UK Pavement Management System

Technical Note 49

Weighting Set Processing: Implementation Guidelines for UKPMS Developers

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Document Information

Title (Sub Title)	Technical Note 49 Weighting Set Processing: Implementation Guidelines for UKPMS Developers
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Description	This Technical Note provides implementation guidelines for UKPMS Developers for UKPMS processing using Weighting Sets.

Document History

Version No	Status	Author	Date	Changes from Previous Version
0.01	Draft	RAC	07.08.13	First draft based on 070v0105 (SCANNER Road Condition Indicator Implementation Guidelines v1.05) but revised as follows: ▪ The terminology and requirements have been updated so that they are consistent with the Annual Health Check. ▪ Some of the material in the Introduction has been moved to a new Background section and updated. ▪ The Main Report has been changed; it is now only based on subsections where all the SCANNER parameters used by the Weighting Set have been recorded. ▪ The Annual Health Check section has been updated. This document has been transferred to the new template. Reviewed by JMG and CCS
1.00	Issue	RAC	16.08.13	Ratified by Amanda Richards for RCMG
1.01	Draft	RAC	24.01.19	The website references have been updated and clarification has been added about the focus of UKPMS accreditation and the Annual Health Check arising from the RCMG Future Vision Workshop.
1.02	Draft	RAC	30.01.19	Reviewed by CCS
2.00	Issue	RAC	18.02.19	Ratified by Amanda Richards for RCMG
2.01	Draft	RAC	02.02.21	Draft based on version 2.00 but revised as follows: ▪ Website references updated ▪ References to archive documents removed
2.02	Draft	RAC	10.02.21	Reviewed by CCS
3.00	Issue	RAC	02.03.21	Ratified by Amanda Richards for RCMG

Document Owner

The owner of this document is the Road Condition Management Group (RCMG).

Document Support

Support for this document is provided by Linhay Consultancy Ltd and Hyperion Infrastructure Consultancy Ltd who can be contacted via ukpms@hyperion-uk.com. These organisations have been appointed as the UKPMS system accreditors by the UK Roads Board.

This document can be found online on the RCMG website.

Introduction

This document provides implementation guidelines for UKPMS Developers for UKPMS processing using Weighting Sets.

The implementation guidelines contain information on the following topics:

- **Changes since the last version**
- **Background:** This gives the history and evolution of UKPMS processing using Weighting Sets.
- **Requirements:** This gives the requirements for processing, handling Weighting Sets and reporting.
- **Data Model:** This provides a data model.
- **Annual Health Check:** This outlines the requirements for the current Annual Health Check and indicates some possible requirements for future Annual Health Checks.

Changes since last version

The website references have been updated and references to archived documents have been removed.

Background

Under a TTS research project, Chris Britton Consultancy developed a preliminary Defects Index and the report from this project was widely circulated, including to all UKPMS Developers. Subsequent work by a Defects Index Working Group took the model further and established the weighting factors used for the first implementation of the Road Condition Indicator for BVPI reporting in 2005/06.[1]

Prior to the introduction of the SCANNER Road Condition Indicator in 2005, Developers were consulted via:

- SCANNER Road Condition Indicator: Preliminary Consultation (061v0103).
- SCANNER Road Condition Indicator: Feedback on preliminary consultation (069v0102).

The model was then further developed and implementation guidelines produced for 2005 and subsequently updated for 2006.

The guidelines were further updated for 2009:
- To allow the Importance parameter to take negative values.

The generic model for UKPMS processing using Weighting Sets can be used with any valid Weighting Set. However, the following two applications are based on the use of specific Weighting Sets:

- The Road Condition Indicator (RCI) is produced using the Weighting Sets designed for national performance reporting.

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[1] The Working Group recommended that, for BVPI reporting, the "Headline" Index should be known as a "Road Condition Indicator".

- The Carriageway Condition Index (CCI) is produced using a CCI Weighting Set and is used for the calculation of accumulated depreciation.

In 2017 RCMG formed a task-and-finish group to develop a future vision for the collection and management of data used by local highway authorities. They held a workshop and produced a paper (*Summary Proposals from Future Vision Workshop, Aug 2017*[2]) which was well-received by RCMG and the Department for Transport (DfT) and was also acknowledged during the Local Roads Inquiry being carried out by the Transport Select Committee (Dec 2018). A key element of the future vision framework described in this paper was that it should be 'led by the outputs not the method used' and that the focus of UKPMS should be on 'those outputs used by Local and central government, and the Devolved Administrations, to meet national and local statistical/benchmarking/financial reporting needs'.

Consequently, the proposals from the 2017 Future Vision Workshop have been used to provide a direction for UKPMS Accreditation and the Annual Health Check. The focus of the tests will be the reports proposed by the external stakeholders of UKPMS and accepted by RCMG for inclusion in UKPMS.

Requirements

The requirements for UKPMS processing using Weighting Sets are given below. Note that there is flexibility for Developers to deliver this functionality in a variety of ways, suited to the design of their own system, and there is also flexibility to extend the functionality provided that this does not compromise the baseline requirements described below.

Note that for the current Annual Health Check the full functionality described here is not required. An indication of the Annual Health Check requirements is given below in *Annual Health Check*.

Notes:
- *The primary aim of the SCANNER Road Condition Indicator is to process SCANNER data to produce performance indicators for 2005/06 onwards. However an important secondary aim is to use this approach to process TTS data collected prior to Apr 2005. This backwards comparability allows for some comparisons to be made between the new Road Condition Indicator results and the old-style TTS BVPI 96. This is only possible where the older data have defects collected using coincident subsections.*

Data Selection

Users must be able to select data for processing. The intention is that the baseline functionality for data selection is the same as that required for the Automatic Pass. In particular the UKPMS system must allow data to be selected based on:

- **Section criteria**
  The user must be able to select one or more sections to be processed, via either the section label or the section attributes.

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[2] 170901_RCMG TaskGroup FutureVision

- **Survey criteria**
  The user must be able to select one or more surveys as for the Automatic Pass, and it is suggested that this is by survey number. At this stage the baseline requirement is that only TTS/SCANNER data will be processed using Weighting Sets. Although there are no plans to do so, it is possible that the Weighting Set approach may in due course be used with other types of data too. Developers are advised that in this eventuality there will be a requirement to be able to select surveys by survey type.

- **Dates**
  The user must be able to specify a 'from' date and a 'to' date, to select data (sections within survey) which have an end date lying on or between these dates.

As for the existing Automatic Pass, of the selected data, only the most recent for each Section/Feature/XSP are used.

Processing

SCANNER data collected for 2006/07 onwards should not contain any data with non-coincident subsections. The UKPMS system should validate the data prior to processing using Weighting Sets and produce an appropriate error message if such data are found. In these circumstances the Weighting Set calculation is invalid. This validation may be carried out by the UKPMS system at any point in the process up to the calculation of the results from Weighting Set processing, but the preferred option is that the data are validated when they are first loaded, and that if non-coincident subsection data are found the entire file is rejected.

It is recognised that data already loaded (2004/05 and 2005/06) may contain data with non-coincident subsections. Developers will have made ad-hoc arrangements for dealing with these data for the 2005/06 BVPI, and such arrangements should continue if these data are processed in the future. The two most likely courses of action open to Developers are:
   a. Continue to check the data prior to the Weighting Set processing and report an error if any of the data to be used by the Weighting Set lie on non-coincident subsections. If such data are found then the Weighting Set calculation is invalid.
   b. 'Correct' the historical data so that the database contains no data lying on non-coincident subsections.

Notes:
- *The validation described above is important to ensure that Weighting Set processing is the same whether the algorithm is built into the Automatic Pass or handled separately. Provided all defects use the same subsections the Automatic Pass chopping logic will have no impact on the results.*
- *Some of the SCANNER parameters used by the Weighting Set may be missing for some subsections. Such subsections are still included in processing because, even though they are not included in the Main Report, other reports (such as the SRMCS PI report) do include them*

UKPMS processing using Weighting Sets is via three main processing steps:

1. **Weight the SCANNER values**

   At this stage each SCANNER value is given a score in the range 0 to 100. The scores are obtained from weighting curves for each defect and these weighting curves have the following characteristics:

   - The score is 0 for any value better than a threshold
   - The score is 100 for any value worse than another threshold
   - The score for values between these two extreme thresholds varies in a non-linear way. This function is expressed as a series of (X,Y) coordinates and uses linear interpolation (as for the current Method1 defect rating).

   - The weighting curves for each defect may vary by the following section attributes:
       i. Road hierarchy
       ii. Speed limit
       iii. Urban or rural
       iv. Road type
       v. DoT classification

     The convention is that the code 'Any' is used for an attribute which can take any value (i.e. the same as for the existing *Ranking Curve* table).

   - The score is multiplied by additional factors to represent the reliability of the measurement and the relative importance of the defect. The reliability factor lies between 0 and 1 and the importance factor between -1 and 1. These factors also depend on the following section attributes:
       i. Road hierarchy
       ii. Speed limit
       iii. Urban or rural
       iv. Road type
       v. DoT classification

     Again, 'Any' is used to indicate that any value is acceptable for that attribute.

   The defect score at the end of this stage should be given to 2dp, and carried forward to the next stage of processing with this accuracy.

   It is recommended that an error message be produced if a defect on a subsection is not weighted despite being present in the DefectFamily table for the Weighting Set.

2. **Combine weighted values for the subsection**

   At this stage a value is obtained for each subsection using the following process:

   - Assign the defects to families, and for each family take the highest scoring defect as the family value. Note that each defect belongs to only one family.

- Combine the family values to obtain a subsection value. The way in which the family values are combined will be specified for the Weighting Set and currently is one of the following:
    i. Sum
    ii. Maximum
    iii. Average
    iv. Weighted average
  Details of how to calculate the Weighted average are given below in *Data Model*.

The subsection value is given to 2dp and carried forward to the next stage of processing with this accuracy.

3. Produce summary results
The final stage is to provide summary results for the following groups of subsections:

- Whole network
- Splits using any combination of the following attributes:
    o Road hierarchy
    o Speed limit
    o Urban or rural
    o Road type
    o DoT classification
- Individual sections (i.e. section label split)

Developers are encouraged to extend this list to include geographical attributes which allow users to group by area, district etc.

Note that these groupings are all based on section attributes. Although there is no immediate requirement for non-section based groupings (e.g. pavement type) such groupings may be required in the future.

There are two different approaches to calculating the summary results, and the one to be used is determined by a setting in the Weighting Set:

- The first approach (known as the Bin approach) divides the subsections into bins and reports the length of subsections in each bin as a percentage of the total length of subsections in that group. The number of bins and the thresholds between the bins will be parameter-driven.
- The second approach (the Probability approach) calculates the summary result using a proportion of the subsection length. Typically, this notional length is based on the length of all the subsections above an upper threshold plus a proportion of those between the upper and lower thresholds; the proportion will be based on a linear function which interpolates between the lower threshold and the upper threshold. Each subsection between the thresholds will therefore contribute according to whereabouts it lies within the range. (Note that in the general case there may be more than two thresholds. See *Data Model* below.)

The lengths are given in km to 3dp, and the percentage to 1dp.

How does this fit with the existing Automatic Pass processing?

There are clearly parallels between Weighting Set processing and the existing Automatic Pass logic; equally there are important differences too. It is for each Developer to decide to what extent they decide to integrate this process into the Automatic Pass. It could be offered to users as a variation on the Automatic Pass in some systems, or as an entirely separate process in others.

Clearly each of these choices has risks, and at this stage it is difficult to anticipate the future direction of UKPMS processing using Weighting Sets. Currently this type of processing is designed to use SCANNER data only, but in the future it is possible that it might be extended to other types of defects. In these implementation guidelines the likely options and flexibility required at this stage have been indicated, but in the future changes may be introduced which take Weighting Set processing further from the Automatic Pass or conversely, move it closer. Note that there may be benefits of simplicity, transparency and speed in separating the Weighting Set algorithm from the Automatic Pass.

Weighting Sets

The processing described above is controlled by parameters known as Weighting Sets.

Some of the broader issues connected with maintaining Weighting Sets are considered here, while the Weighting Set structure is given below in *Data Model*. Note that for the current Annual Health Check the full functionality listed here is not required. An indication of the Annual Health Check requirements is given below in *Annual Health Check*.

- There is a need to store and use several Weighting Sets. Some of these are current 'standard' weightings used for national results. Others may be old sets, used to help process new data using old weightings and hence compare new and old results. And others will be local sets which users have set up and customised to suit their own requirements.
- Users must be able to view and report the Weighting Set values.
- Users must be able to select a Weighting Set for a particular run.
- Each Weighting Set is designated as either 'Master' or 'Local'. Master Weighting Sets can be added or deleted but cannot be edited. Local Weighting Sets can be added, deleted or edited. Any Weighting Set may be copied to produce a new Weighting Set, which will always be a 'Local' set.
- There are integrity considerations for processed data when a Weighting Set is deleted or edited. While the details of data integrity are for each Developer to determine depending on how they implement the algorithm, a suggestion is that a Weighting Set cannot be edited or deleted if there are any processed data associated with it.
- There may be a need to be able to load new Master Weighting Sets frequently, and quickly. To achieve this, the Master Weighting Sets are available via the UKPMS web site and downloaded by users when required (but not necessarily automatically). The UKPMS system is required to be able to load a new Weighting Set via functionality which imports or links the Weighting Set. Loading and using a new Weighting Set should not require Developer involvement.
- Weighting Sets are published in MS Access, CSV and Excel format. In due course it may be possible to offer XML format too.

- The Weighting Set version control is separate from the Rule Set version control, but there is a control table linking the two. This specifies which Rule Sets are compatible with each Weighting Set. This control table is separate from both the Rule Sets and the Weighting Sets, so that it can be updated whenever a new Weighting Set is made available, or whenever a new Rule Set is made available. Local Weighting Sets will always be based logically on an 'ancestor' Master Weighting Set, and will use that for Rule Set compatibility.
- Each Weighting Set is issued in separate file(s). This is in keeping with the convention used for Rule Sets in that logically the issued database could contain multiple Rule Sets, but in practice each Rule Set is issued in its own database.

Reporting

Two of the main requirements of UKPMS processing using Weighting Sets are:

- To produce the SCANNER Road Condition Indicator (RCI) used for national performance indicators; these requirements are given in the UKPMS Technical Notes (TN41 for Scotland, TN42 for Northern Ireland, TN43 for Wales and TN44 & TN45 for England).
- To produce the Carriageway Condition Index (CCI) used for the calculation of accumulated depreciation; this requirement is given in UKPMS Technical Note 46.

In addition to these reports, three more general reports for UKPMS processing using Weighting Sets are required:

- **Main Report**
  This is a report which gives the run details and the summary results for each group in the selected network.

- **Detailed Results**
  This report (or reports) offers drill-down results to support the main report.

- **Coverage Report**
  This report provides summary coverage information giving the total subsection length and the coverage length for each SCANNER defect (for a user-selected part of the network).

Given the relative simplicity of the algorithm, it is possible that some Developers may wish to carry out Weighting Set processing dynamically, on demand. This is acceptable provided that users are able to obtain drill-down information to support the summary results.

Main Report

Although aspects of this report are similar to the PI reports and some Developers may choose to provide a single report to cover both sets of requirements, there is a distinction between this report and the PI reports. Some of the main differences are:

- The PI report is designed for the national PI Weighting Sets; the Main Report must be able to accommodate any Weighting Set, including those produced locally in due course.

▪ Since the national Weighting Sets currently use only the Bin threshold type, the PI report is only required to present bin results; the Main Report must also be able to present results for Weighting Sets using the Probability threshold type.
▪ The PI report is only required for certain parts of the network (e.g. Principal roads for 130-01, and non-principal classified for 130-02); the Main Report must be able to report on any part of the network and on groups within that network, as specified by the user.
▪ The PI report must provide certain background statistics about the surveyed network; this is not required for the Main Report.
▪ The PI report must provide a PI figure in addition to the summary results; for 130-01 this is simply the 'red' bin figure expressed to the nearest whole number, for 130-02 the PI figure is calculated using a weighted average of the B Class and C Class figures.

By default, the Main Report is based only on those subsections where all SCANNER parameters used by the Weighting Set have been recorded. Developers may, if they choose, also provide an option to include subsections where some SCANNER parameters used by the Weighting Set are missing but this option will not be required for the current Annual Health Check.

The Main Report is divided into two main parts.

1. Run Details & Data Selected

This part of the report contains the details and identifiers for the run.

Ref	Description	Example
a	Authority	Oldshire CC
b	UKPMS System	Bloggs PMS
c	UKPMS System Version	2.45
d	Run Identifier	ABC01
e	Run Date	25/08/2005
f	Weighting Set Identifier	WSFv0207
g	Rule Set Identifier	RP6.01
h	From Date	01/04/2004
i	To Date	31/03/2006
j	Combination method	Sum
k	Threshold type	Bin

Note that for those Developers who choose to implement Weighting Set processing as a type of Automatic Pass, the Run Identifier is simply the Automatic Pass identifier.

If the combination method is Weighted Average, then the weights used should be listed. (See the *Data Model* below for more information about calculating the Weighted Average).

Ref	Description	Example
l	Family Order Number	1
m	FamilyWeight	0.50

This should then be followed by the criteria used to select the sections and surveys used in the run. The report must give the type of criteria (e.g. survey number, section label, or a specified section attribute) and the values included for that attribute. In the example below, all sections with a DoT Classification Code of 3 have been selected. Note that in a general case there may be none, one or several criteria types, and for each criteria type there may be one or more criteria values.

Ref	Description	Example
n	Criteria Type	DoT Classification Code
o	Criteria Value	3

2. Summary Results

This part of the report contains the network groupings used and the summary results for each of the groups.

Ref	Description	Example
p	Network Group	Urban
q	Network Group Length (km)	120.030

As it is possible to set up groups using combinations of attributes then the Network Group may be a composite e.g. DoT Classification 3, Urban.

The Network Group Length is required in km to 3 dp.

If the Weighting Set uses a Bin type threshold then the length and percentage in each bin for this group is given.

Ref	Description	Example
r	Bin description	Red
s	Bin threshold	>100
t	Length (km) in bin	32.963
u	Percentage in bin	27.5%

Note that the percentage is calculated within the group i.e. the length in that bin for that group expressed as percentage of the total length for that group.

The length in the bin is required in km to 3dp, and the percentage is expressed to 1dp.

If the Weighting Set uses a Probability threshold type then the thresholds and their corresponding Pvalues (see *Data Model* below) are listed and these are then followed by the notional length and percentage for the group.

Ref	Description	Example
v	Threshold	100
w	Pvalue	1.00

Ref	Description	Example
x	Notional Length (km)	45.128
y	Percentage	37.6%

The notional length is required in km to 3dp and the percentage is expressed to 1dp.

Example of Main Report

```
Authority:              Oldshire CC
UKPMS:                  Bloggs PMS v2.45
Run Identifier:         ABC01
Run Date:               25/08/2013
Weighting Set ID:       WSFv0207
Rule Set ID:            RP10.01
Dates:                  From 01/04/2012 to 31/03/2013
Combination method:     Sum
Threshold type:         Bin

Criteria:
      DfT classification       3
      Survey number            1254
      Survey number            1298

Network Group:          Urban
Length:                 120.030
      Green (<=0)               44.726        37.3%
      Amber (>0)                42.341        35.3%
      Red (>100)                32.963        27.5%

Network Group:          Rural
Length:                 231.562
      Green (<=0)               115.942       50.1%
      Amber (>0)                74.532        32.2%
      Red (>100)                41.088        17.7%
```

Detailed Results

In addition to the summary results, drill-down functionality is required. The aim of this is to allow users to have access to more detailed information to help them to understand and investigate the final figures given on the Main report and PI reports. Developers are encouraged to provide this in a way to help their users make best use of the results, and the style and contents of the report(s) will vary between systems to suit the way in which Weighting Set processing has been implemented in the system and the user interface.

Suggestions for a typical 'drill-down' package include:
- Report giving subsection values, family and individual defect scores, for selected sections.
- Report listing those subsections which have contributed to the summary results.
- A GIS interface or other visual presentation of the results across the network.
- Business graphics and statistics to analyse the summary results.

The current minimum requirement for the Annual Health Check is a report giving subsection values plus either family or individual defect scores, for a user-selected part of the network.

Coverage Report

A simple summary coverage report is required which lists the total subsection length and the coverage length for each SCANNER defect, for a user-selected part of the network.

The selection of the data by the user should correspond to that offered for Weighting Set processing, namely Section Criteria, Survey Criteria and Dates and only the most recent data for each section/feature/XSP should be included. This will ensure that the data correspond to those actually used for a particular processing run. Equivalently, the interface may simply require the user to specify the processing run.

A possible (and at this stage, optional) refinement, is to extend the report to allow the user to produce grouped coverage results in addition to the summary coverage results. The groupings offered should match, as a minimum, those offered for Weighting Set processing.

Data Model

The tables listed below provide a data model for the Weighting Sets.

Note that Master Weighting Sets cannot be edited. In the data model below it is indicated when an attribute may be edited within a local Weighting Set.

A fundamental assumption of the data model is that any defect included in the Weighting Set must have one and only one measured parameter. If in the future there is a requirement to include defects with zero or multiple measured parameters then the model will need to be extended accordingly.

WeightingRuleSetLink

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
Rule Set identifier	✓	Text (20)

This table resides outside the Rule Set and the Weighting Set and provides a complete list of all currently compatible Weighting Set and Rule Set combinations. Users should use the latest available version of the WeightingRuleSetLink. Each new version of the WeightingRuleSetLink entirely replaces the previous version and although generally the new version is based on the previous version with the addition of new records, this cannot be assumed. There may be occasions when unforeseen problems have arisen with linking a particular Weighting Set and Rule Set and in this case that combination will no longer be present in the new version of the table.

This table cannot be edited; any local Weighting Sets use the WeightingSetID for the Master Weighting Set on which they are based to determine with which Rule Sets they are compatible.

WeightingSetList

Field Name	Key?	Data Type	Notes
WeightingSetID	✓	Text (20)	'WS' for master
MasterAncestor		Text (20)	
MasterFlag		Boolean	
WeightingSetDescription		Text (80)	
Combination method		Text (10)	Sum, Avg, Max, WtAvg
Threshold Type		Text (1)	P or B

Weighting Set ID
All master WeightingSetIDs begin with the two characters 'WS'. Local Weighting Sets should be prohibited from beginning with these two characters.

Master Ancestor
The MasterAncestor is the identifier of the Weighting Set originally used as the basis for the Weighting Set and is used to link the Weighting Set to Rule Set(s) via the WeightingRuleSetLink. For Master Weighting Sets the MasterAncestor is the same as the WeightingSetID.

Master Flag
The MasterFlag is set to True for all supplied standard Weighting Sets, and this indicates that these sets cannot be edited. Any copies will have this flag set to False and will be able to be edited locally.

Combination Method
The combination method is used to determine how to obtain the subsection value. At this stage the required methods are Sum, Avg, Max and WtAvg. It is possible that other combination methods may be introduced in the future. This may be edited by users when customising a local Weighting Set.

Threshold Type
Threshold Type 'B' is used to indicate that the Weighting Set uses Bins, and 'P' is used to denote the Probability approach. This may be edited by users when customising a local Weighting Set, in conjunction with setting up thresholds.

DefectWeightings

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
Survey Type Code	✓	Text (5)
Defect Type Code	✓	Text (4)
CurvePriorityID	✓	Integer
CurveID		Text (5)
Road hierarchy code		Text (5)
Speed limit code		Text (5)
Urban or rural		Text (3)
Road type code		Text (5)
DoT classification code		Text (3)

The reserved word 'Any' is used to indicate when a particular section attribute can take any value for the defect weighting curve, and it is for this reason that some of the field lengths are longer than would normally be the case (e.g. were it not for this, Urban or Rural would be Text(1)).

If more than one record fits the data then the DefectWeightings record with the lowest CurvePriorityID should be selected. For example if the DefectWeightings table included the following records:

WS ID	Survey Type Code	Defect Type Code	Curve Priority ID	CurveID	Road Hier	Speed Limit	Urb or Rur	Road Type	DOT class
WSA	TTS	LLRT	1	C4	2a	Any	U	S2	3
WSA	TTS	LLRT	2	C6	2a	Any	Any	S2	3

Then the LLRT data for a section with the following attributes:

- Road hierarchy: 2a
- Speed limit: 50
- Urban or Rural: U
- Road Type: S2
- DoT Classification: 3

would satisfy both these records. However, CurveID C4 would be selected as this has the lower CurvePriorityID.

If there is no record in *DefectWeightings* for a defect (for the section attributes) then that defect does not contribute. However, it is recommended that if a defect is listed in the *DefectFamily* table but is not weighted then an error message should be produced.

For local Weighting Sets, users should be able to set up weightings (via the CurvePriorityID, CurveID and values of the section attributes) for the defects listed in the *DefectFamily* table.

WeightingCurveList

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
CurveID	✓	Text (5)
CurveDescription		Text (80)

This table lists the weighting curves available for this Weighting Set. For local Weighting Sets, users should be able to define the curves.

WeightingCurvePoints

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
CurveID	✓	Text (5)
X	✓	Decimal 4dp
Y		Decimal 2dp

For any defect the minimum and maximum values for X correspond to the start range and end range numbers given in *Valid Defect Parameter* in the Rule Set. The minimum value for Y is 0.00 and the maximum value is 100.00.

For a defect with a value lying between two given X values, linear interpolation is used to find the defect score (Y) correct to 2 dp from a defect value (X) given to 4dp. For example, if two of the X and Y values provided in the Weighting Set are:

X	Y
15.0000	25.00
16.0000	36.00

Then if the defect has a value of 15.3200, the defect score would be 28.52

For local Weighting Sets, users should be able to define the WeightingCurvePoints.

DefectConfidence

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
Survey Type Code	✓	Text (5)
Defect Type Code	✓	Text (4)
ConfidencePriorityID	✓	Integer
Road hierarchy code		Text (5)
Speed limit code		Text (5)
Urban or rural		Text (3)
Road type code		Text (5)
DoT classification code		Text (3)
Reliability		Decimal 2dp
Importance		Decimal 2dp
FactorDescription		Text (80)

If there is more than one eligible DefectConfidence record then that with the lowest ConfidencePriorityID should be selected.

The Reliability factor lies between 0 and 1 and the Importance factor between -1 and 1; both are given to 2 dp. If there is no *DefectConfidence* record for the defect (and the appropriate section attributes) then the Reliability and Importance factors should default to 1.

The FactorDescription provides an opportunity to store a background note explaining the rationale for the factor.

For local Weighting Sets, users should be able to define the DefectConfidence factors.

Family

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
FamilyID	✓	Text (20)
FamilyDescription		Text (80)

This table defines the families available for this Weighting Set. For local Weighting Sets, users should be able to define the families.

DefectFamily

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
Survey Type Code	✓	Text (5)
Defect Type Code	✓	Text (4)
FamilyID		Text (20)

Each defect belongs to only one family. Note that if a defect is not assigned to a family then it will not contribute. For local Weighting Sets, users should be able to decide which defect belongs to which family. It is suggested that the user should be warned if they have set up a family but not assigned any defects to contribute to it.

Weighted Average

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
Family Order Number	✓	Integer
FamilyWeight		Decimal 2dp

The Weighted Average table is only necessary if the Combination Method is WtAvg. An example table is shown below:

Family Order Number	Family Weight
1	0.50
2	0.25
3	0.15
4	0.10

For local Weighting Sets, users should be able to decide how many families to include and what the weights are, subject to the following validation:

- The family order numbers must begin with 1, and follow sequentially.
- The number of family order numbers should not exceed the number of families, but may be less than the number of families.
- The user should be warned if the family weights do not add to 1.00, but this should be allowed.

The subsection value is obtained as follows:

- Order the family values from highest to lowest.
- Multiply the highest family value by the weight for order number 1, and the second highest family value by the weight for order number 2, and so on.
- Sum the weighted family values to give the subsection value.

If the Combination Method is Sum, Avg or Max the Weighted Average table is not required.

Thresholds

Field Name	Key?	Data Type
WeightingSetID	✓	Text (20)
Operator	✓	Text (2)
Threshold	✓	Integer
Pvalue		Decimal 2dp
ThresholdDescription		Text (80)

Bin threshold type

For the 'B' threshold type, the permitted operators are <, <=, >= and >. When records have the same threshold then certain combinations of operator are prohibited to avoid ambiguity in the bin definitions. The table below indicates by ✓ which combination are permitted when two records have the same threshold value.

Same threshold value				
	<	<=	>=	>
<	x	x	✓	x
<=	x	x	x	✓
>=	✓	x	x	x
>	x	✓	x	x

Equivalently, the string obtained when concatenating the two operators for two records with the same threshold value must contain '<', '>' and '='.

The bins are defined by listing the records in ascending threshold order. If two records have the same threshold, then the '<' or '<=' operator should be listed before the '>' or '>=' operator. Once in this order then adjacent records with different threshold values are subject to the operator constraints listed in the table below.

Different threshold value				
	<	<=	>=	>
<	✓	✓	x	x
<=	✓	✓	x	x
>=	x	x	✓	✓
>	x	x	✓	✓

If the thresholds and operators are:

Threshold	Operator	ThresholdDescription
20	<=	Green
20	>	Amber
50	>	Red

then there will be three bins:

- Green containing values up to and including 20.
- Amber containing values above 20 and up to and including 50.
- Red containing values greater than 50.

The length of subsections in each bin is summed, and the summary result for the bin is this length expressed as a percentage of the total length of subsections in all bins (for that network group).

The minimum threshold value is 0. The maximum threshold value cannot be predetermined in advance as if the combination method is 'Sum' it depends on the number of families in the Weighting Set. A suggested maximum would be 10,000 (which would allow for up to 100 families!)

The Pvalue is not used for the 'B' threshold type, and will be set to a default value of 1.00.

For local Weighting Sets which have been set to 'B' threshold type, the user can decide how many thresholds to provide and what the thresholds, operators and descriptions are, subject to the constraints described above.

Probability threshold type

For the 'P' threshold type, the Pvalue stores the proportion of the subsection length which contributes for that threshold value. For subsections with a subsection value lying between two thresholds, linear interpolation is used to find the proportion to use. For subsection values below the lowest threshold the Pvalue for the lowest threshold is used; for subsection values above the highest threshold the Pvalue for the highest threshold is used.

If the thresholds and Pvalues are:

Threshold	Pvalue
20	0.00
50	1.00

Then if a subsection had a value of 30, the Pvalue for that subsection would be 0.33. Note that for reporting purposes the Pvalue should be given to 2dp, but any calculations involving the Pvalue should use sufficient accuracy to allow the Notional Length in km to be given correct to 3dp and the percentage to 1dp.

The Notional Length is defined as:

$$\sum_i L_i Y_i$$

Where:

L_i is the length of subsection i

Y_i is the Pvalue for subsection i.

The summary result is calculated as the Notional Length divided by the total length of subsections:

$$\sum_i L_i Y_i \Big/ \sum_i L_i$$

The minimum threshold value is 0. The maximum threshold value cannot be predetermined in advance as if the combination method is 'Sum' it depends on the number of families in the Weighting Set. A suggested maximum would be 10,000 (which would allow for up to 100 families!).

The minimum P value is 0.00 and the maximum value is 1.00.

The Operator attribute is not used for the 'P' threshold type, and is always set to '='.

For local Weighting Sets which have been set to 'P' threshold type, the user can decide how many thresholds to provide and what the threshold values, P values and descriptions are.

Annual Health Check

UKPMS processing using Weighting Sets was introduced in the 2005 Annual Health Check and has continued to be required for each subsequent Annual Health Check since then.

The functionality was introduced progressively. For the 2005 AHC the requirement was for basic functionality to enable the BVPIs to be produced consistently by all UKPMS systems. In outline the requirements were:

- UKPMS processing using Weighting Sets, using the algorithm described above and in accordance with the given data model.
- The capability to accommodate multiple Weighting Sets and to allow the user to choose which to use for any particular run.
- Summary reporting, including any specific BVPI report requirements.

For the 2006 AHC onwards, in addition to the above functionality, the requirements were:

- The ability to view and report Weighting Set values.
- Drill down reporting.
- Functionality to load Weighting Sets (via import or link).
- Validation to reject data on non-coincident subsections, and an explanation of how any existing historical data on non-coincident subsections are handled.
- A coverage report.

The following requirements have not been included in the AHC to date, but some or all of them may be included in AHCs in the future:

- The capability to set up and manage local Weighting Sets.
- The ability to output the results to file(s).
- Grouping results (Stage 3 of the algorithm) by geographical attributes (e.g. area) or by pavement.

For the 2019 AHC onwards the focus of the tests will be in line with the RCMG Future Vision Workshop. That is the tests will focus on the reports required by the external stakeholders of UKPMS rather than on the details of the processing or other functionality underpinning these reports.