Guidelines for BS 7666:2006

Section 3. Quality assessment and reporting

Version 1

January 2007

This section of the Guidelines covers quality assessment and reporting. It introduces the principles and concepts of data quality in the context of gazetteer creation, maintenance and utilisation and provides general guidance on how to test and report on gazetteer quality in conformance with BS 7666: 2006. This includes a description of some basic data quality measures and quality evaluation procedures, some quality test methods, the outline of a data quality report and an overall process for controlling quality of a gazetteer. It is at a generic level, and will be expanded in later sections in the context of particular types of gazetteer

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Preface

These Guidelines are intended for use with BS 7666: 2006 *Spatial datasets for geographical referencing*. They complement the Standard with more detailed explanation of the content and a general approach to creation of gazetteers. They are not specific to any particular implementation, for which it is expected that specific data specifications and capture and maintenance rules will be produced.

The Guidelines are aimed at:
- gazetteer owners – those with ultimate responsibility for the gazetteer;
- gazetteer custodians – those responsible for the creation, maintenance and quality of gazetteers;
- suppliers of gazetteer software;
- those developing and implementing gazetteer systems
- providers of gazetteer data;
- others who are responsible for aspects of the quality management of gazetteers.

The Guidelines are currently in four Sections:
1. Introduction to BS 7666;
2. How to create a gazetteer of a new type of geographic object;
3. Quality assessment and reporting;
4. How to create a national gazetteer.

Further Sections will cover specific implementation issues:
- How to create a street gazetteer;
- How to create a land and property gazetteer;
- How to create a delivery point gazetteer.

No guidelines for public rights of way which form an informative annex to Part 1 of the Standard are planned at present.

These Guidelines have been produced under the auspices of BSI IST/36 geographic information who are responsible for BS 7666. They were written by Rob Walker and Les Rackham working under the guidance of a Steering Group comprising representatives of major stakeholders in the Standard. The work is sponsored by the Department for Communities and Local Government (DCLG), Ordnance Survey, Office for National Statistics and Mayrise Ltd.

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1. Introduction

All users of a gazetteer need to be aware of the degree to which it is current, complete, accurate and consistent. They also need to understand the gazetteer's history and how and why it was derived so that they can judge the suitability for their purposes. In other words, they need to know something of the quality of the gazetteer data.

All parts of BS 7666: 2006 include the requirement that the quality of data in a gazetteer must be tested and reported. Each gazetteer must have associated with it a data quality report containing details of the results of tests covering aspects of the quality of the data.

The purpose of this section of the Guidelines is to introduce the principles and concepts of data quality in the context of gazetteer creation, maintenance and utilisation and to provide general guidance on how to test and report on gazetteer quality in conformance with BS 7666: 2006.

Since neither this Section nor any other section of the Guidelines relates to any specific implementation of the Standard, acceptable levels of quality cannot be recommended. However, this Section gives general guidance to users of the Standard on designing tests and arriving at acceptable levels of quality for their own implementations. Further details relevant to particular parts of the Standard are to be found in those sections of the Guidelines dealing with these parts.

This Section of the Guidelines does not cover the managing of quality of national gazetteers compiled from local gazetteers. This topic is dealt with in Section 4 of the Guidelines.

Just as for manufacturing, software development or service provision, quality should not be an "add-on" to gazetteer production. It should not be a cursory check at the end of the process. To create and maintain a gazetteer which is fit for the purpose, quality needs to be built into the processes of data capture, compilation and update. Given the right tools, procedures and above all, people trained in the processes, this need not be exacting. Other downstream processes are likely to rely on the quality of the gazetteer. They will incur additional costs if the gazetteer does not meet acceptable levels of quality or, in common parlance, is not "fit for purpose".

2. The management of quality

2.1 What is quality?

Gazetteers are a type of geographic dataset; they record information about locations on the earth's surface. To achieve an acceptable level of quality in any geographic dataset requires careful control of the processes involved in their creation and maintenance and adequate testing to ensure that acceptable levels of quality have been achieved.

This sub-section sets out some basic concepts in the management of quality. These concepts and their application to gazetteer data are explored in more detail in the next sub-section.

First we need to establish what we mean by quality. Quality can be defined as:

- 'Fitness for purpose';

- 'Performance against specification';
- 'Totality of characteristics of a product that bear on its ability to satisfy stated and implied needs'[1].

In the case of gazetteer data conforming to BS 7666, this could be redefined as:

- Fitness for use in the locating of information to a specific geographic place;
- Degree of conformance to BS 7666 and the data specification for a particular implementation of a gazetteer;
- Suitability of a gazetteer for particular purposes.

Quality is frequently described by terms such as "correct", "comprehensive", "accurate", "consistent" and "reliable". These are all subjective terms - "accurate" for one user is "inaccurate" for another. Likewise, saying that all geographic data has to be of the "highest quality" to ensure that all needs are satisfied is largely meaningless because, once again, it is a relative term. If by "highest quality" is meant that all data must be completely accurate, correct and consistent then this is both unrealistic and unachievable. It is unrealistic because it implies that all records need to be checked against the real world as it existed at a particular point in time. It is unachievable because the effort required in attempting to reach "100% quality" is out of all proportion to the value added.

2.2 Achieving acceptable quality in geographic data

To achieve an acceptable quality in geographic data we need to have:

- quality designed into the data creation and maintenance process – in other words – provide quality assurance;
- clear quality goals relating to specific aspects of quality (e.g. accuracy, completeness, consistency) which are based on user needs;
- quality control of the creation and maintenance processes to ensure that errors are minimised;
- adequate testing at the end of the process to provide assurance that quality levels are being achieved;
- clear roles and responsibilities for quality management.

None of the above is possible without a comprehensive data specification. Without this, it is impossible to construct measures and tests and provide an overall assessment of the quality of the data because there is no detailed indication of what you are testing against.

Further, we need to be able to tell the users about the quality of the data. Thus a system of quality reporting is needed.

2.3 Establishing quality goals

To establish quality goals it is necessary to analyse quality into a number of quality aspects that are applicable to the data. These can include, for example, positional accuracy, attribute accuracy and completeness. We need to arrive at acceptable quality levels for each of these, in doing this they need to be SMART i.e.

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[1] International Standard - ISO 8402: 1994 Quality Management and Quality Assurance – Vocabulary.

- **S**pecific – they should absolutely clear about the aspects of quality or the quality elements for which levels are being set;

- **M**easurable – an acceptable quality level has to be measurable or else it cannot be evaluated effectively;

- **A**chievable – setting levels which are unachievable has no purpose since all data will fail;

- **R**ealistic – this means that there needs to be a compromise between what can feasibly be achieved by the data producer, what can feasibly be tested and what is deemed acceptable by the user;

- **T**imely – in the sense of being expedient and practical e.g. to conduct tests to measure the quality level.

2.4 Quality control of the creation and maintenance process

Quality is not an "add-on" at the end of a process. To best meet specified quality levels, quality needs to be built into the data creation and maintenance processes; it is not just a question of testing at the end of the production process.

"**Quality control**" refers to the way in which quality checks are carried out during the production process and items failing quality checks are managed.

During data creation and maintenance, there may be a number of checks carried out most notably at data entry. Depending how the data is compiled it may be possible to build in the validation of certain quality components such that all mandatory entries are completed, all values fall within specified domains and certain basic consistency checks are made. If any data does not pass one of these checks then there have to be procedures for identifying, quarantining and dealing with the failures.

2.5 Quality testing

To ensure that the data reaches acceptable quality levels and to be able to report data quality, tests need to be devised. These can take a number of forms:

- tests of some aspect of all records in the dataset;

- tests of a sample of records, usually chosen at random, of the whole dataset;

- comparisons with the original source of the data such as the real world;

- comparisons with other sources of information regarded as being true such as maps or other geographic data;

- automatic tests using software – these tend to be used to establish the degree of internal consistency within a dataset;

- manual tests using inspection – these tend to be used where original sources or other information needs to be compared with the dataset.

Should the dataset fail to meet the specified quality levels then it should not be released but should be corrected and retested.

2.6 Reporting quality

A standard approach to reporting quality needs to be adopted, preferably using some type of *pro forma*. This should include:

- information about the dataset,

- how it was produced or the lineage,

- how up to date it is or its currency,

- what aspects of quality were tested,

- details of the tests (complete dataset or sample, automatic or manual),

- the source information used for the tests (original source or secondary) and

- the results.

Where a dataset is being maintained and changes are frequent, it will not be practical to update the quality report after every change and a decision will have to be made about what triggers another report, elapsed time (e.g. monthly, annually) or amount of change (e.g. change to 5% of records).

2.7 Quality roles and responsibilities

Meeting acceptable quality levels in the end comes down to people, people to design and manage the whole process, people to capture and maintain the data and people to test the data. For the management of quality to be effective, there need to be clear roles and responsibilities.

- The owner of the data should ensure that:

  (i) a comprehensive data specification is in place,

  (ii) clear quality goals are set which are going to meet user needs, and

  (iii) those managing the data production process have the skills and are adequately resourced.

- The manager of the production process needs to:

  (i) design the process such that there are adequate quality controls and a final test process to be able to deliver data meeting the agreed quality levels,

  (ii) ensure that those capturing and maintaining the data have the right tools, instruction and training to do the job,

  (iii) have in place mechanisms for acting on user feedback, and

  (iv) always be seeking quality improvement and ways of raising quality levels.

- Those producing and testing the data need to be quality aware and understand the quality levels required.

The users also have a key role; they after all will be looking at individual records and will inevitably spot errors and inconsistencies. This needs to be exploited and users encouraged to feedback any perceived errors. However, unless these users see the feedback acted upon, they will cease to provide it and confidence in the dataset will be eroded.

3. Managing the quality of gazetteers

3.1 Data quality and gazetteers conforming to BS 7666

Having introduced some basic concepts of managing the quality of geographic data we now go on to examine how these concepts can be applied to gazetteers conforming to BS 7666: 2006.

This sub-section concludes with a more general discussion about managing quality including quality roles, quality control and quality improvement.

Aspects of quality relating to particular types of gazetteers are given in the Guidelines specific to parts 0, 1, 2 and 5 of BS 7666: 2006.

3.2 What is special about managing the quality of gazetteers?

Gazetteers present particular challenges when trying to manage their quality. Notable amongst these are:

- the volumes of records that need to be compiled in a gazetteer – even for a local gazetteer this can involve many thousands of records and for a national gazetteer, many millions;

- the diverse sources of information – apart from the real world, there are address lists, existing records, maps, all created for different purposes at different times and all having different qualities;

- the difficulty of ensuring and enforcing consistency in recording when geographic objects, even within one class, can be so varied – for example the diversity of land and property objects;

- the lack of consistency in the naming, numbering and describing of objects in the real world – this can result in a lack of consistency in records;

- maintaining consistency when creating and maintaining gazetteers where a number of people may be involved who are spread across several work areas;

- the dynamic nature of many types of gazetteers – the geographic objects recorded in a gazetteer will be changing rapidly – for example business premises;

- the user requirement for a high level of currency, completeness and accuracy in a gazetteer such that they can link their information to the locations recorded in a gazetteer with assurance.

(These problems can be compounded if local gazetteers are amalgamated into national gazetteers. For a discussion of these problems see Section 4 of the Guidelines.)

3.3 Errors frequently found in gazetteers

Because of the nature of gazetteers, certain types of errors tend to be prevalent. Many of these errors can be overcome by a more rigorous approach to managing quality. These errors include:

- excessive division of geographical objects such as streets (including paths) adding little or no value for the user and complicating the maintenance of the gazetteer;

- entering the same object in a gazetteer multiple times leading to duplicate records – for example the same street having several "unique" street reference numbers (USRNs);

- objects being entered which are out of the scope of the gazetteer - examples being railway lines or canals masquerading as streets, or lampposts and bus shelters masquerading as land and property units;

- objects referencing other objects which do not exist e.g. Basic Land and Property Units (BLPUs) referencing streets which are not included in the relevant street gazetteer;

- inconsistencies of identifiers, for example names of geographic objects and spatial units;

- missing mandatory attributes, such as spatial references;

- streets with an incomplete descriptive identifier e.g. missing locality, town or administrative area such that the street cannot be located and identified uniquely within the territory of use;

- inconsistencies and misapplication of parent-child relationships, for example primary and secondary addressable objects.

3.4 Requirements in BS 7666

BS 7666-0: 2006, Clause 6 "Data quality" states that the quality of data in a gazetteer must be tested and reported. A data quality report is required recording a standard set of data quality measures associated with each gazetteer, and containing details of:

- any tests carried out – including details of the test methods;

- the date of each test;

- the name of the tester;

- details of any source material or other information used in the testing.

Particular sections and their contents are specified in respect of the following quality aspects:

- lineage;

- currency;

- positional accuracy;

- attribute accuracy;

- completeness;

- logical consistency.

Aspects of data quality to be included in a quality report

The quality of gazetteers can be described in terms of a number of distinct components or elements referred to as "aspects" in BS 7666: 2006. These can be divided into two types:

Descriptive – these provide information and background to the production and purpose of the dataset so that the user may judge the general suitability of the dataset to their particular application;

Quantitative – these describe numerically, as a percentage or as a pass/fail, how well a dataset meets the criteria set out in its product specification and enable the user to determine whether the quality levels achieved meet their quality requirements.

In the case of BS 7666: 2006, the descriptive aspects are:

Lineage – this describes the history of the dataset, the sources used, the maintenance applied and the methods used in the derivation of the data and changes made since its inception.

Currency – this gives an indication of how up-to-date the gazetteer is by providing a date for which the gazetteer is current.

In the case of BS 7666, the quantitative quality aspects are:

Positional accuracy – closeness of the stated positions to those accepted as true. Although not specified in BS 7666, positional accuracy can be either:

o **Absolute accuracy** - closeness of reported coordinate values to values accepted as being true (e.g. coordinate values on an Ordnance Survey large-scale map);

o **Relative accuracy** – closeness of the relative positions of features in a dataset to their respective relative positions accepted as being true (e.g. position relative to the extent of a street or a Basic Land and Property Unit).

Attribute accuracy – correctness of the values, including dates, entered for each attribute. The Standard distinguishes between discrete attributes i.e those carrying discrete values such as a classification code or an address and continuous attributes i.e. those carrying any value within a specified range such as a date. Detailed quality aspects relating to discrete attributes are:

o **Classification correctness** – the correctness in the application of a particular class to an item;

o **Non-quantitative correctness** – the correctness of an entry which does not contain a quantitative or class value in relation to that believed to be true (e.g. a descriptive identifier);

And that relating to continuous attributes is:

o **Quantitative accuracy** – the accuracy of a value expressing a quantity - this includes dates.

Completeness – degree to which the data is complete in respect of the stated gazetteer scope and the currency. Although not termed as such in BS 7666, this can include errors of **omission** (items missing) or **commission** (items duplicated).

Logical consistency – degree of consistency to rules for the recording and encoding of data items within the dataset. These can include **conceptual consistency** (e.g. is object within the scope of the gazetteer?), **consistency of association** (e.g. does this record correctly reference another record?), **domain consistency** (attribute values fall within a permitted range of values), **format consistency** (data is of the specified format including data type) and **temporal consistency** (dates are correctly ordered e.g. update date not earlier than entry date).

These requirements are echoed in the other parts of the standard relating to streets, land and property and delivery points where similar or identical wording is used for the data quality clauses.

The verification of conformity of a gazetteer to BS 7666 includes a check that it has a quality report meeting the requirements set out the Data Quality clause.

It should be noted that lineage and currency are descriptive quality aspects, there are no tests associated with these aspects.

3.5 What needs to be implemented

The Standard only outlines a requirement for the reporting of data quality, the detail needs to be specified in any implementation of a gazetteer.

The Standard sets out data quality measures for some quality aspects although in no case is the test method specified. These need to be developed as part of an implementation.

The data quality aspects which have specified measures are as follows:

- Positional accuracy - accuracy of coordinates in the gazetteer in terms of distance on the ground;

- Attribute accuracy:

  - Discrete attributes - percentage found correct;

  - Continuous attributes - mean error;

- Completeness:

  - Entries included in the gazetteer in accordance with its stated scope expressed as a percentage of those which should have been present at the date when the gazetteer was current;

  - Duplicate entries included in the gazetteer expressed as a percentage of all entries as of the date when the gazetteer was current.

The above should not be taken to mean that other measures cannot be used in addition. No data quality measures are specified for logical consistency for example, these have to be developed.

Again the Standard does not state whether the whole population of records has to be tested or a sample. If random[2] methods are used, the method of generation of the sample needs to be reported however.

There is no requirement in BS 7666: 2006 to report on the quality of the metadata although normal practice would be to include tests of the metadata content as part of an overall test strategy for a gazetteer.

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[2] Methods of random sampling and the reporting of results based on sampling are out of scope of these Guidelines.

Data Quality Evaluation

There are a number of terms used in relation to assessing the quality of datasets. Aspects of quality have already been described.

Data quality scope – this refers to the degree of applicability of a data quality aspect to the data. The aspect may relate to all attributes and associations in a complete gazetteer but more likely it will relate to:

- o only some classes of geographic objects (e.g. metalled public roads), certain attributes (e.g. descriptive identifier) or associations (e.g. streets and their subdivision into elementary street units);

- o a particular geographic extent – only part of the territory of use of a gazetteer;

- o a particular temporal extent – only those records collected within a certain time frame (e.g. between 1st June 2004 and 21st July 2005).

Data quality measure – this is what is measured about each of the data quality aspects. For example if the data quality aspect is completeness then we may choose to measure the number of missing records in a dataset as a percentage of those entered. A data quality measure may have several tests associated with it.

Test methods or data quality evaluation methods – these are how the data is tested to provide a particular data quality measure. These test methods may be applied to all the records or data items within the data quality scope or a sample. They may compare the data with the real world or some other dataset.

Test results or data quality results – these are the results from applying the test methods. The results may be expressed as percentages, as a mean error or root mean square error, or as simple pass/fail depending on the data quality measure and whether the test is against an acceptable quality level.

Thus in any implementation of a gazetteer conforming to BS 7666: 2006, the following needs to be specified:

- the aspects of quality to be assessed (as a minimum this has to be those given in the Standard) ;
- the data quality scope or scopes relating to a quantitative data quality aspect;
- the data quality measures (these have to include those specified in the Standard);
- the test methods including the sources of information for any tests;
- acceptable quality levels;
- the exact form of the quality report;
- how and when quality reports are to be issued e.g. at every release of the gazetteer, every 6 months, after so many changes to gazetteer entries.

Details are given in later parts of these Guidelines dealing with specific Parts of the Standard.

3.6 Data quality measures and users' priorities

In addition to the data quality measures mandated in the Standard, it is necessary to prioritise what other data quality measures are to be included and then specify their test methods.

It is not going to be feasible to measure all possible quality aspects for all possible attributes and associations. Apart from basic computing requirements for domain and format consistency and some degree of referential integrity, priorities have to be set for assessing the quality of the data content

In setting priorities, it is essential to consider the user. Beyond currency, completeness and accuracy of position, it is suggested that for the user, the accuracy and consistency of certain attributes is going to be a priority, notably the:

- spatial references (e.g. Land and Property Identifier, descriptive identifier of a street) so that they can recognise and confirm that the location described in the gazetteer is correct.

Other priorities may be:

- Update date – to indicate the likely currency of the record.

Of lower priority are likely to be (for example):

- Administrator;
- Secondary classification.

4. Test methods

4.1 Introduction

Having arrived at a number of data quality measures for the gazetteer, then specific test methods need to be devised to arrive at a data quality result.

In deciding on suitable tests, there are a number of basic issues that need to be resolved:

- What is going to be the basis for evaluating quality, are external sources available (other datasets or the real world) or can we only test against the data itself?
- Can some or all of the methods be automated?
- Are tests going to be based on a full inspection of the data or only a sample?

Test methods[3].

Tests or data quality evaluation methods can be divided into two main types, **direct** and **indirect.**

With **direct methods** data quality is determined by making a comparison of the data with various reference information. This information can be either:

- **internal** - contained within the data itself. For example, tests of domain and format consistency need only the data itself;

- **external** – using whatever is available other than the dataset itself. For example tests of positional accuracy or content correctness require information from other datasets or the real world.

Indirect methods infer or estimate data quality using external information on the data such as data sources and reports or knowledge of the data production process.

To measure effectively all elements of data quality in a gazetteer, direct methods using both internal and external information sources are likely to be required although indirect methods may be necessary when compiling national gazetteers (indirect in the sense of having to rely on the quality reports supplied with local gazetteers – see Section 4).

For some types of measures, the tests may be susceptible of **automation**, this is typically so in the case of direct methods using internal sources. Measures of logical consistency frequently fall into this category where data types or domains are being tested. In other cases **visual inspection** will be needed.

Full inspection involves the testing of every data record within scope. Typically, full inspection is relevant to small populations of records or automated methods.

Larger datasets such as gazetteers are likely to have to use **sampling** where manual inspection is required, such that sufficient items are tested to give a meaningful data quality result.

These Guidelines do not include specific guidance on sampling methods; this is a major topic in its own right. The reader is referred to the relevant ISO Standard on quality evaluation[4].

Examples of test methods relevant to the data quality measures discussed above are given in Table 1. Under test method, the use of random sampling is proposed.

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[3] What follows is based in part on International Standard, ISO 19114:2003 Geographic information – Quality evaluation procedures.
[4] International Standard, ISO 19114:2003 Geographic information – Quality evaluation procedures.

Data quality aspect	Detailed data quality aspect	Data quality scope	Data quality measure	Test method
Positional accuracy	Absolute accuracy	Positions of all geographic objects recorded in the gazetteer	Mean error in metres of recorded coordinates of representative points against those believed to be true	1. Take each point from a random sample of all geographic object records. 2. Determine by inspection of a large-scale OS map if each point is correctly positioned according to the data specification. 3. Where point is incorrect, measure distance from where point is believed to be and convert to distance on the ground. 4. Take all test results and compute the mean error. (Mean error = the mean value of all the errors without regard to sign.)
Attribute accuracy	Non-quantitative correctness (of discrete attribute)	Spatial references of all geographical objects recorded in the gazetteer	Number of location records with incorrect spatial references as a percentage of all location records	1. Take a random sample of all geographic object records. 2. Determine by inspection of a large-scale Ordnance Survey map and any other external sources if each spatial reference conforms to the data specification. 3. Take all test results and compute a percentage of those incorrect.
	Quantitative accuracy (of continuous attribute)	Start dates of all location records in the gazetteer where not notional dates (i.e where the true start date is not known)	Mean error of the start dates of all location records in the gazetteer where this is known	1. Select those geographic object records that have start dates that are not notional dates. 2. Determine as far as possible from external sources the accuracy of the start dates and determine the difference between that and the recorded date. 3. Take all test results and compute a mean error for the overall result. (Mean error = the mean value of all the errors without regard to sign.)
Completeness	Omission	All geographic objects within scope of the gazetteer and the territory of use existing on the date the gazetteer was current.	Geographic objects present in gazetteer as a percentage of those present in the real world (or believed to be present) at the time the data was current	1. Take a random sample of areas within the territory of use. 2. Determine by inspection of a large-scale Ordnance Survey map, aerial photography of an appropriate date and any other external sources (or, if necessary, by visits on the ground) whether each geographic object existing in the sample areas at the date when the gazetteer was current had been captured. 3. Take all test results and compute those geographic objects recorded in the gazetteer as being present in the sample areas as a percentage of those actually believed to have been present when the gazetteer was current.

	Commission	All geographic objects within scope of the gazetteer and the territory of use existing on the date the gazetteer was current.	Duplicate entries in the gazetteer for the same geographic object as a percentage of those geographic objects present in the real world at the time the data was current	1. As above but determine by inspection if the same geographic object recorded more than once (albeit with different identifier). 2. Take all test results and compute those geographic objects duplicated in the gazetteer in the sample areas as a percentage of those actually believed to have been present when the gazetteer was current.
Logical consistency	Conceptual consistency	Records of all geographic objects recorded in the gazetteer.	Geographic objects outside of gazetteer scope (i.e. not of the types as specified in the scope) as percentage of all geographic objects recorded in the gazetteer	1. Take each record from a random sample of all records. 2. Determine by inspection of each record (and, if necessary, any other external sources available) if the geographic object is within the geographic scope. 3. Take all test results and compute the number of geographic objects recorded which are outside the gazetteer scope as a percentage of all geographic objects recorded in the sample.
	Association consistency	All attributes that cross-refer to other attributes within this or associated gazetteers[5] (cross-references to external entities are out of scope)	Pass if all cross-references refer to valid items existing in the gazetteer or associated gazetteers	1. Pass all records through a software validation which checks that all cross-references exist in the gazetteer or an associated gazetteer. 2. Fail the gazetteer if any failures.
	Format consistency	All attributes in all geographic object records in the gazetteer	Pass if all formats (maximum occurrences, data types) consistent else fail	1. Pass all records through a software validation which checks that all attributes are consistent with the format rules set out in the data specification. 2. Fail the gazetteer if any failures.
	Domain consistency	All attributes in all geographic object records in the gazetteer	Pass if all values fall within valid domains else fail	1. Pass all records through a software validation which checks that all attributes are consistent with the domains set out in the data specification. 2. Fail the gazetteer if any failures.
	Temporal consistency	All attributes with data type of date in the gazetteer.	Records with incorrect date ordering (e.g. start date earlier than entry date: entry date earlier than update date) as a percentage of all records	1. Pass all records through a software validation which checks that all dates are correctly ordered. 2. Compute the number of records that fail as a percentage of all records.

Table 1: Examples of data quality aspects, scopes, measures and test methods applicable to gazetteers

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[5] For example land and property gazetteer and its associated street gazetteer.

4.2 Development of acceptable quality levels for gazetteers

Testing the quality of a gazetteer and reporting the results is a valuable exercise in its own right. However, it is far more valuable if the gazetteer quality is compared to pre-determined quality levels such that the dataset is not released unless these levels or quality goals are reached. As stated previously, acceptable quality levels or AQLs need to be SMART i.e. **S**pecific, **M**easurable, **A**chievable; **R**ealistic and **T**imely. Organisations may aspire to "100%" quality but it can never be achieved, better to state a realistic and achievable level and ensure that it is met.

BS 7666: 2006 does not specify AQLs, these need to be established as part of a gazetteer implementation. In setting AQLs, the user must always be borne in mind and their priorities made paramount. As discussed above, the users' priorities are likely to be completeness, and the accuracy and consistency in the recording of spatial references.

Acceptable quality levels (AQLs)

Acceptable quality levels (AQLs) are threshold values applied to the results of testing data quality to determine whether the data meets criteria determined from a data specification or user requirements.

AQLs can be based on various types of values such as Boolean (true or false), numeric or percentage depending on the types of measures adopted.

AQLs can be applied to the results from tests for a specific component of quality such as 'absolute accuracy' and be specific to one attribute such as 'type of property' to determine whether that attribute meets the specified criteria. These are called **simple** AQLs.

Alternatively, AQLs can be applied to the aggregated results from a number of tests to determine whether a gazetteer meets the specified criteria[6]. These are called **aggregated** AQLs. For example, aggregated AQLs could be:

- 100% pass/fail – all attributes in a dataset must reach or exceed the AQL for each attribute;

- Weighted pass/fail – all data quality results are weighted and scored according their perceived significance. Those not achieving a threshold score are deemed to have failed;

- Subset pass/fail – only those data quality results considered important e.g. all mandatory elements, must pass to achieve an overall pass.

These Guidelines do not propose any specific AQLs since these are implementation dependent. More specific guidance is given in those Sections dealing with Parts 1, 2 and 5.

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[6] Derived in part from International Standard, ISO 19114: 2003, Geographic information – Quality evaluation procedures, Annex J

5. Reporting gazetteer quality

5.1 Requirements

The Standard does not mandate the form of the quality report although it mandates that certain details are included, these are set out in **3** above.

The general form of a quality report that would be suitable is given in **5.3** below. This assumes that tests were completed on a single version of the gazetteer current at a stated date. The report does not include any item for metadata, if this is tested this should appended to the report.

5.2 When to report gazetteer quality

Gazetteer data will not be static; the real world which is represented in the data is continually changing. The approach to quality reporting that is adopted will depend on how and when the changes are made available to the user, two possible scenarios are:

1. the changes are made available as soon as the location records are created or updated – albeit with some degree of quality control (see below);

2. the changes are made to a production gazetteer with formal periodic releases of a user version.

In the first scenario it will not be feasible to repeat tests on the whole gazetteer and update the quality report after every change or even after a number of changes. In effect, some sort of **benchmarking** will be needed, that is taking a copy of the gazetteer periodically e.g. once a week, once a month, after 100 changes depending on how much change there is and the size of the gazetteer. The copy of the gazetteer is then tested and reported upon as if it was static. If the testing shows that the acceptable quality levels are no longer being achieved, then action will have to be taken to correct the location records (see below).

In the case of the second scenario a more controlled approach will be possible and tests can be run on the whole gazetteer and assurance gained that acceptable quality levels are being maintained before release of the next user version of the gazetteer. This approach is preferable but may not be feasible in a particular business context where updates are required daily.

5.3 Data quality report applicable to gazetteers conforming to BS 7666
(notes on each entry are given in italics)

Covering page
This page should appear on the front of all reports

Name of gazetteer:	*As stated in the metadata e.g. "Land and Property Gazetteer of the City of Winchester".*
Scope of the gazetteer:	*As stated in the metadata – e.g. "public streets and streets used for creating addresses of residential and commercial property".*
Date of quality report:	*Date the report compiled, not the date of testing, this is indicated against individual tests.*
Report compiled by:	*Name and position of the compiler of the report e.g. "J Smith, Street Gazetteer Custodian, Borsetshire County Council".*
Owner of gazetteer:	*As stated in the metadata e.g. "Borsetshire County Council".*
Testing organisation	*Organisation which actually conducted the tests, it may be the organisation owning the gazetteer, a department within the organisation or some separate organisation. Details should include name and address and contact for the organisation.*
Additional information	*Add any other information relevant to the gazetteer quality e.g.:* • *whether the report relates to the initial creation of the gazetteer or is an update of a previous report following changes to the gazetteer;* • *for a national gazetteer compiled from local gazetteers, whether this is a summary of local testing or the result of testing at the national level.*

Summary of results for each quality aspect
Additional summary information may be added, that shown is for minimum conformance to BS 7666. If this is a national gazetteer compiled from local gazetteers and the results are indirect (e.g. aggregated from local quality reports), then this should be made clear in the summaries below.

Lineage of gazetteer:	*The history of the dataset, the sources used, the maintenance applied and the methods used in the derivation of the data and changes made since its inception. Provide sufficient information such that a potential user can form an initial judgement of the applicability and value of the gazetteer.*
Currency at time of testing:	*This is date at which the gazetteer was considered current at the time of testing e.g. 9th June 2006.*
Positional accuracy	*Summary of result(s) of tests of positional accuracy of the coordinates in the gazetteer in terms of distance on the ground. State whether based on sample or the whole dataset.*
Attribute accuracy	*Summary of the results of tests carried out on:* *1. the accuracy of the discrete attributes in the gazetteer expressed as the percentage found correct;* *2. the accuracy of continuous attributes in the gazetteer expressed as a mean error.* *List the summary results by attribute tested. State whether based on sample or the whole dataset.*
Completeness	*Summary of the result(s) of tests to verify:* *1. that all entries have been included in the gazetteer in accordance with its stated scope - express results as a percentage present;* *2. that there are no duplicate entries - express as a percentage of duplicates.* *State whether based on sample or the whole dataset.*
Logical consistency	*Summary of the results of tests to verify that entries in the gazetteer have been recorded in a consistent manner.* *List the summary results by type of consistency tested e.g. format consistency, domain consistency. Express results as a pass or fail or percentage failures as appropriate.* *State whether based on sample or the whole dataset.*

Details of tests
Each page should contain information about one test. Entries for detailed quality aspects, data quality scopes and data quality measures may need to be repeated where multiple scopes, measures or tests are employed.

Quality aspect	*As a minimum there should be reports on tests of positional accuracy, attribute accuracy, completeness and logical consistency*
Detailed quality aspect	*These are subdivisions of the major quality aspects, for example:* • *for positional accuracy - absolute positional accuracy;* • *for attribute accuracy - classification correctness, non-quantitative correctness;* • *for completeness - commission and omission;* • *for logical consistency - conceptual consistency, association (cross-referencing) consistency, temporal consistency, domain consistency and format consistency.*
Data quality scope	*Degree of applicability of a data quality aspect to the data. Indicate whether this is all attributes and relationships in the gazetteer, only some data items (e.g. specific attributes, certain associations), only some types of geographic objects (e.g. streets but not elementary street units), a particular geographic area which is only part of the territory of use or only a certain time frame.*
Data quality measure	*Details of what is measured about the data quality aspect (e.g. if the detailed data quality aspect is completeness – omission then the measure might be records omitted as percentage of those present in the gazetteer).*
Test method	*A description or a reference to the method used to apply the data quality measure to the data quality scope*
Internal/external sources	*Describe the information sources used i.e. internal - contained within the data itself or external – outside sources of information. If the latter, then the sources should be described e.g. OS Land-Line, aerial photography, Postcode Address File.*
Automatic/manual	*Indicate whether automatic e.g. software, manual inspection or both were used for test.*
Full inspection/sampling	*State whether there was a full inspection of the data or a sample, in which case the method of generating the sample should be described or referenced.*
Test result	*Give in units as stated in the data quality measure.*
Date of test	*This is the date the test was actually run.*
Name of testers	*List all those involved starting with the lead tester.*
AQL	*Acceptable quality level if available or applicable.*
Pass/fail	*Where applicable, indicate whether the acceptable quality level was passed.*

6. Overall processes for controlling quality

6.1 Introduction

As was stated in the introduction to this Section, quality is not an "add-on". To maintain and improve quality levels, quality needs to be built into the gazetteer creation and maintenance processes. It is not just a question of testing at the end of the production process and then relying on the user to report errors.

The overall planning of production processes to ensure that the product meets the required quality levels is often referred to as **quality assurance**. **Quality control**[7] refers to the way in which quality checks are carried out during the production process and how items failing quality checks are managed.

During data creation, maintenance and release or supply to users there may be a number of checks carried out:

- at data entry – depending how the data is compiled it may be possible to build in validation of certain quality components such that all mandatory entries are completed, all values fall within specified domains and certain basic consistency checks are made;

- prior to release to the user – more comprehensive checks are made using manual and automatic checks.

If any data does not pass one of these checks then there have to be procedures for identifying, quarantining and dealing with the failures.

The production of gazetteers may be in the context of a broader "quality management system" in operation throughout the whole organisation. This goes further than quality assurance and embraces all those activities needed to deliver quality i.e. planning, operations, evaluations and staff training. There is a strong emphasis on prevention rather than correction and continuous quality improvement.

6.2 Gazetteer creation and maintenance

A simple flow model of gazetteer creation and maintenance is presented in Figure **1**1 which shows the quality related processes.

It is assumed that:

1. the gazetteer has already been created and that there is a working or production copy of the gazetteer as well as the released copy available to users;

2. the gazetteer is formally released in versions to users.

The flow is much idealised and relates to the general case and not to a particular class of locations such as streets. Processes and the sequence in which they are performed may vary widely between specific implementations.

(The processes involved in building national gazetteers from local gazetteers are not included. These are discussed in Section 4 of the Guidelines.)

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[7] The terms "quality assurance" and "quality control" are frequently interchanged leading to an erosion of meaning. The terms are used in the way defined here throughout the remainder of these Guidelines

Gazetteer Custodian   **Gazetteer user**
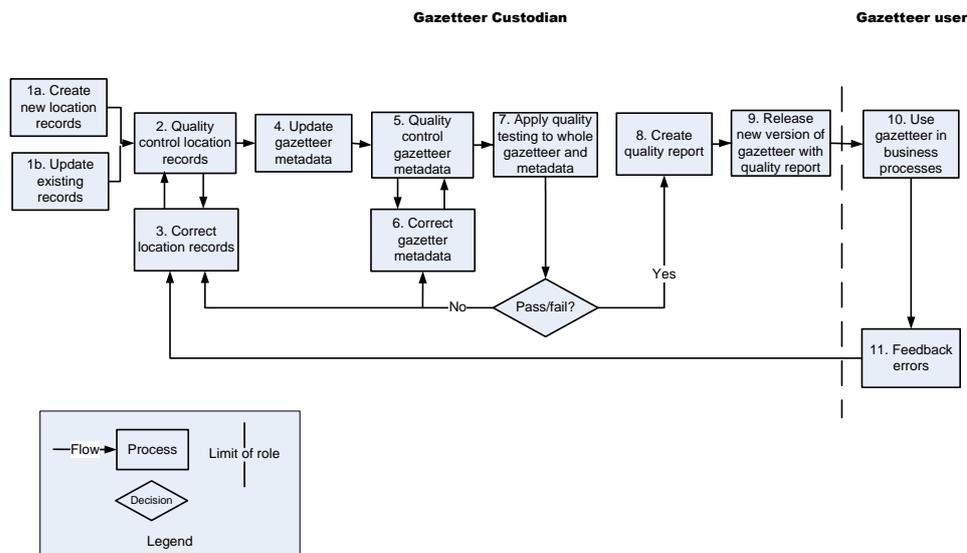
Figure 1: Simplified flow diagram showing gazetteer creation and maintenance

The terms and processes used in the diagram are described in more detail below. The model serves to provide an overview and a context.

1. Location records are created (1a) or updated (1b) in the production or working copy of the gazetteer as the first stage.

2. The location records are quality controlled by manual inspection or validation at entry or both. If by inspection, this may be by random sampling within batches. If any batch fails then the whole batch is quarantined and checked.

3. Location records failing quality control are corrected and subjected to further quality control until the batch passes.

4. The gazetteer metadata is updated if required.

5. The gazetteer metadata is also subject to quality control.

6. If the metadata fails quality control it is corrected and rechecked until it passes.

7. The whole gazetteer is subjected to a comprehensive testing quite independent of the production process using different staff. If the tests show that any of the quality aspects do not meet acceptable quality levels then the location records or the metadata or both need to be corrected and resubmitted for final testing.

8. If the acceptable quality levels are achieved then a quality report is compiled.

9. The new version of the gazetteer is released with the quality report.

10. Users make use of the new version of the gazetteer in their business processes.

11. Users' feedback any errors which are corrected as part of the process of creating the next version of the gazetteer.

The key points to derive from this flow diagram are the need:

- to make quality integral to the gazetteer creation and maintenance process;
- for an overall approach to quality assurance with clear points at which there are quality controls;
- for documented quality evaluation procedures and agreed AQLs;
- for good feedback loops from user to gazetteer custodian.

Two quality roles are shown on the flow diagram, gazetteer custodian and gazetteer user. These are described in the following paragraph.

6.3 Quality roles for gazetteers

The two primary roles for managing gazetteer quality are:

- the **gazetteer owner** – the organisation that has overall responsibility for the gazetteer;
- the **gazetteer custodian** - the organisation or individual that is responsible for the compilation and maintenance of the gazetteer.

(These roles may be performed at a higher level where local gazetteers are amalgamated into regional or national gazetteers. These national roles are discussed in more detail in Section 4 of the Guidelines.)

A third role, often overlooked, is:

- the **gazetteer user.**

These roles, in general terms, are described below.

The gazetteer owner is responsible for ensuring that:

- a comprehensive data specification for the gazetteer implementation conforming to BS 7666 is in place;
- clear quality goals in the form of acceptable quality levels are set which are feasible to maintain and will meet user needs;
- there is an overall quality assurance which is properly planned and implemented and involves quality control and final and independent testing;
- those managing the gazetteer production process have the skills and are adequately resourced.

The gazetteer custodian is responsible for assuring the quality of the gazetteer. Key responsibilities are likely to include:

- ensuring that detailed capture and maintenance instructions and guidance are in place;
- understanding the quality requirements for the gazetteer;
- having clear procedures for dealing with errors and user feedback;
- establishing or agreeing AQLs that meet user requirements (or at least can be practically achieved) with the gazetteer owner;
- providing quality assurance through flowline design with adequate quality control built-in;

- ensuring that adequate procedures are in place for both gazetteer creation and maintenance;

- ensuring that suitable tools are available for gazetteer capture and maintenance which conform to BS 7666 and the data specification for the implementation;

- having quality control and final testing procedures backed by suitable testing tools;

- providing for the identification, quarantining and correction of gazetteer data failing quality evaluation;

- providing for adequate training such that staff have an understanding of the purpose of the gazetteer and are familiar with the capture and test tools;

- having a quality reporting procedure which ensures that quality reports conforming to BS 7666 are available when the gazetteer is released and during maintenance;

- having change control procedures;

- creating a culture of quality improvement where feedback is encouraged and lessons are learned and applied.

The gazetteer users are the ultimate beneficiary. Without the users there is no point in creating a gazetteer or building a service around it. They do not have to be passive players in this; they can be tremendous source of free (and unsolicited) comment and informal quality control. They will experience inconsistencies and notice errors. By submitting comments they can contribute to the improvement process but it has to be seen that the gazetteer custodian is pro-active in this area or else the users will cease to submit feedback and become more disgruntled with the gazetteer.

6.4 Maintaining and improving data quality

Users will be looking for continuing improvements in data and this means that there will be a drive for further quality improvement. To achieve this there need to be mechanisms for:

- feeding back and acting on errors found in data;

- feeding back on improvements to processes by operators of those processes;

- learning and applying lessons from the use of current processes;

- managing change whether to the data specification or the AQLs.

To use that old adage "prevention is better than cure", it is always going to be more cost-effective to create data that meets AQLs than to have to correct it every time. This is likely to be achieved through a combination of better procedures, tools and staff training. No-one knows better than the staff doing the job, they deserve to be heard and responded to where they have ideas for improving the process.