the product, to restrict the generally noxious impact of their operation and management of residuals and waste, and, all the while, having to submit to pressures to reduce the price of the product. Hence, private undertakings were beset with bankruptcies, changes in ownership and the phenomenon of "consolidation" in which the more urban companies became merged into larger and more financially secure owners. Meanwhile the strong public ownership movement eventually led, in 1949, to nationalization, caused even more perturbation to the knowledge of former gas works.

The authors have approximated the general historical trend in the UK as to timing and numbers of individual gas undertakings (Table 1). Of course, the main caveat here is that it is generally quite difficult to determine how many individual gas plants were operated by a single manufactured gas undertaking. Beyond this aspect is the fact that the most urban of undertakings did not possess sufficient ground in terms of area, to manage all of their plant wastes, including the inevitable gas treatment sludge and residues, the spent purification media, and the residuals that were not converted to by-products or consumed in recycling (mainly as fuel) around the plant. Therefore, it is wise to consider that even the smallest gas plant may not represent the footprint of all of the toxic residuals and wastes generated by that plant.

Also, we understand that some UK gas plants were built anew upon the footprints of original gas works, in which cases it has been discovered that original subsurface gasometer tanks became buried under the subsequent works, and, finally, again buried under successive buildings of later-generation redevelopment.

Reviewer Peter Braithwaite has suggested that we comment on the degree of certainty surrounding these estimated numbers of the various types of coal tar sites. Our rationale represents a transposition of Hatheway's (2002) assessment of the relative numbers of such sites in the United States. That rational begins with the actual number of particular categories of sites discovered in the course of his research, then tempered with a sense of the manner in which the products of each category fit into the regional and national economy of the times. This sense was then extrapolated with a feeling of the relative level of present-day awareness, both historical and in the environmental regulatory sense, then cross-compared with the developing numbers of the other categories. In the final sense it is the authors' opinion that the numbers estimated are likely accurate to within about +/- five percent for actual gas works

and within +/- ten percent for the remainder of categories in which the estimated number exceed a total of up to 20 locations.

Table 1. Estimated numbers of former manufactured gas plants and other coal tar sites of the British Isles*

Category of Site	Number	Remarks
Statutory Gas Undertakings, as authorized by Parliament	400	From 1817 through 1870
Statutory Gas Undertakings, as authorized by the national Board of trade	700	From 1870-1949
Local Authority Gas Works	450	Owned and operated by corporations (municipalities), urban district councils and other authorized public agencies
Non-Statutory Companies	430	Incorporated stock companies or sole ownership gas companies
FMGPs not reported in various UK journal directories	200	Non-detection by virtue of non-membership in gas associations or non-participation in voluntary reporting to publishers of the directory. Non-reporting of multiple or replacement plants by some gas-making entities.
District Gas Holders built as below-ground components (To about 1910)	500	Common to larger cities with distribution holders and gas compressors were used to extend the radius of distribution beyond the original area. Below-grade holders subject to out-leakage of tars and tar oils accumulated from water-seal contact of storage of purified gas.
Railway Oil Gas Plants; Pintsch plants at rail yards (1882-1960)	pre-1907 to 1940s 25-50	"Light Hydrogen Plants" using recovered oil-gas tar to produce railway lighting gas rich in methane and hydrogen. Compressed gas carried in special tank cars or within tanks mounted beneath rail car flooring. Great Western and Great Eastern Railways in particular.
Gas plants at military posts, yards and stations (1849-1945) Gas plants and gas producers at arsenals and munitions plants	50-100 25-500	Virtually any post in operation prior to 1910; As a result of general isolation from commercial sources. Particularly of the WW I era.
Institutional gas machines (1850-1950)	2000-4000	Rural-area hotels, resorts, hospitals, colleges and schools, estates and mansions, and asylums.
Kerosene refiners (from soft coal); (1848-1870)	50-100	Distilled lamp oil from boghead coal; Mainly from lower Carboniferous Scottish oil shale.
Gas producers (1880-1950)	3000-5000	From around 1880 Britain was world leader in producer gas plants, starting with the inventions of Ludwig Mond, a German immigrant. Fuel supply units for industrial plants incorporating furnaces or kilns; Factories, smelters, iron and steel plants, brick, terra cotta and cement plants, and shipyards. 1920: National Gas Engine Co. (UK) was advertising gas producers to operate on common UK fuel sources such as anthracite and bituminous coals, coke, sawdust, wood refuse, lignite, peat and vegetable waste. 1942-1944: Hundreds of Mond gas producers were set up "to provide supplementary fuel resources in case munition factories were bombed."
Domestic/Residential gas machines (1890-1950)	3000-5000	Large homes, mansions and country estates
Bottled manufactured gas plants (1912-1940)	100	Manufactured enriched water gas or solvent-vapor gas; compressed to liquid state into small, portable cylinders.
Compressed fuel briquette plants (1910-1940)	50	Blends of breeze and/or oil-gas lampblack; bound with tar and compressed into small bye-product briquettes.
Beehive charcoal ovens	400-500	From 17th through 19th century.
Beehive coke works (1800-1930)	300-500	Produced coke without recovery of by-products from single-oven hives and from block ovens (after about 1870).
Bye-product coke ovens at collieries	50-100	Post-1890; many likely would have had associated tar distilleries
Bye-product tar and pitch-coke ovens at collieries	25-50	Generally post 1910
Merchant and utility coke works (1890-1996)	100-150	Produced coke with recovery of coal-tar by-products.

Tar distilleries (1900-1960)	200-400	Converted purchased gas-works tar residues to industrial chemicals and useful by-products.
Wood preservation plants	800-1000	Pressure and non-pressure impregnation of timber with dominantly coal-tar products, mainly creosote. Many timber and lumber companies also participated.
Shale-Oil Plants	50 plants, 100's of "bings"	West-Lothian Scotland, operating from about 1850-1960 in extraction of mineral oil from oil shales, leaving hundreds of mounded ("bings") of spent, pink residue containing low-ring PAHs as contaminants.
National Fuel Research Board Experimental Stations	5	Largely since 1917, originally as a branch of the Department of Scientific & Industrial Research; first at London
WW-II Coal Gasification Plants (1938-1945)	5-15	Manufactured liquid fuels from coal
1990s Coal Hydrogenation Plants	5	Cooperative venture to synthesize liquid hydrocarbons, as funded jointly between Government and the oil industry; energy intensive to foster molecular cracking; suffered the same limitations as the 19th century Scottish shale-oil plants.
Totals	12,920-20,355	Individual sites at which substantial amounts of coal-tar residuals can be expected to be encountered.

*Compiled by the authors, on various lines of evidence.

Many gas works were constructed on sites overlying active or abandoned coal mines. Historic British gas literature is rife with examples where such gas works were reported as plagued by ground loss and deformation stemming from collapse of underlying coal mine workings. This consideration naturally leads to geological concerns for various aspects of leakage and transport of gas works residuals and wastes, in the terms of contaminated ground and ground water.

GIS Plots of Gas Works and Coal Tar Sites of the British Isles

We have collected all manner of supporting information about individual gas works, including their formal addresses of location, but, for the purposes of this paper, we have identified individual gas plants and other coal-tar sites by the proper geographic name of the town, city or district of the day. We have attempted to plot these on the four maps in this paper (Figures 1-4), but with reference to the present-day location name and the re-designated county boundaries of 1970.

Regrettably, the page limitations of this paper do not allow for presentation of a helpful list of our actual site discoveries. We are presently in discussion with a prominent British geological journal for the means to make this declaration and some sense of this arrangement should be available from the authors at the time of the Nottingham Symposium in 2006.

As for national and greater administrative boundaries, we recognize all sites in Northern Ireland and the Irish Republic as they were known at the time of their establishment, be they in either of the current administrations.

The four location maps were created in the GIS program ArcIMS by ESRI. Base maps are from ESRI 2005 data on Europe and Great Britain, and initial location data were obtained from the U.S. National Geospatial Intelligence Agency GEOnet Names Server. Additional site data were also obtained from the Ordnance Survey maps of Great Britain and the Republic of Ireland. In total, 2,180 known or suspected gas plant and related coal tar sites were entered into the project GIS database. All maps were created in the World Geodetic System of 1984; coordinate systems shown on the maps use the British National Grid.

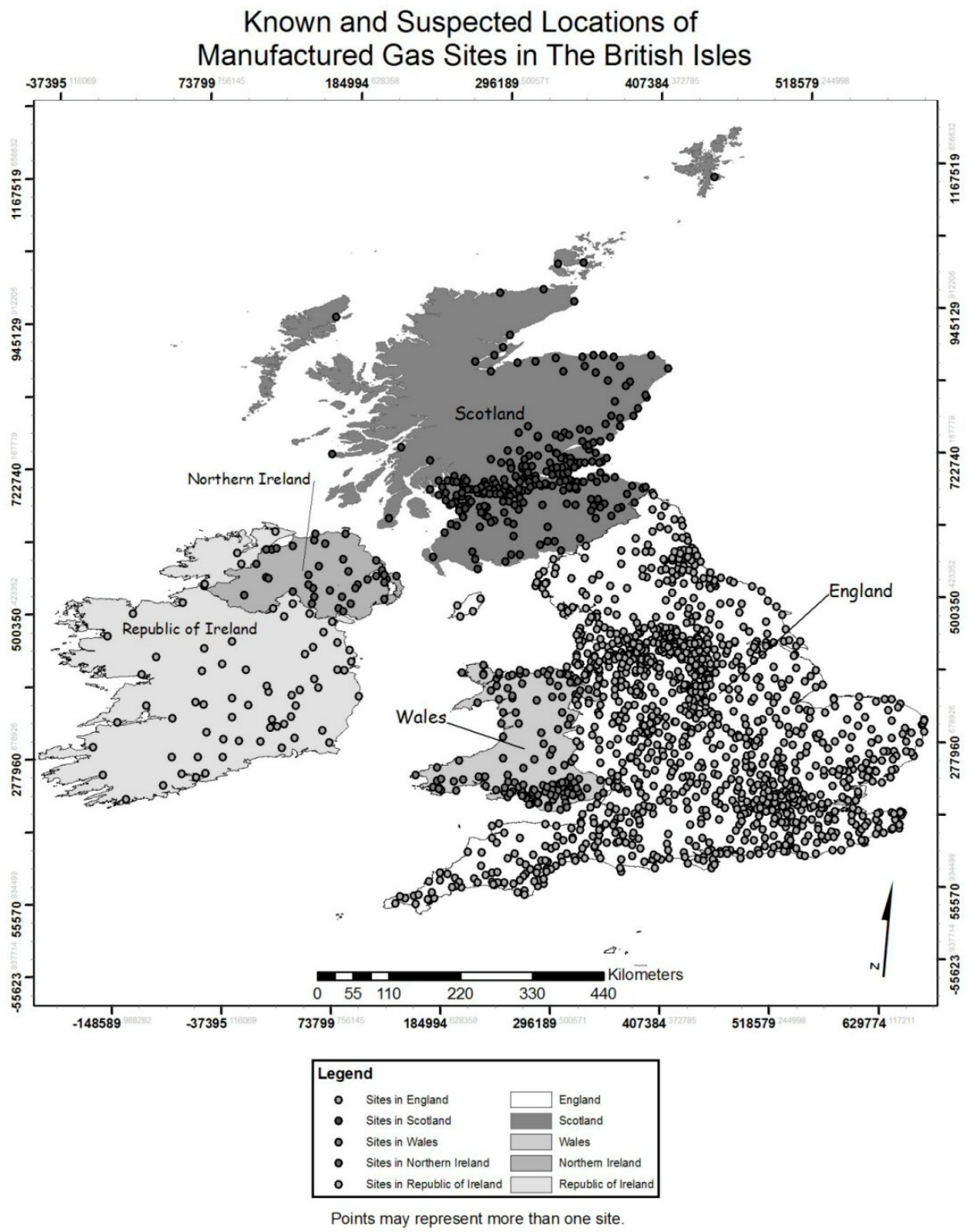

Figure 1. Map showing the location (by town or municipality) of gas works and related coal tar sites in Great Britain and the Republic of Ireland.

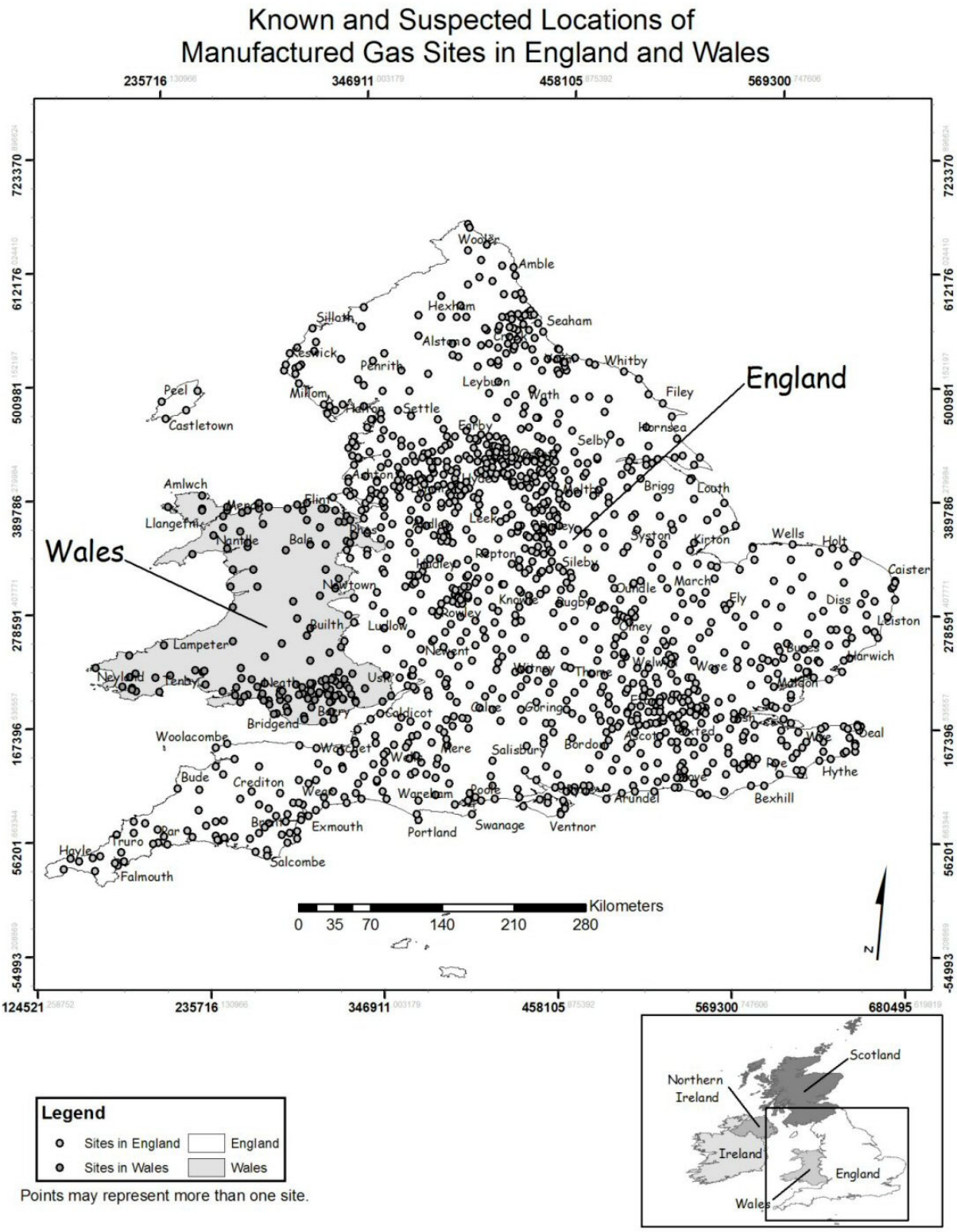

Figure 2. Map showing the location (by town or municipality) of gas works and related coal tar sites in England and Wales.

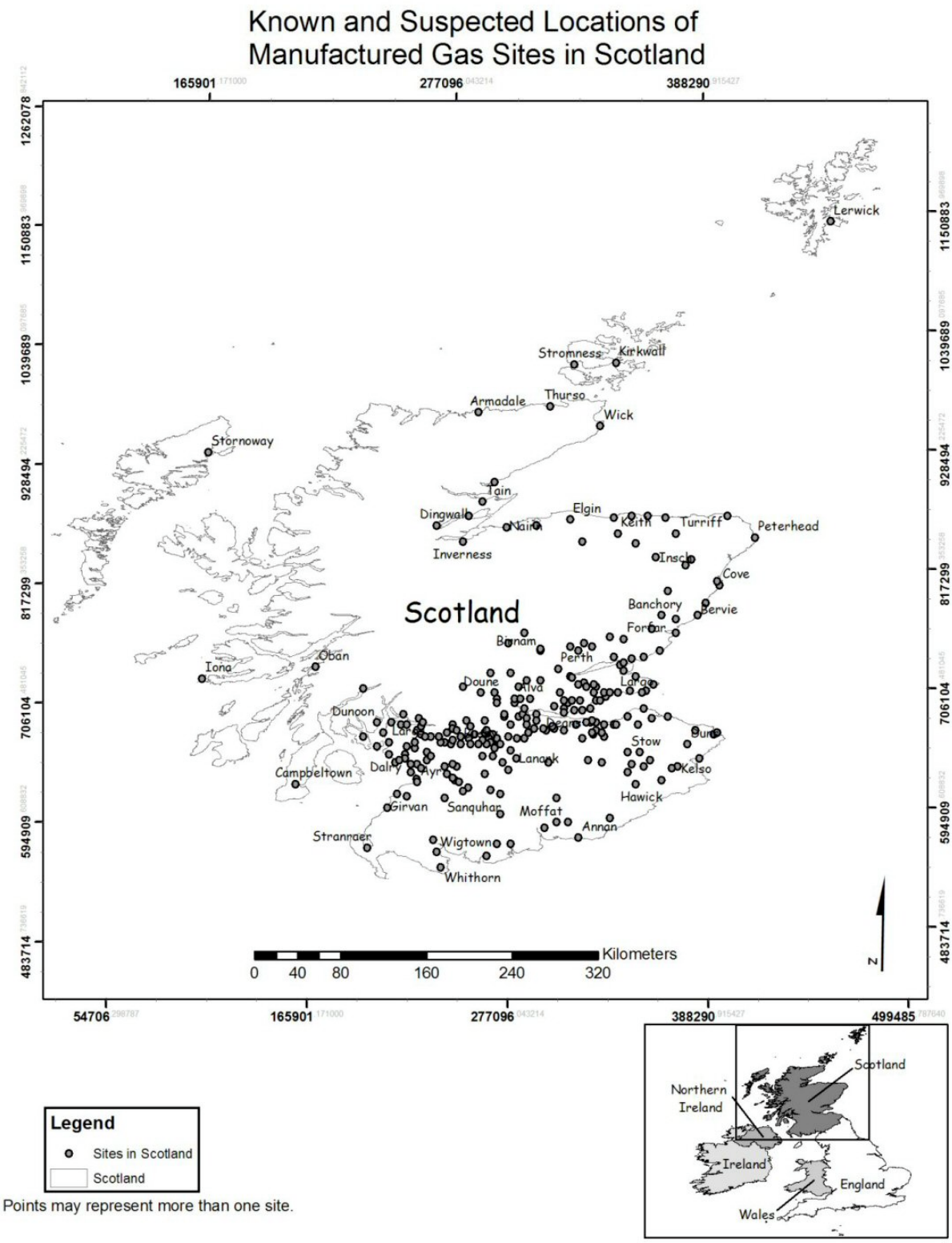

Figure 3. Map showing the location (by town or municipality) of gas works and related coal tar sites in Scotland.

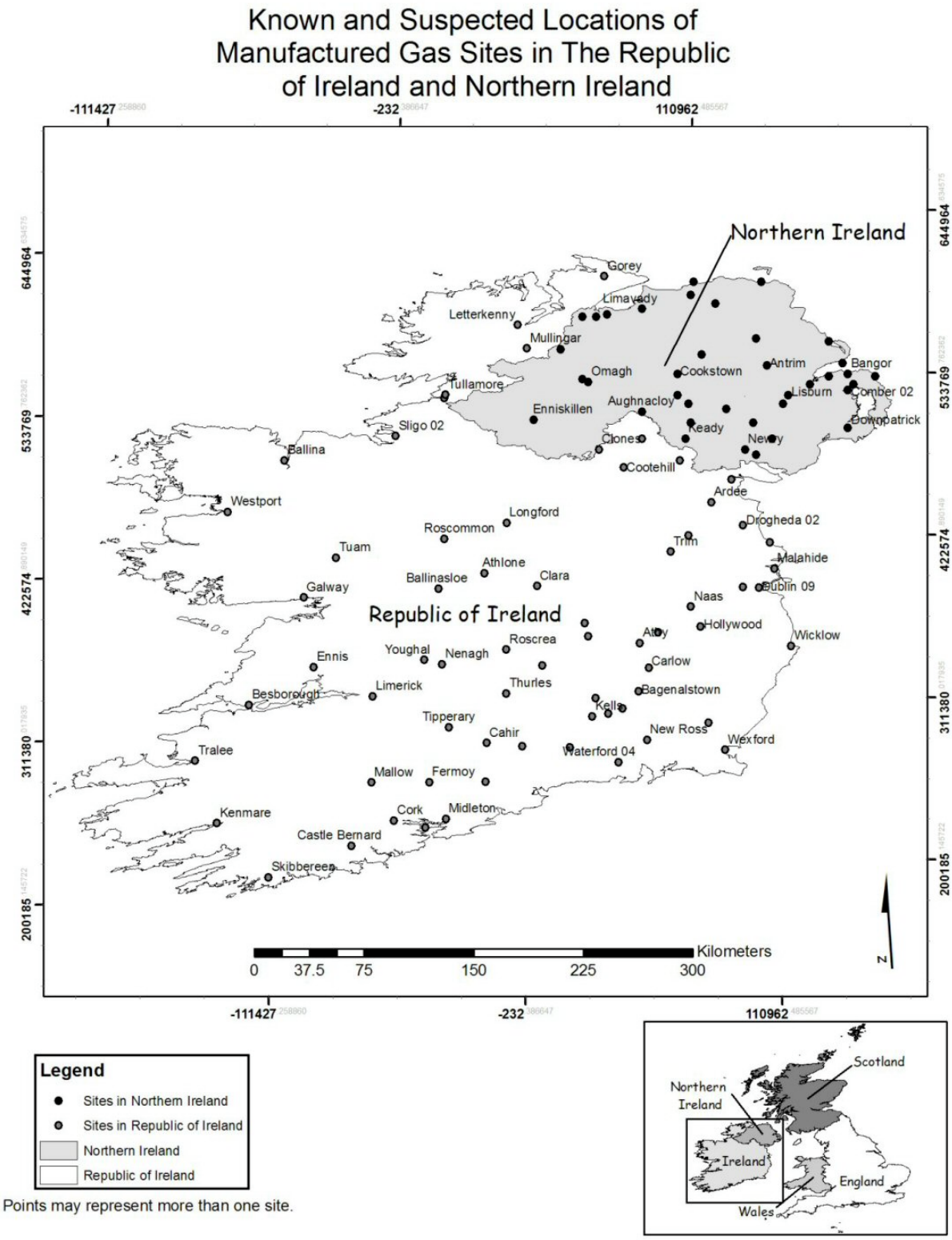

Figure 4. Map showing the location (by town or municipality) of gas works and related coal tar sites in Republic of Ireland and Northern Ireland.

Our protocol for locating individual sites is based on four precepts:

- We consider adjacent gas plants or other coal-tar facilities as separate sites and count them in our numbered tally as such. For example, we show and list two separate gas works at Oxford, Oxfordshire, as based on the original gas works established in 1818, on the north bank of the River Thames, and the second works constructed in 1925 and 1925, on a large site bordering the south bank of the river. (See Figure 1) These sites are listed in the GIS database as Oxford 01 and Oxford 02, with only the total number of sites at that city displayed as (Oxford 02);
- Locations with multiple sites will be annotated with the total number of such sites, as known to the authors;

- Each location known or believed to have a site is identified on the geographic plot by an appropriate symbol;
- For our purposes of documentation, we have recovered, with notion of their being a considered site, the proper reference citation of the source of that information (this information is not provided with this paper, but is contained in the authors' databases).

Myths about Numbers of Former Gas Works in Great Britain

There is a misconception that the total number of former manufactured gas works of the British Isles is somewhere equivalent to the maximum number of identifiable gas undertakings. There are seven outstanding reasons why such a listing would be under conservative (too few in number) in respect of the actual number of expected gas works:

- Gas works became obsolescent as soon as the demand for their product was exceeded by their ability to produce, store and distribute such;
- The occasional gas works became so damaged by fire, explosion or flooding as to warrant rebuilding and, under this imperative, the decision often was made to look elsewhere in the area of distribution, and under new design and operational concepts;
- Rival (opposition) gas works are to be expected to have existed in many mid to large-size towns and the possibility of those both being detected or known at the present time is reduced, especially when non-statutory undertakings are to be considered, in light of their traditional low historic profile;
- Under some circumstances, there would have been no regulatory opposition to a rival gas company, operating in the same city, but competing only for territory yet remaining undeveloped as a consumer base;
- Consolidating gas companies tended to deactivate their smaller and older works on the advent of the increased funding associated with most mergers;
- The social temperament of the area around the gas works sometimes became intolerant of the nuisances associated with or perceived to be associated with the gas making operation, and;
- Prior to about 1900 it was often necessary to add one or more additional gas plants as the area served expanded into the surrounding suburban area and the distribution pressure could no longer economically support the greater distances of distribution.

SUMMARY

It will be some years before a thoroughly accurate accounting of individual coal tar sites is available for the British Isles. At the present time, the authors herewith present our discovered locations and our sense of the numbers of the various categories of tar-related sites, as based on information collected in a 17-year assessment of the literature. The tables and plots have been developed particularly for this paper. It is nearly certain to us that actual numbers presented on Table 1 are conservatively less than the actual manufactured gas residuals and waste sites not only in the United Kingdom, but in the Irish Republic as well.

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