Modelling and analysis of the salt supply chain for British roads

A technical report prepared by LCP Consulting Ltd on behalf of the Winter Resilience Review Team

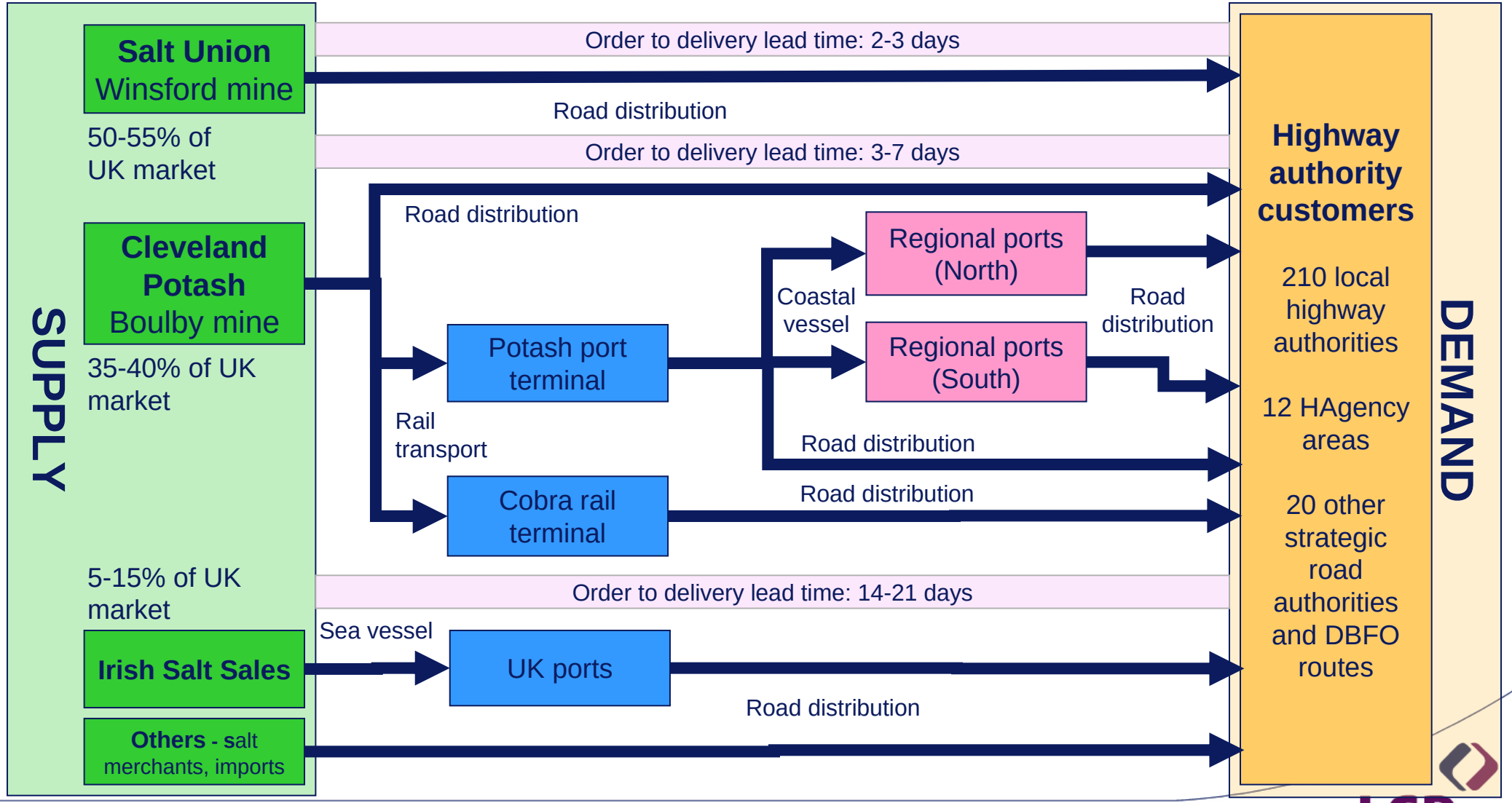
Winter Resilience Review

Contents

Introduction

- This technical report by the Winter Resilience Review Panel describes the work that was completed by LCP Consulting Ltd in support of the Panel's Review
- The work was completed in two stages:
  - First, a short initial review in May / June 2010 to establish whether supply chain thinking was applicable to the work of the Panel
  - Second, the creation of a strategic planning model, as described in section 7.9 of the Interim Report to "explore a range of options for organising the supply chain, against a number of different weather scenarios"
- Through the modelling work and the interactions with the Panel and the DfT, the Recommendations for the supply chain in both the Interim Report and the Final Report have been developed
- The Panel considered that it would be helpful to provide interested parties with a fuller description of the analysis that has been completed
- LCP Consulting has been pleased to support the Panel's work and the preparation of this technical report

The Salt Supply Chain Map



The Salt Supply Chain management view

- LCP used its “models and levers” methodology in the first stage of work to develop an initial view of the supply chain against a strategy, design, planning and execution framework enabling points of tension and inconsistency to be highlighted.
- The following page illustrates the approach
- Each box contains a short description of the attributes of that part of the chain and beneath that are the implications
- The conclusion of this assessment was that supply chain modelling would contribute to preparing detailed recommendations around resolving adverse implications in the salt supply chain

As Is Supply Model	 Mining Production	 Mine Stocks	 Primary transport from mine (rail)	 Other stock holding points (Teesport)	 Regional Trunking (coastel vessel)	 Road distribution	 Customer stock & operations	 Customer commercials
Strategy	Lean constant-rate manufacturing to deliver lowest cost Reduce risk of over production	Minimise stocks at mine to contain investment Push out to customers Use as buffer for demand volatility	**Cleveland Potash only** Move by rail to minimise cost and despatch from mine in bulk volumes	**Cleveland Potash only** Minimise stocks at intermediate points to contain investment Push out to customers Use as buffer for demand volatility	**Cleveland Potash only** Use lower cost coastal vessels to transport high volumes close to demand points Mitigate poor road conditions in severe weather	Minimise road distance to minimise cost Flexible arrangement to manage lows and extremes Full truck point-to-point is lowest cost, excluding use of rail	Evidence of stock reduction and facility closure to reduce costs and tied up expenditure	Attain lowest price for delivered tonne Minimise stock investment and operational cost Maintain commercial flexibility through short contracts
Implications	Limited ability to ramp output for exceptional demand. There will be a demand level beyond which supply cannot cope if severe winter. Commercial objectives of mines differ to the service obligation to the local authorities	Low buffer stocks may lead to shortfall in severe winter; stocks at mine and at intermediate points is key strategic decision Replacing exceptional demand to stock may be constrained by production capacity	Bulk volume moved removes transport bottleneck from mine in severe weather Rail travel more resilient than road in severe conditions	Low buffer stocks may lead to a shortfall in severe winter; stocks at intermediate points is key strategic decision Investment in port side loading/unloading facilities is required	Lessens road transport in severe weather conditions Volumes are committed to regions earlier in order-delivery cycle; less flexibility to divert at short notice if demand poorly estimated	Significant availability risk during severe weather Could be mitigated with rail to regional distribution and at lower cost	Minimising stock will lead to potential for stock outs during extreme conditions, made worse by commercial arrangements	Balance of stock holding cost vs. resilience level not formally evaluated Service expectations may not fit with commercial objectives of suppliers during periods of intense demand
Design	Both key suppliers have designed equipment capacity to reflect the strategic perception of their strategic model e.g. weighbridges, lifts, mining trucks	Capacity for stock holding is operationally designed by key suppliers subject to development constraints	**Cleveland Potash only** Investment made in railhead at mine to enable rail transport direct from mine Salt Union would need railhead and in-land terminals	**Cleveland Potash only** Investment made in portside facilities with rail link for unloading and onward distribution	**Cleveland Potash only** Group customer demand, based on supply channel, and bulk ship to regional ports for cost efficiency	3rd party hauliers contracted to distribute from mines, terminals and regional ports	Locate storage capacity adjacent to main roads Recognise DfT target stock figures Assume minimal supplier lead time	Generally single supplier contracts - 1 to 4 year horizon No contracted volumes - to allow for flexibility
Implications	Physical and operational constraints are built in that will impede additional agility	Stock and holding capacity at mines may not be sufficient for resilience purposes - can this be held regionally?	Requires long term visibility and confidence of sufficiently high volumes to return the asset investment	Stock at intermediate points may not be sufficient for resilience purposes - can this be held regionally? Requires long term visibility and confidence of sufficiently high volumes to return the asset investment	Requires visibility of demand and high level of throughput to return the asset investment	Local road infrastructure at mine cannot cope with heavy truck traffic in severe weather	Not always adopting DfT targets means too low pre-winter stock; this reduces resilience in prolonged heavy winter	Call-off and delivery scheduling is a crucial capability to give suppliers and logistics providers an economic task in a tight market
Planning	Use stock management systems and history to plan summer restock and winter replen Proactive intervention with LAs to plan requirements	Buffer level based on estimated demand; forecast and resilience plan is therefore nationally crucial	Plan for best utilisation of train capacity and fit to route schedule	Buffer level based on estimated demand through each supply channel; forecast and resilience plan by region is crucial	Aggregate forward visibility of estimated demand by regional LAs to plan schedule	Delivery schedule to customers determined to minimise contracted haulier cost	Orders to supplier to restock to target pre-winter level LAs with VMI provide mines with some flexibility on delivery schedules	Contract tender process to select most cost and service competitive supplier
Implications	No consolidated view of total national demand and stock plan to monitor LA compliance with DfT recommendations		Cost effective mode of bulk transport	No consolidated view of total or regional demand and stock plan to monitor LA compliance with Dft recommendations	Geographic spread of customer base is around regional ports - reflecting logistics cost	Volatile demand caused by severe conditions cause more ad hoc planning; incurring higher transport costs	Essentially a good process but not integrated to provide national picture; crucially dependent on right stock levels	Clearly divides the country based on logistics costs
Execution	Steady run-rate over summer; can ramp-up a bit during winter as required	Rebuild buffer stock before start of winter	Full loads of 900 tonnes, 5.5 trains a day from mine to Teesport No other rail currently used	Rebuild buffer stock to estimated level before start of winter Top-up during season in line with demand	On average 10kT shipped per day to regional ports; proportionally in line with LA demand	29 tonne vehicles, all contracted, deliver to customer facilities	Orders placed with suppliers to replenish stocks mid-winter based on demand and VMI Prioritisation of supply becomes difficult in periods of intense demand - hence the Salt Cell	Main restock during lower cost summer period; replenishment orders mid-winter as usage requires
Implications	Ramp-up in salt mining increases operational costs and erodes margin against fixed price contract Maximum run rate of mines are not sufficient to directly replenish demand in a prolonged heavy winter	Risk for availability when stocks heavily depleted Risk on suppliers if over-stock	Low transport costs for this part of the supply chain	Risk for availability when stocks heavily depleted and replenishment must come from mine stocks or production as lead time will be extended	Inaccurate demand information could cause displacement of stock; 'surplus' in one region, shortfall in other	Heavy demand periods cause bottleneck at Salt Union site restricting the despatch rate; reducing agility	Poor control of stock (both pre-winter restock and replenishment) leads to reduced resilience	When demand is excessive and supply cannot cope, market price rises and "snowflake ordering" occurs

Modelling the salt supply chain – terms of reference - 1

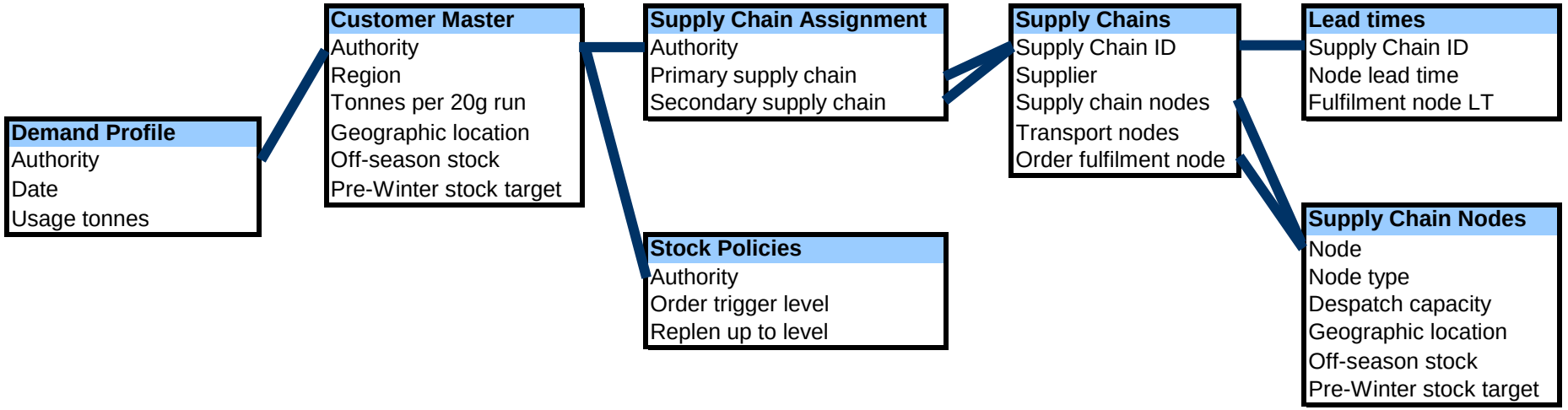
- The objective of building the model for the salt supply chain was to test the impact of different weather / demand, stock and supply chain network profiles
- The model was built to run in two stages; pre-winter restock and the winter season – which is split into two phases: initial run and then a secondary run with a form of intervention set (if required)
- The modelling process was described as:
  - First, the model is configured for the option scenario and run
  - The output resilience dashboard is reviewed
  - In the event the supply chain "breaks" then a form of intervention can be determined and set, and a second run of the model undertaken to see what the impact is
- It was anticipated that it would be an iterative process for each option / scenario to conduct some sensitivity analysis of different interventions
- Multiple supply chains are able to be setup in the model – to reflect the different supply channels
- Each supply chain configured in the model consists of a series of connected elements from supplier through to highway authority: illustrated in the diagrams on the following pages
- The lead time between nodes determines the time-phasing of volume flow through the network

Modelling the salt supply chain – terms of reference - 2

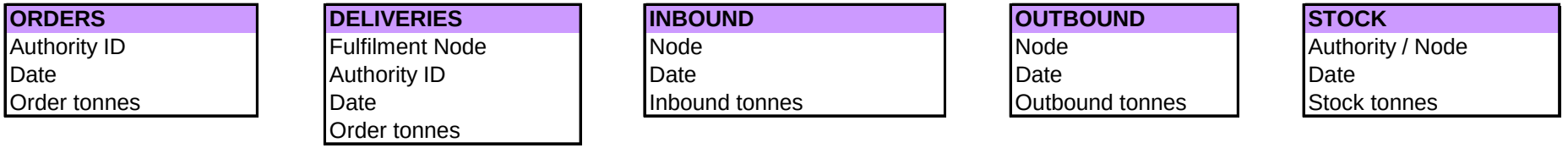
- The nodes and links in the chain to be modelled were specified as:
  - Mine
  - Mine stock (specifically at mine site)
  - Primary transport (mine site to first transit or stock point)
  - First stock point (supplier held stock at other site e.g. Teesport)
  - Trunking leg 1 (transport from first stock point to transit, or other stock point)
  - Transit point (e.g. regional port, effectively a x-dock, with stock only ‘held’ for limited period pending onward shipping)
  - Trunking leg 2 (transport from transit point to regional stock point)
  - Second stock point (regional stock point)
  - Secondary transport (delivery to highway authority – from stock or transit node)
  - Customer (highway authority)

Model design - 1

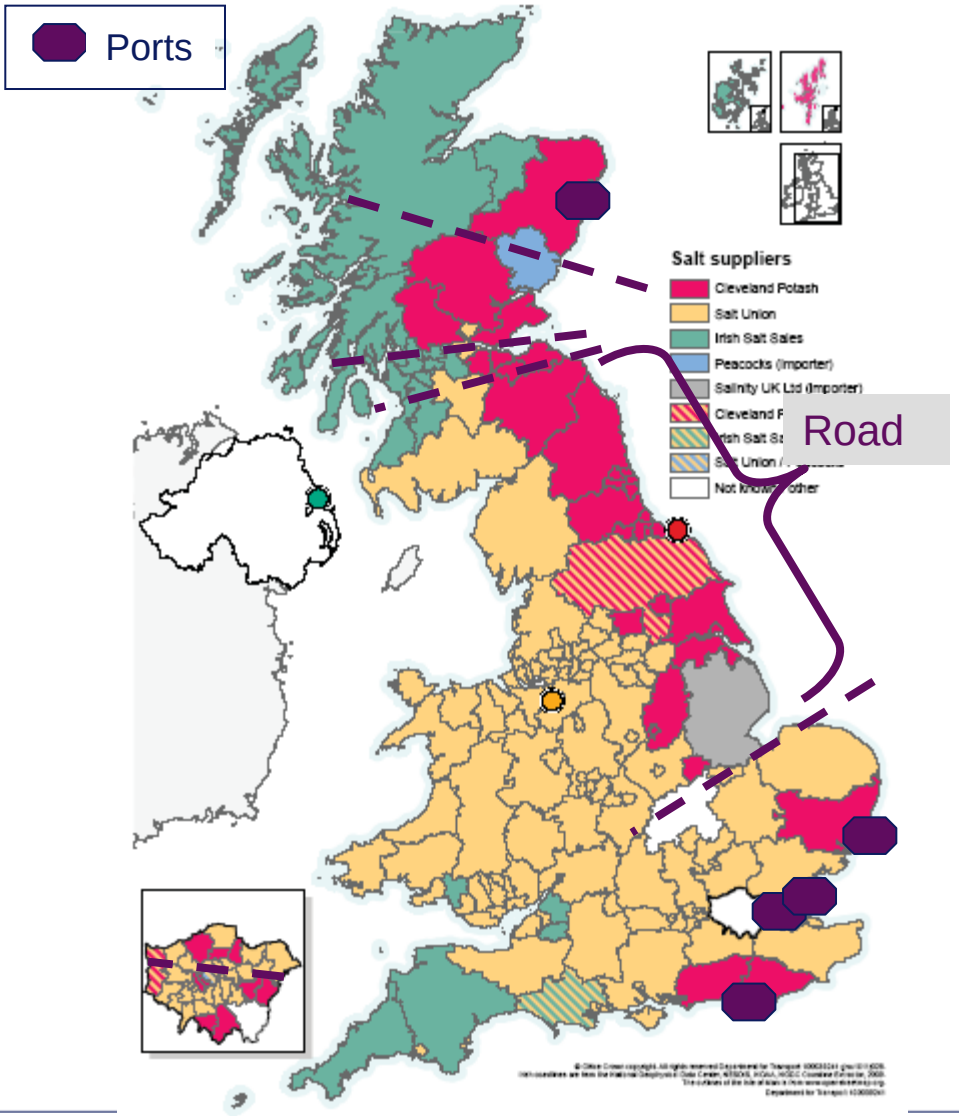
- Customer master, demand profile and stock policy tables generate orders
- Supply chain and node tables determine where the orders are directed
- Lead times added to order date phases the volume in time



Generated in model processing



Model design – 2
CP supply chains are defined in the model



Road from Cobra rail terminal:

- Local highway authorities between dotted lines plus HAgency area 12 & 14, Bear South East

Shipping (3kT ships)

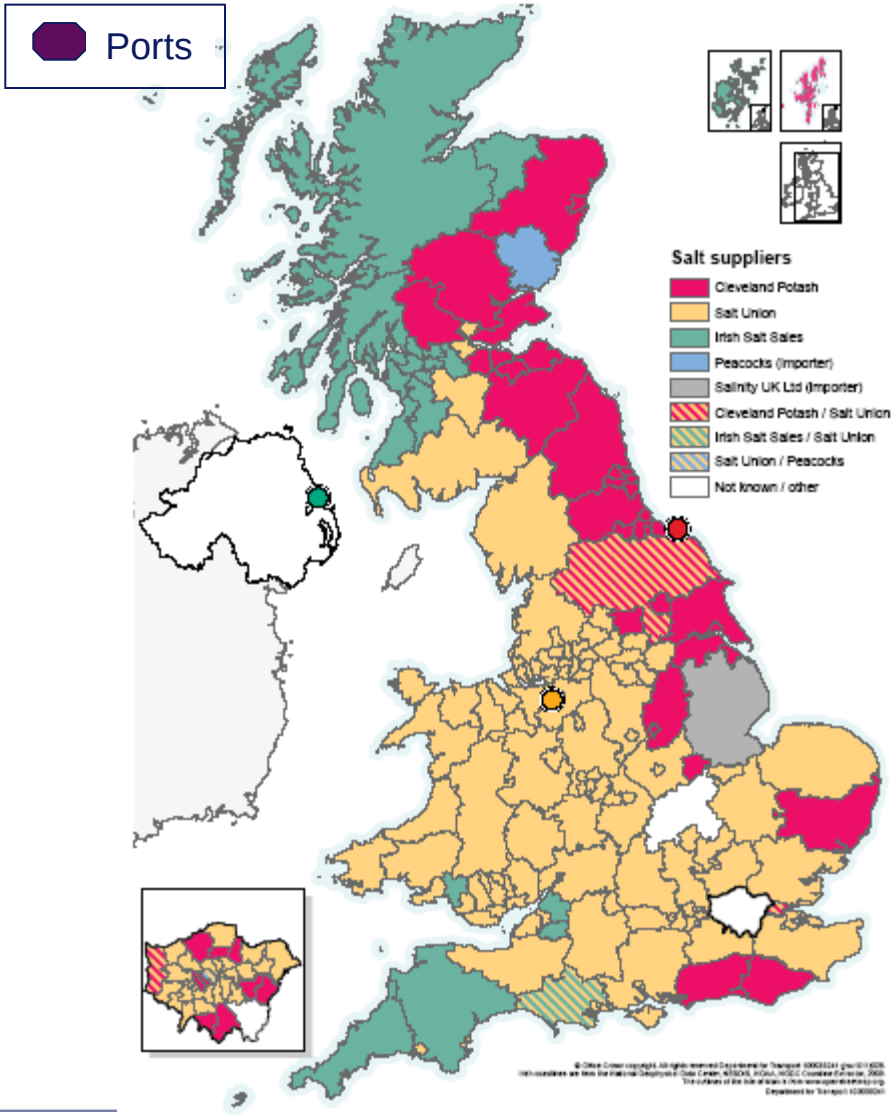
Ports used (with physical lead time to nearest day). Order to despatch from Potash port lead time is 2 days

Scotland (all 1 day)

- Aberdeen for north Scotland inc Bear North East
- Rosyth for Perth, Stirling, Fife
- Rosyth for the Lothians for during winter, pre-winter is by road

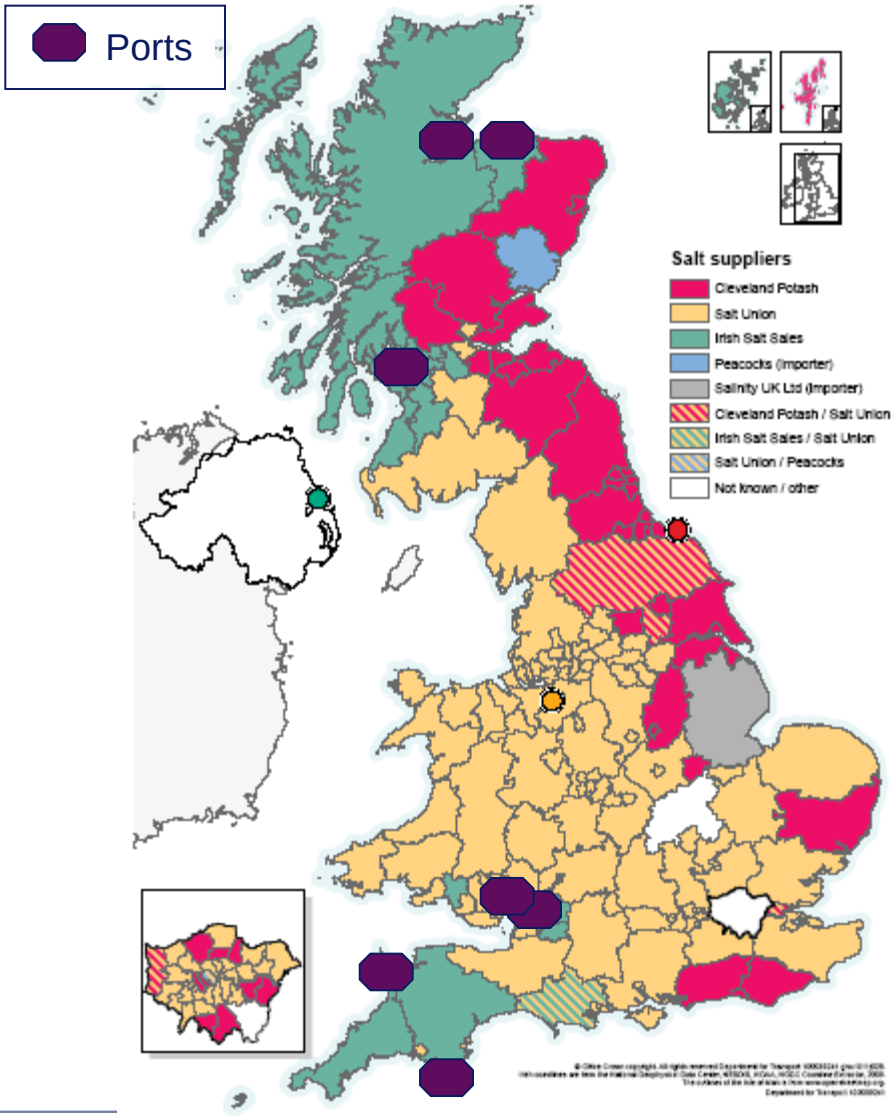
- England
  - Ipswich and HAgency Area 6 for Suffolk (1 day)
  - Tilbury for Essex, Thurrock, N.London (1 day)
  - Ridham for S.London and HAgency Area 4 & 5 (1 days)
  - Shoreham for East & West Sussex (2 days)
- Usually have reserve stockpiles at (5kT at Shoreham, 2kT at Tilbury, 2kT at Ridham, 6kT at Aberdeen)

Model design – 3
SU supply chains are defined in the model



- All by road
- Order to despatch lead time = 1 day
- Plus physical lead time of 1 day
- Despatch capacity from site is ~ 500 trucks (assume 29 tonne trucks) per day for 5 day operation

Model design – 4
ISS supply chains are defined in the model



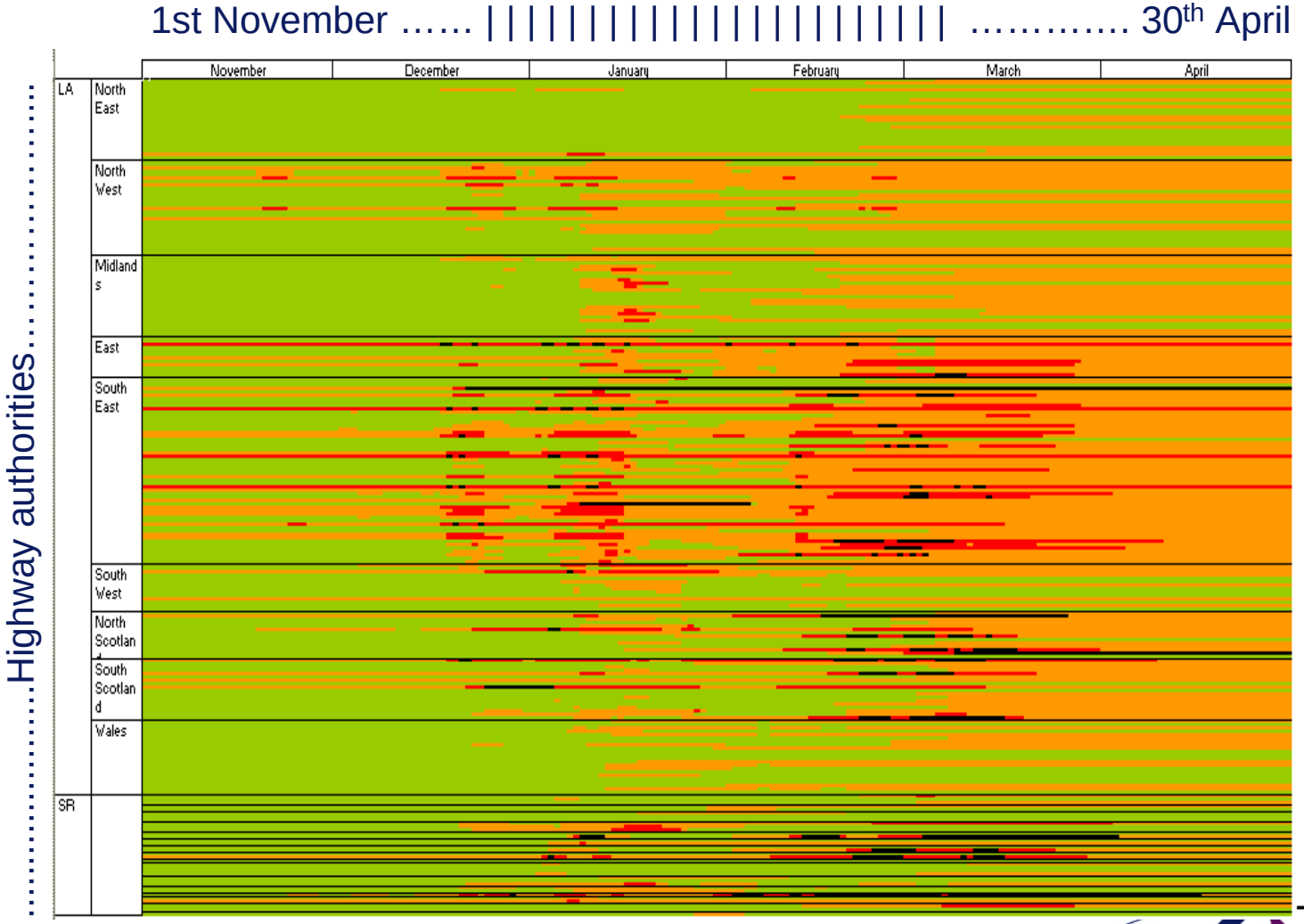
Ports used (with physical lead time to nearest day). Order to delivery lead time is 2-3 weeks (assume 15 days) due to finding available ship etc

- Scotland
  - Glasgow for Argyll & Bute + all local highway authorities to the south (1 day)
  - Inverness for Highlands (2 days)
  - Buckie for Moray (2 days)
- England
  - Bideford/Plymouth for Devon (2 days)
  - Fowey for Cornwall (2 days)
  - Avonmouth for Glouc/Bath (2 days)
  - Swansea for Neath Port Talbort (2 days)
- Reserve stockpiles at Avonmouth (6kT for Wales and SW Eng); Glasgow (18kT for Scotland)

Model design – 5
Interpreting the key model output via the Resilience dashboard

- Each row of the dashboard is a highway authority
- Each column is a date in the Winter season – from 1st Nov to 30th April
- At each date, for each highway authority their stock level is converted to the number of 20g runs capability
- These are coloured coded RYG based on the number of days of heavy runs in stock (4x for LHAs, 6 for SR authorities) as follows:

RYG	Days of 4x/6x 20g runs
	> 6
	2 to 6
	< 2
	0



Using the different data, demand scenarios were profiled in terms of tonnes and 20g runs …

The high level totals have been validated and carry a high level of confidence – the relativity of the different weather intensity shows a range from 1.5m tonnes to 3.3m tonnes of unconstrained demand in 2009/10

Nationally severe winter profile

Country	Authority	Total Demand Tonnes	Total 20g runs
England	LHA	1,760,000	14,600
	SR	470,000	4,100
England Total		**2,240,000**	**18,600**
Scotland	LHA	670,000	3,200
	SR	90,000	800
Scotland Total		**760,000**	**4,000**
Wales	LHA	290,000	3,100
	SR	10,000	200
Wales Total		**300,000**	**3,400**
GB Total		**3,300,000**	**26,000**

Regionally severe winter profile

Country	Authority	Total Demand Tonnes	Total 20g runs
England	LHA	1,670,000	14,000
	SR	350,000	3,000
England Total		**2,020,000**	**17,000**
Scotland	LHA	560,000	2,600
	SR	60,000	500
Scotland Total		**620,000**	**3,100**
Wales	LHA	210,000	2,300
	SR	10,000	200
Wales Total		**220,000**	**2,500**
GB Total		**2,860,000**	**22,600**

Average winter profile

Country	Authority	Total Demand Tonnes	Total 20g runs
England	LHA	840,000	7,300
	SR	210,000	1,700
England Total		**1,050,000**	**9,000**
Scotland	LHA	260,000	1,400
	SR	50,000	400
Scotland Total		**310,000**	**1,800**
Wales	LHA	130,000	1,500
	SR	10,000	100
Wales Total		**140,000**	**1,600**
GB Total		**1,500,000**	**12,400**

These profiles are based on the available data and broadly reflect the winter conditions experienced in previous years – nationally severe profile based on 2009/10, regionally severe on 2008/09 and average on 2007/08

The graph over the page shows the way in which the demand falls during the nationally severe winter season. This will obviously change in timing from year to year but the overall demand will vary less

Note: tonnage figures have been rounded to the nearest 10,000 and runs figures to the nearest 100

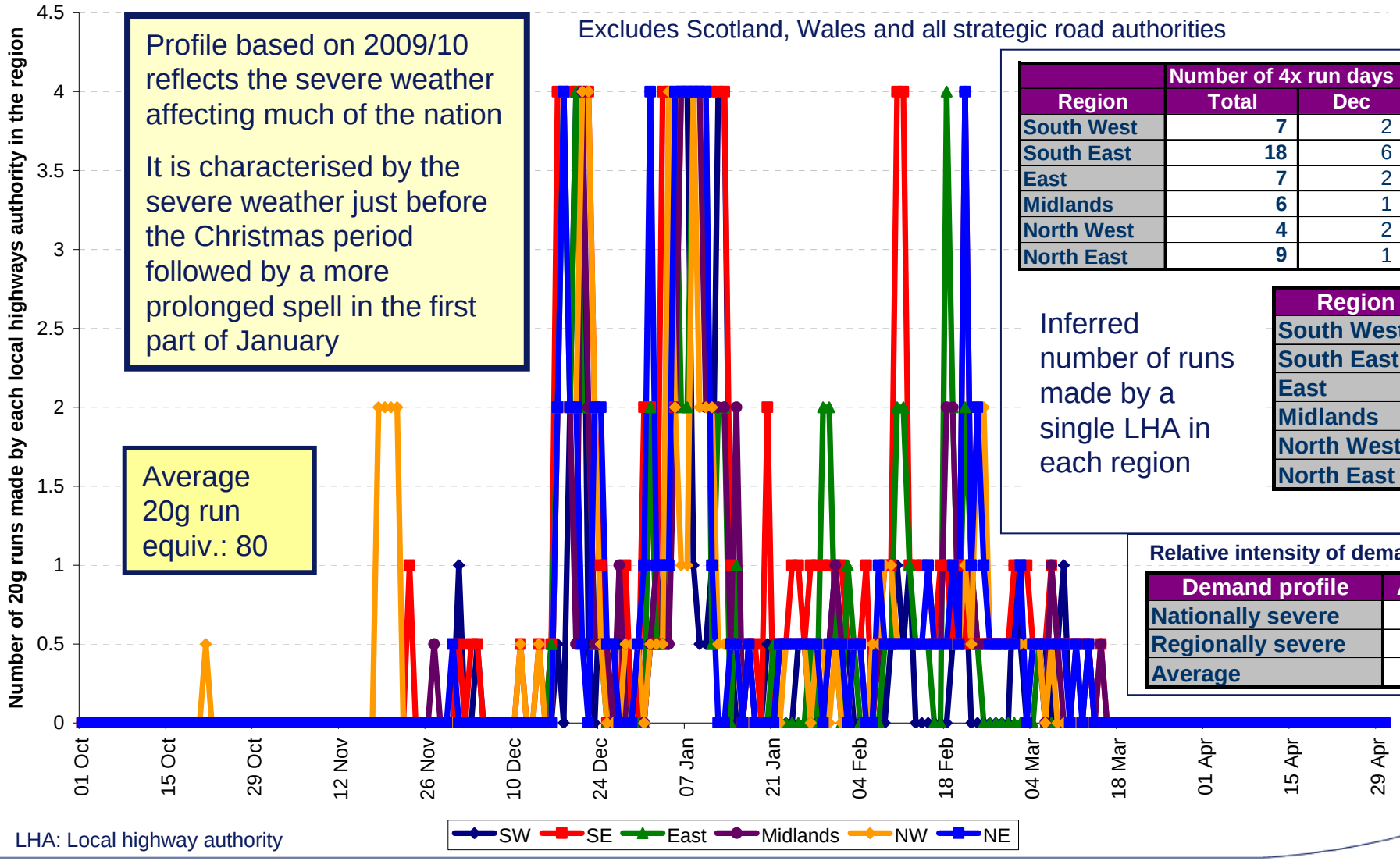
England LHA – nationally severe demand profile

Profile based on 2009/10 reflects the severe weather affecting much of the nation

It is characterised by the severe weather just before the Christmas period followed by a more prolonged spell in the first part of January

Average 20g run equiv.: 80

Excludes Scotland, Wales and all strategic road authorities



Region	Number of 4x run days Total	Dec	Jan	Feb
South West	7	2	5	-
South East	18	6	10	2
East	7	2	4	1
Midlands	6	1	4	1
North West	4	2	2	-
North East	9	1	7	1

Inferred number of runs made by a single LHA in each region

Region	Total 20g runs
South West	57.5
South East	127.0
East	72.0
Midlands	78.5
North West	74.5
North East	81.0

Relative intensity of demand profiles

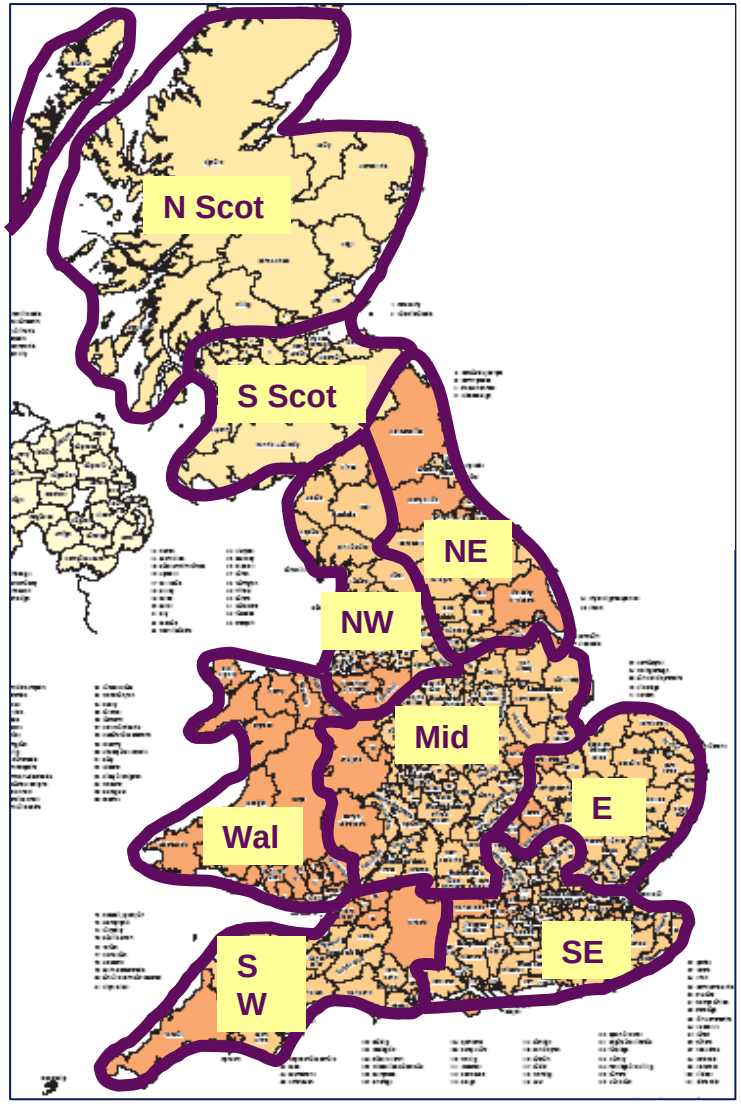
Demand profile	Avg 20g run equiv.
Nationally severe	80
Regionally severe	75
Average	40

LHA: Local highway authority

Seasonal weather profiles

- On the following page are the salt application profiles that are embedded in the model representing the winter of 2009/10 – the number of times a gritting lorry goes out and spreads in a day – expressed in terms of 20g runs
- These profiles have been derived from various sources, pulling together available data for England and extrapolating for Scotland and Wales
- The profiles have been reconciled to high level usage data for 2009/10 and illustrates the timing of the severe weather events
- The data for profiles for a regionally severe and an average winter were less detailed due to smoothing of the data sources as data was not well collected at the time and proxy of actual usage was applied
- In the context of the overall seasonality of demand and the high stocks in the chain at the start of the winter, this was not judged to be a major shortcoming in most scenarios

Regions used in profiling and the model



The demand / usage data has been organised into regions so that weather profiles can be applied at region level

- English regions set in the model are broadly based on the Highways Agency regional areas – and include a collection of Local Highway Authorities
- Strategic roads (Highways Agency areas, DBFOs, trunk operators) have been assigned to the most appropriate region

Storage capacity analysis and implications

- The storage capacity in the supply chain and the level to which it is filled was identified as a crucial driver for supply chain resilience in the initial assessment
- A figure of 6 days spreading as a recommended level had been mentioned as the nominal standard for local highway authorities but this is vague since it does not specify the runs
- Data was captured from DfT surveys by highway authority and compiled to show a picture of stock capacity and stocking intentions for the coming season
- The analysis on the following pages shows the conclusions of that work and it has been used to inform the analysis and modelling scenarios
- The first page following shows that most highway authorities have much more than the 6 days when that is set as 4 runs per day for 6 days – a few, which have been identified in the work by name, have less
- This position is summarised in the table on the following page, assuming that each highway authority fills its capacity
- In summary, total storage capacity (barns, sheeted, open) for all highway authorities in England, Scotland and Wales is approximately 2,150kT based on Salt Cell data
    - At the total level this is sufficient for an ‘average’ winter – but does not reflect regional weather and the imbalance of storage capacity between highway authorities
    - There are local capacity constraints which mean that some highway authorities cannot hold the recommended minimum stock level

Current LHA storage capacity – many authorities have much more than 6 days….some have less!

Majority of LHAs will have > 6 “snow days” capability if all storage capacity is full

Each dot represents an LHA – classified by the following colours

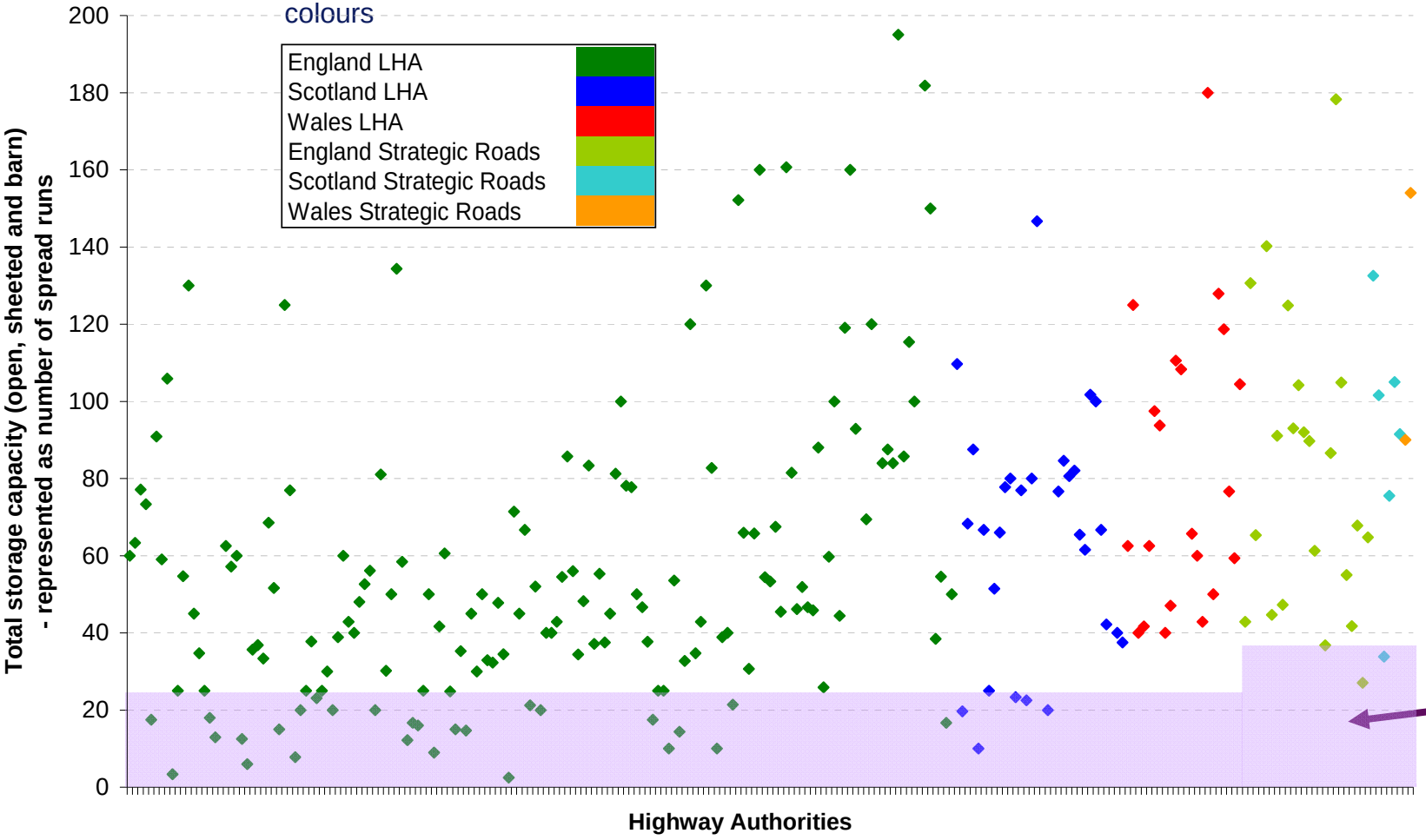


Chart generated by combining two data sets:

- LHA tonnes per 20g spread run (from Salt Cell data)
- LHA total storage: open, sheeted, barns (DfT survey)

Each dot is an LHA storage capacity represented as the number of spreads that (full) stock level would enable

Where storage data not available, it has been assumed to be equal to the total orders placed for 10/11 Winter plus existing stock

6 “snow days” capability

LHAs: 24 runs

SRs: 36 runs

Local highway authority resilience given full capacity

32 local authorities have insufficient (local) storage capacity to enable at least 6 days of heavy spreading resilience (24 runs)

Number of Local Authorities	Days of heavy spreading < 6 days (< 24 runs)	6 - 12 days (24 - 48 runs)	> 12 days (> 48 runs)
England	27	51	77
Scotland	5	4	23
Wales	-	5	17
UK total	**32**	**60**	**117**

Assumption: Days heavy spreading @ 4 runs / day

A higher proportion of strategic road authorities can hold enough salt for over 12 days of heavy spreading than local highway authorities

Number of strategic authorities	Days of heavy spreading < 6 days (< 36 runs)	6 - 12 days (36 - 72 runs)	> 12 days (> 72 runs)
England	1	10	13
Scotland	1	-	5
Wales	-	-	2
UK total	**2**	**10**	**20**

Assumption: Days heavy spreading @ 6 runs / day

Some of these may have other arrangements in place, such as:

- mutual aid agreements
- plans/discussions for shared regional stockpiles
- supplier buffer stocks at nearby ports

This gives total of 241 individual HAs (model splits HAs served by two suppliers)

Highway authorities behaviour assumptions

- In discussion of the stocking capacity with the Review Panel it was determined that the key implication of the variations in the capacity potential at highway authorities was the extent to which they would plan to fill it
- If an highway authority plans to fill capacity of more than, say, 50 runs, in effect it will be taking that salt away from other authorities that started with less and need to be replenished in season, when the supply is constrained
- The term Highway Authority Behaviour Assumptions (HABA) was coined and analysis completed to understand their stock intentions in relation to their capacity
- The following pages show the output of that analysis

The total of stocking intentions is 1.87m tonnes

- The graph following shows that 61% of highway authorities are planning to fill their capacity and if filled successfully this will total 1.87m tonnes
  - That is more than enough to cover a mild winter without replenishment as shown in the profiles previously where a mild winter demands less than 1.6m tonnes
  - Some authorities are planning to store more than their capacity which may reflect special arrangements or reporting errors
  - Clearly the local weather conditions and the storage capacity of individual authorities would require some in-season replenishment even if the demand is low
- Regional analysis (see the maps with colour coding) shows that the southern regions of England have a systemically lower stock holding resilience, which doubtless reflects their history of gritting requirements
  - The North West is also a low stock region but is clearly relying on being close to Salt Union and able to get replenishment directly from the mine quickly
- The graphs following the map shows individual highway authority stocking intentions in relation to their storage capacity which makes it clear that highway authorities are tending to fill their capacity where it represents a lower number of runs
  - However there are some with higher capacity that are planning to fill it, potentially impacting availability for other and some that have low capacity and are still not planning to fill it
  - Note that the trend line is indicative of the boundary and is not a regression analysis

2010/11 stocking intentions total 1,870 kT

Highway authorities 2010/11 plans as a percentage of their storage capacity

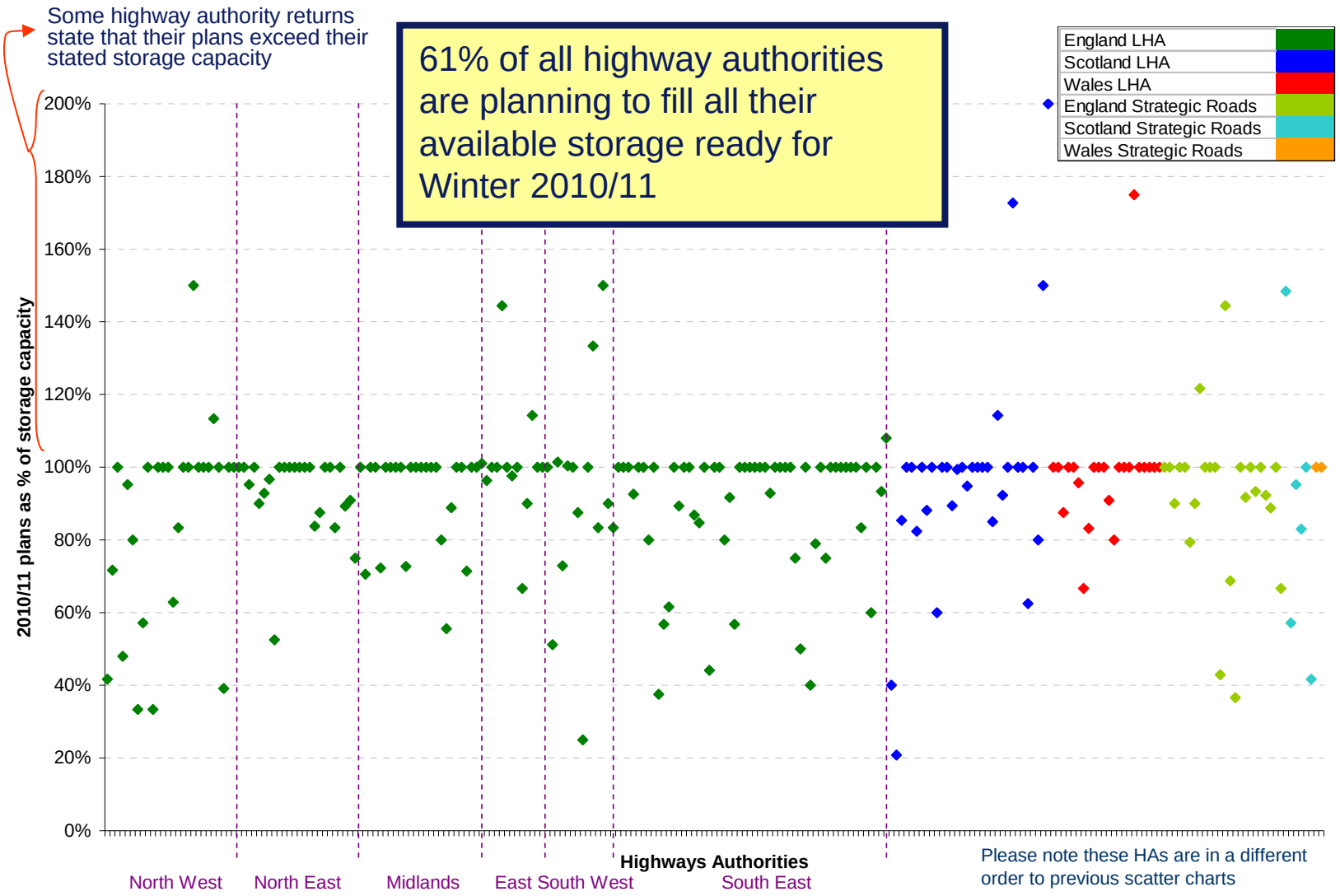


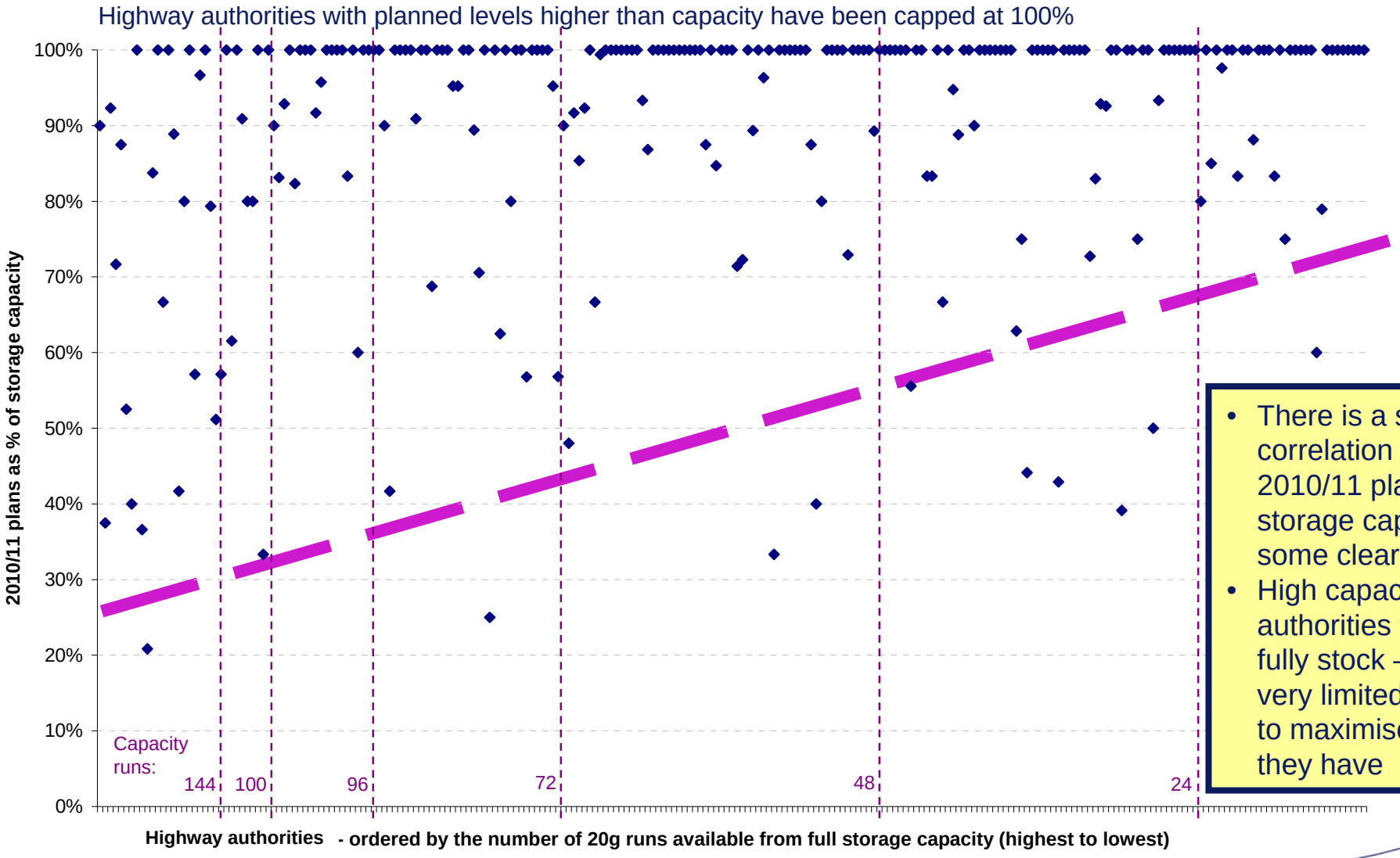
Chart generated by combining two data sets:

- Highway authority stock plans for start of Winter 2010/11 (DfT survey)
- Highway authority total storage: open, sheeted, barns (DfT survey)

Each dot is a highway authority's planned stock divided by storage capacity

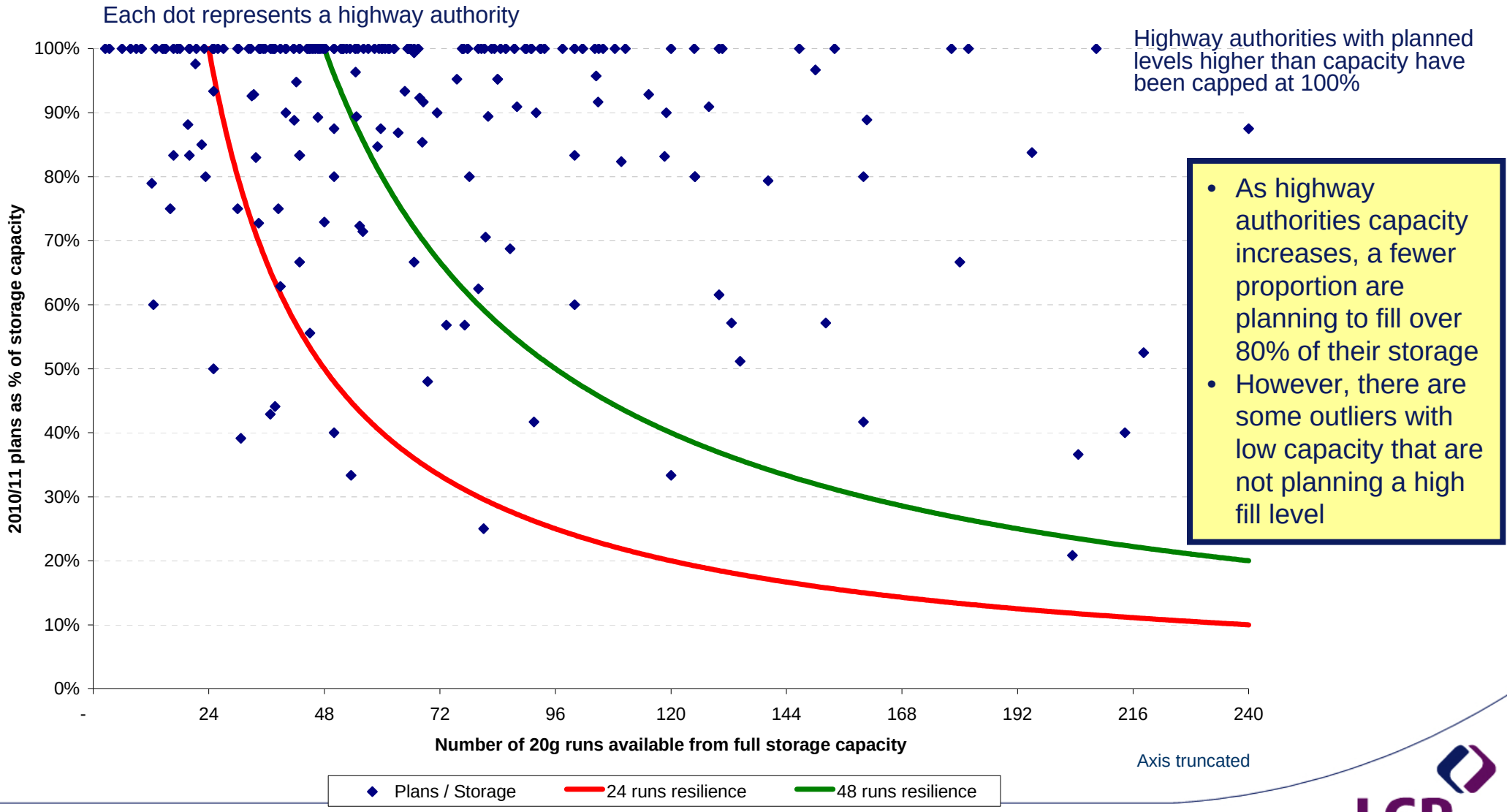
Where storage data not available, it has been assumed to be equal to the total orders placed for 10/11 Winter plus existing stock at June

2010/11 plans as % of capacity (as at June 2010)



- There is a slight correlation between 2010/11 plans and storage capacity – with some clear outliers
- High capacity highway authorities tend not to fully stock – those with very limited capacity tend to maximise the space they have

Some low capacity highway authorities are not maximising their capacity



- As highway authorities capacity increases, a fewer proportion are planning to fill over 80% of their storage
- However, there are some outliers with low capacity that are not planning a high fill level

Analysing highway authorities stocking behaviour

In summary, highway authorities stock behaviours are as follows:

- For Local Highway Authorities (LHAs) as their storage capacity increases, their tendency to fully stock decreases slightly
  - and drops considerably as they get towards 100 runs capacity
- The average planned fill of capacity is around 90-95% for all but the LHAs with very large capacity – however the range of different plans increases with the capacity size
- For Strategic Road (SR) authorities, the sample is smaller - but suggests a generally high level of capacity filling

LHA

Storage capacity (as 20g runs)	No. of LHAs	No. planning to fill capacity *		Average fill	Average runs	Std dev
		Number	Percentage			
< 24	32	23	72%	95%	16	8
24 - 48	59	43	73%	93%	36	12
48 - 72	50	32	64%	92%	54	11
72 - 96	29	19	66%	90%	77	22
96 - 120	14	7	50%	92%	98	13
120 - 144	8	2	25%	75%	94	30
> 144	17	3	18%	72%	143	54
All HAs	**209**	**129**	**62%**	**90%**	**58**	**40**

* Includes 15 LHAs whose stated plans are greater than their recorded storage capacity

SR

Storage capacity (as 20g runs)	No. of SRs	No. planning to fill capacity *		Average fill	Average runs	Std dev
		Number	Percentage			
< 36	2	1	50%	91%	28	1
36 - 72	10	5	50%	88%	51	19
72 - 108	12	7	58%	91%	89	27
108 - 144	4	2	50%	84%	111	25
144 - 180	2	2	100%	100%	166	17
180 - 216	1	-	0%	37%	75	-
> 216	1	-	0%	90%	789	-
All HAs	**32**	**17**	**53%**	**88%**	**102**	**131**

* Includes 3 SR authorities whose stated plans are greater than their recorded storage capacity

Averages includes capping of those highway authorities with plans > capacity

Highway authority stockholding behaviour assumptions (HABA)

The implications of this analysis for modelling was considered in the context of highway authority decision making; the key points were:

- Highway authorities should/will take individual stockholding decisions based on national recommendations and a variety of local factors, such as
  - annual usage, capacity constraints and regional co-operation initiatives
- A set of assumptions for modelling can be made to broadly mirror the behaviour seen for 2010/11 preparation and these are shown in the box and table below

- Local highway authorities (LHAs)
  - Those with capacity < 24 runs, fill to capacity
  - Those with capacity up to 96 runs, fill 50% of the capacity over 24 runs (plus the 24 runs level)
  - Those with 96 runs or over, fill to 96 runs
- Strategic Road authorities (SRs)
  - Those with capacity < 36 runs, fill to capacity
  - Those with capacity up to 144 runs, fill 75% of the capacity over 36 runs (plus the 36 runs level)
  - Those with 144 or over, fill to 144 runs

Storage capacity (as 20g runs)	2010/11 plans Avg runs	Behaviour assumptions runs (using upper capacity)
LHAs		
< 24	16	24
24 - 48	36	36
48 - 72	54	48
72 - 96	77	60
96 - 120	98	96
120 - 144	94	96
> 144	143	96
SRs		
< 36	28	36
36 - 72	51	54
72 - 108	89	86
108 - 144	111	111
144 - 180	166	144
180 - 216	75	144
> 216	789	144

Modelling HABAs based on 10/11 behaviour

This assessment lead to the key modelling assumptions being set as follows:

- Starting Winter stock level assumptions
  - Highway authorities start winter with levels according to the following HABAs
    - Total highway authority tonnes: 1,540 kT
    - Suppliers have their 'usual' buffer stocks at mine and port sites
    - Total starting stock: 2,374 kT
- Initial secondary fulfilment channels
  - Wales – ISS customers – Avonmouth stock pile; rest as primary
  - Scotland – ISS customers – Glasgow stock pile; rest as primary
  - England – direct from mine(s)
- Stock management rules were agreed and applied in terms of min/max replenishment

LHAs	SR authorities
If capacity below 24 runs then fill to capacity	If capacity below 36 runs then fill to capacity
If capacity up to 96 runs then fill to 24 runs plus 50% of remaining capacity	If capacity up to 144 runs then fill to 36 runs plus75% of remaining capacity
If capacity 96 runs or over, fill to 96 runs	If capacity 144 runs or over, fill to 144 runs

Supplier site	Tonnes
SU - Winsford site	400,000
CP - Potash port	150,000
CP - Cobra rail terminal	200,000
ISS - Kilroot site	60,000
ISS - Avonmouth	6,000
ISS - Glasgow	18,000
Total supplier buffer	**834,000**

Date	Order Trigger Level	Order Up To
November	HABA	HABA
December	HABA	20% above
January	HABA	20% above
February	Days resilience: LHA 6, SR 12	Days resilience: LHA 6, SR 12
March	3 days resilience	3 days resilience
April	3 days resilience	3 days resilience

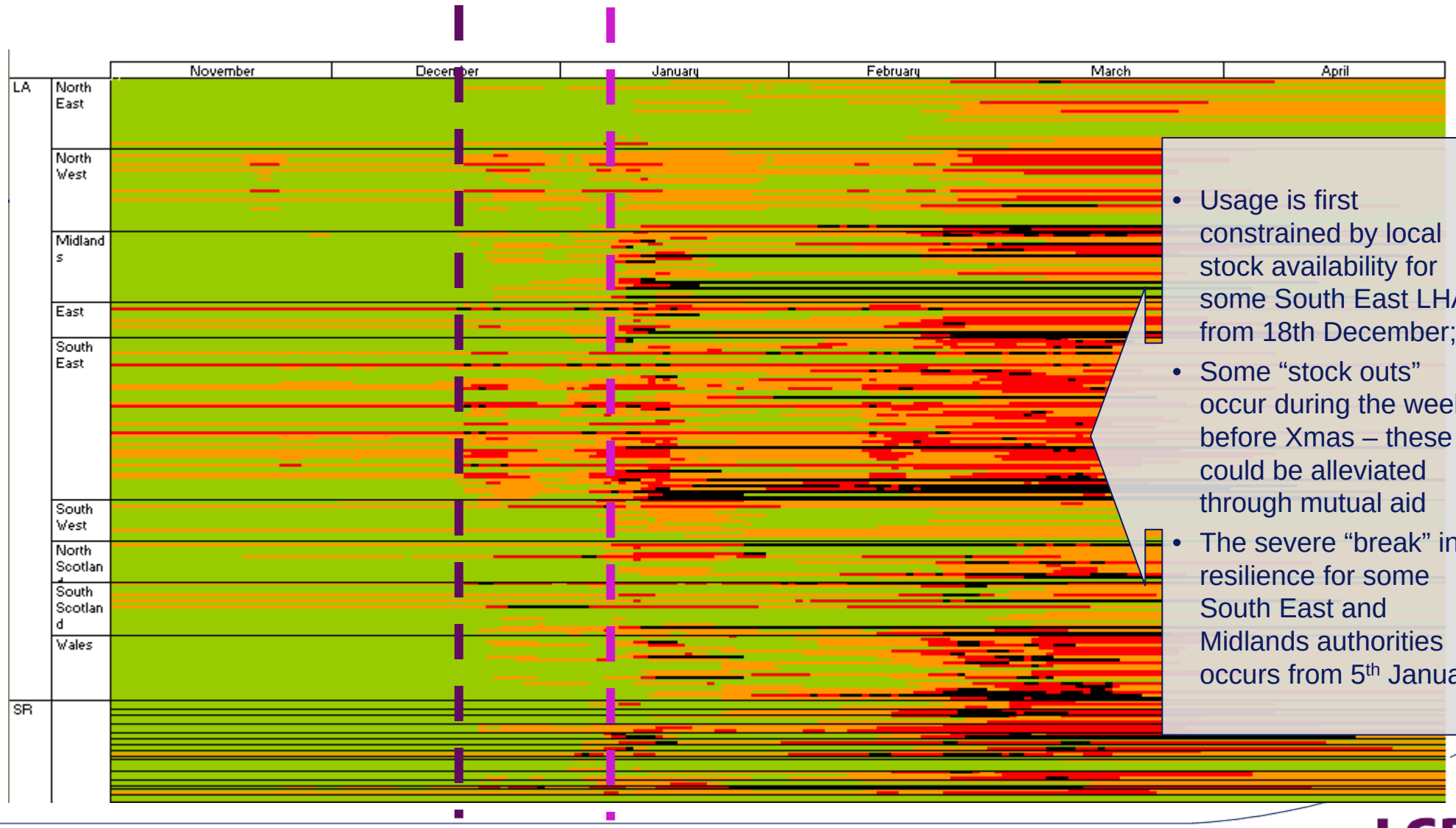
Modelling resilience

- The following pages show some of the scenarios modelled based on the approach described earlier (2 steps – base case and intervention) and using the dashboard and maps to illustrate the likely outcomes
  - The modelling was focused on the Review Panel benchmark of having a supply chain that would handle a winter of comparable severity to 2009/10 without central intervention
- First the situation of a nationally severe winter was examined with 3 interventions dealing with spread rates and imports
  - All the scenarios use the HABAs determined in the previous section
- Second the HABAs were increased in terms of initial stock holding

Highway authorities resilience dashboard

HABA base scenario – Nationally severe winter

RYG	Days of 4x/6x 20g runs
	> 6
	2 to 6
	< 2
	0



- Usage is first constrained by local stock availability for some South East LHAs from 18th December;
- Some "stock outs" occur during the week before Xmas – these could be alleviated through mutual aid
- The severe "break" in resilience for some South East and Midlands authorities occurs from 5th January

Intervention is required

HABA base scenario – Nationally severe winter

- Total demand is constrained by 485 kTonnes due to supply issues
- An intervention review (and decision) would be required in mid-December to ensure..
  - imports can be arranged and the shipment received in early January

    and/or
  - salt savings measures can be implemented to proactively (rather than reactive) save salt – in preparation for heavy demand period in January
- Interventions to be modelled
  - Salt savings measure of 20% - 4th Jan to 15th March
  - England national reserve import arriving 4th Jan (200 kT to South East location(s), 50 kT to other more centrally accessible site e.g. SU mine site)

Base scenario – no interventions

	kTonnes
1st November stock	**2,375**
of which highway authorities	*1,540*
of which buffer/reserves	*835*
Winter UK production	1,010
LHA supply from P'cocks / Salinity	60
Winter unconstrained demand	- 3,290
Winter constrained demand (salt savings)	- 3,290
Winter supply constrained usage	- 2,805
Winter imports	-
30th April stock	**635**
of which highway authorities	*560*
of which buffer/reserves	*75*

Region	Demand shortfall
North West	12,650
North East	2,155
Midlands	59,780
East	17,605
South West	2,705
South East	249,780
England total	**344,675**
North Scotland	43,705
South Scotland	71,875
Scotland total	**115,580**
Wales total	**24,020**
Total GB	**484,275**

Note: Numbers have been rounded to the nearest 5 – so totals may not appear to equal the sum of the parts

Applies to all subsequent model output tables

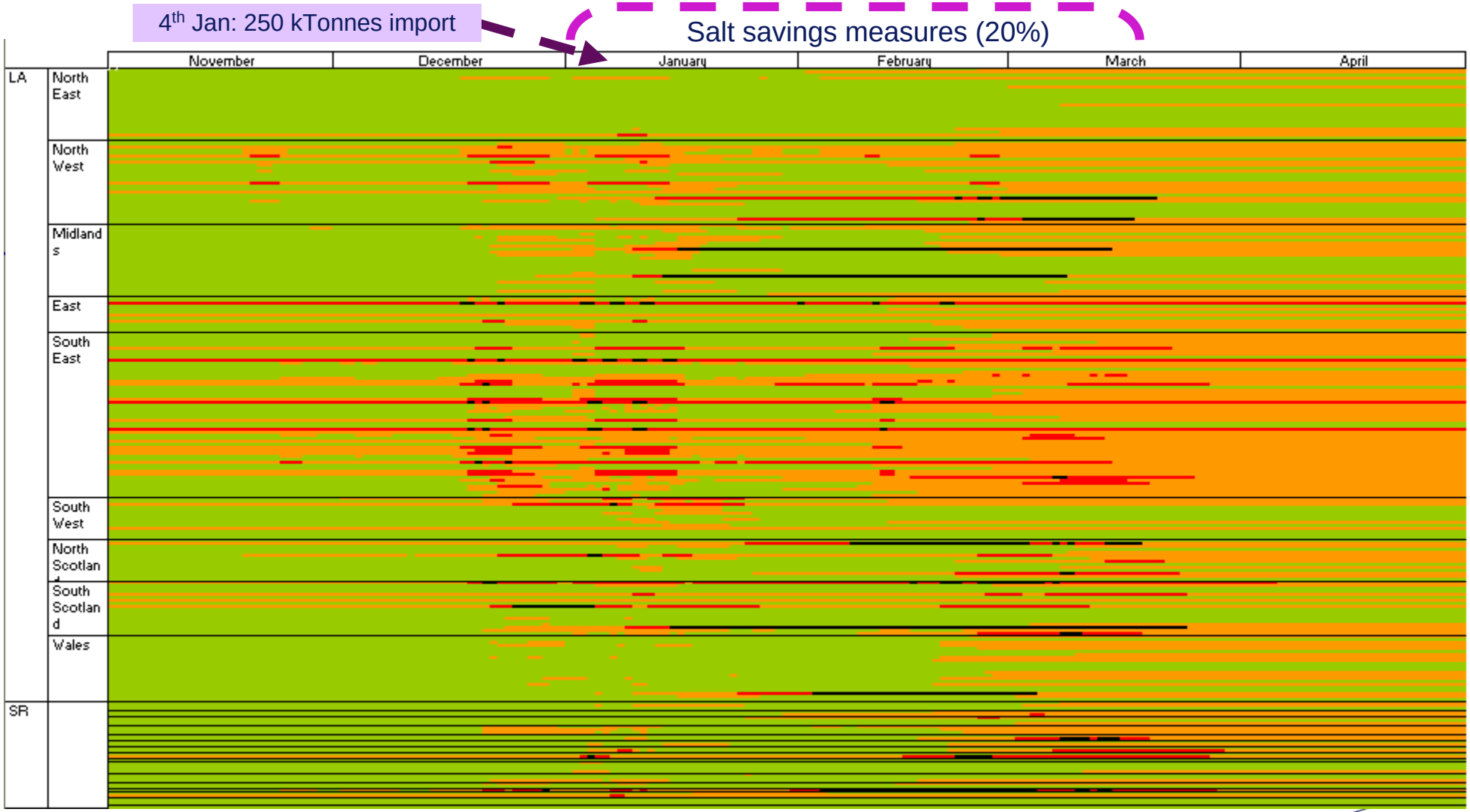
Intervention scenarios modelled

HABA base scenario – Nationally severe winter

- Interventions modelled:
  - Scenario 1
    - GB-wide salt savings measure of 20% - 4th Jan to 15th March; plus
    - England national reserve import arriving 4th Jan (200 kT to South East location(s), 50 kT to other more centrally accessible site e.g. SU mine site)
  - Scenario 2
    - No salt savings measures and;
    - England national reserve import arriving 4th Jan (200 kT to South East location(s), 50 kT to other more centrally accessible site e.g. SU mine site)
    - Further imported reserves to achieve similar resilience levels to Scenario 1 – without the application of salt savings measures
  - Scenario 3
    - GB-wide salt savings measure of 25% for whole of Winter period – to reflect spreading efficiency improvements/good practice
    - No in-season imports

Highway authorities resilience dashboard

HABA intervention scenario 1 – Nationally severe winter



Results of the intervention

HABA base scenario – Nationally severe winter

- Total demand is constrained by 150 kTonnes
  - of which 85 kTonnes is for England – the regional maps suggest mutual aid from the Midlands and North East could lower this significantly
- The salt savings measures have reduced demand by 460 kTonnes
- Interventions modelled
  - GB-wide salt savings measure of 20% - 4th Jan to 15th March
  - England national reserve import (200 kTonnes to South East location(s), 50 kTonnes to other more centrally accessible site e.g. SU mine site)
- No import interventions were modelled for Scotland and Wales
- Increasing the salt savings to 25% saves a further 115 kTonnes, the effect being:
  - reduction in the demand shortfall by 40 kTonnes
  - Increase in the closing stock by 75 kTonnes

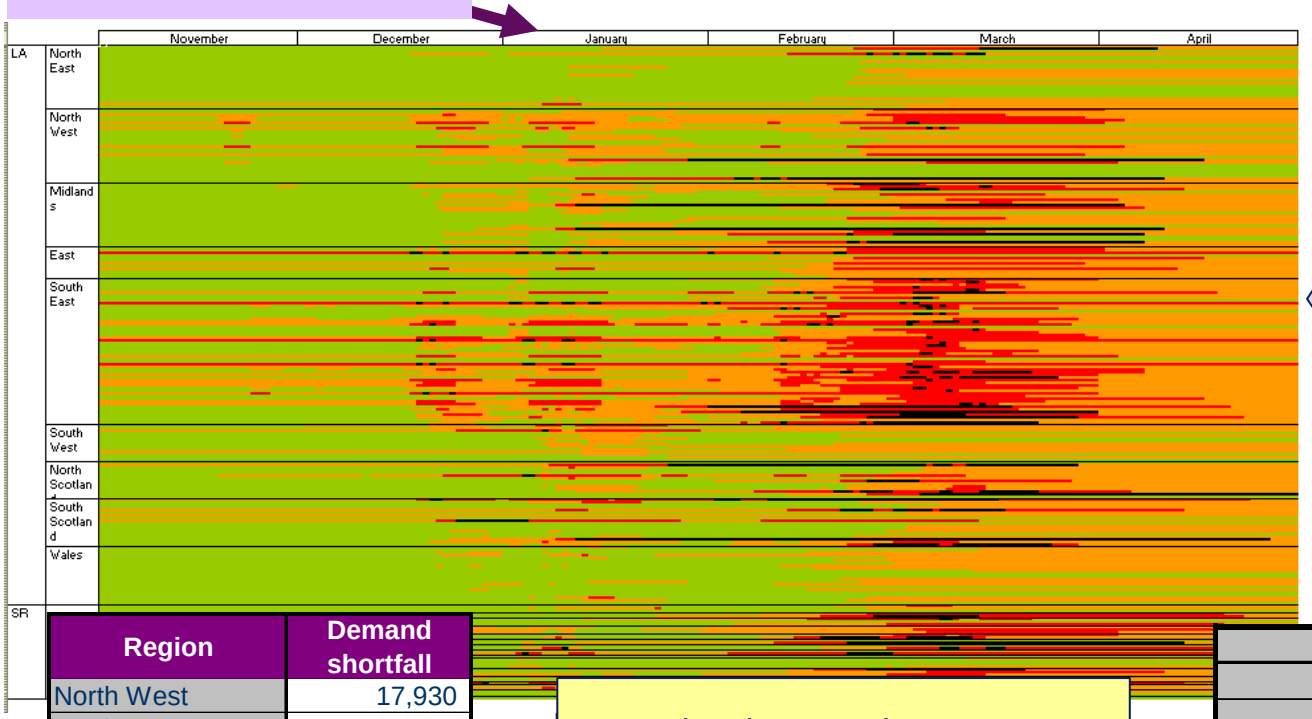
Intervention scenario	kTonnes
1st November stock	**2,375**
of which highway authorities	*1,540*
of which buffer/reserves	*835*
Winter UK production	1,010
LHA supply from P'cocks / Salinity	55
Winter unconstrained demand	- 3,290
Winter constrained demand (salt savings)	- 2,825
Winter supply constrained usage	- 2,675
Winter imports	250
30th April stock	**1,010**
of which highway authorities	*770*
of which buffer/reserves	*235*

Region	Salt savings made	Demand shortfall
North West	32,845	4,950
North East	55,905	-
Midlands	63,410	15,500
East	26,005	2,735
South West	20,120	315
South East	116,050	61,475
England total	**314,330**	**84,970**
North Scotland	58,570	20,325
South Scotland	48,210	35,105
Scotland total	**106,775**	**55,430**
Wales total	41,680	**8,820**
Total GB	**462,785**	**149,225**

Demand shortfall based on demand reduced by salt savings

Modelling without any salt savings…

HABA intervention scenario 2 – Nationally severe winter



- Removing the salt savings intervention results in resilience issues in February & March
- There is a total demand shortfall of 310 kTonnes

Region	Demand shortfall
North West	17,930
North East	2,050
Midlands	34,235
East	3,410
South West	3,575
South East	140,040
England total	**201,240**
North Scotland	42,175
South Scotland	63,085
Scotland total	**105,260**
Wales total	**-**
Total GB	**306,500**

- Further imported reserves are required to reduce the supply / demand shortfall
- ….to get closer to the position from salt savings intervention
  - closing stock ~ 1,000 kT
  - demand shortfall ~ 150 kT

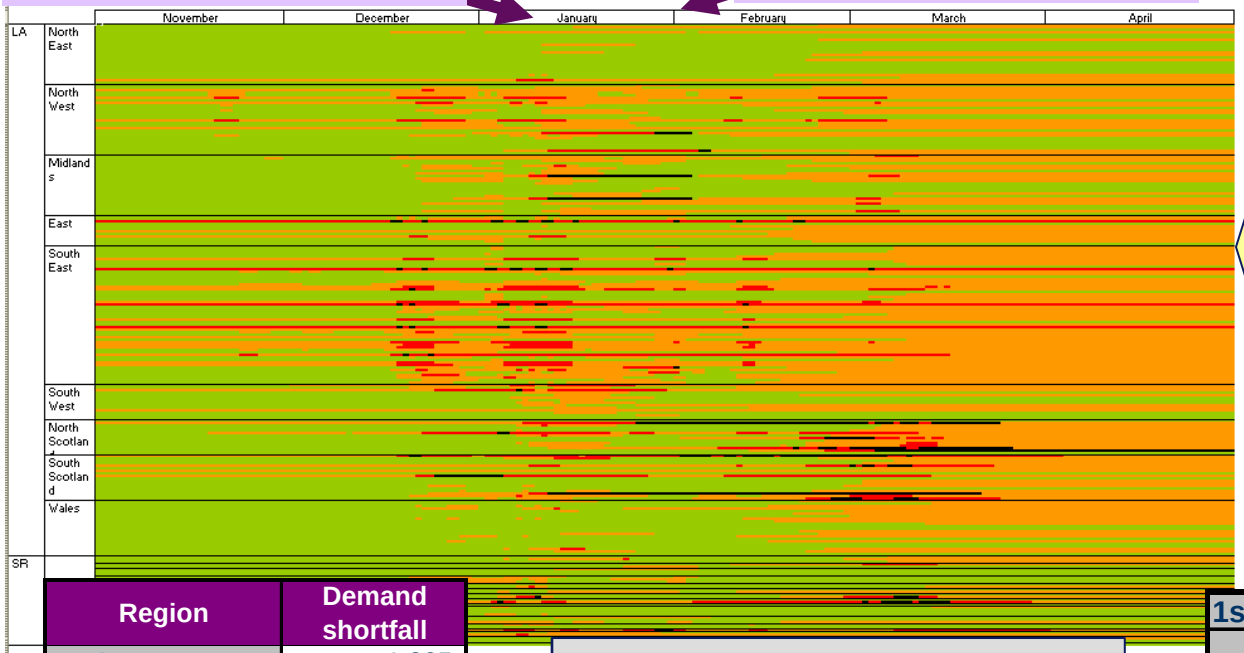
	kTonnes
r stock	**2,375**
of which highway authorities	*1,540*
of which buffer/reserves	*835*
Winter UK production	1,010
LHA supply from P'cocks / Salinity	60
Winter unconstrained demand	- 3,290
Winter constrained demand (salt savings)	- 3,290
Winter supply constrained usage	- 2,980
Winter imports	250
30th April stock	**710**
of which highway authorities	*625*
of which buffer/reserves	*85*

…another imported reserve is required

HABA intervention scenario 2 – Nationally severe winter

4th Jan: 250 kTonnes import

1st Feb: 350 kTonnes import



- The following imports give a similar resilience level to applying salt savings and a 250kT import
  - 4th Jan: 250 kT
  - 1st Feb: 350 kT
- Pre-Winter HA stocks: 1,540 kT
- Pre-Winter supplier reserves: 835 kT
- In-season imported reserves: 600 kT

Region	Demand shortfall
North West	1,205
North East	-
Midlands	8,600
East	3,410
South West	590
South East	64,060
England total	**77,865**
North Scotland	42,335
South Scotland	57,005
Scotland total	**99,340**
Wales total	**-**
Total GB	**177,205**

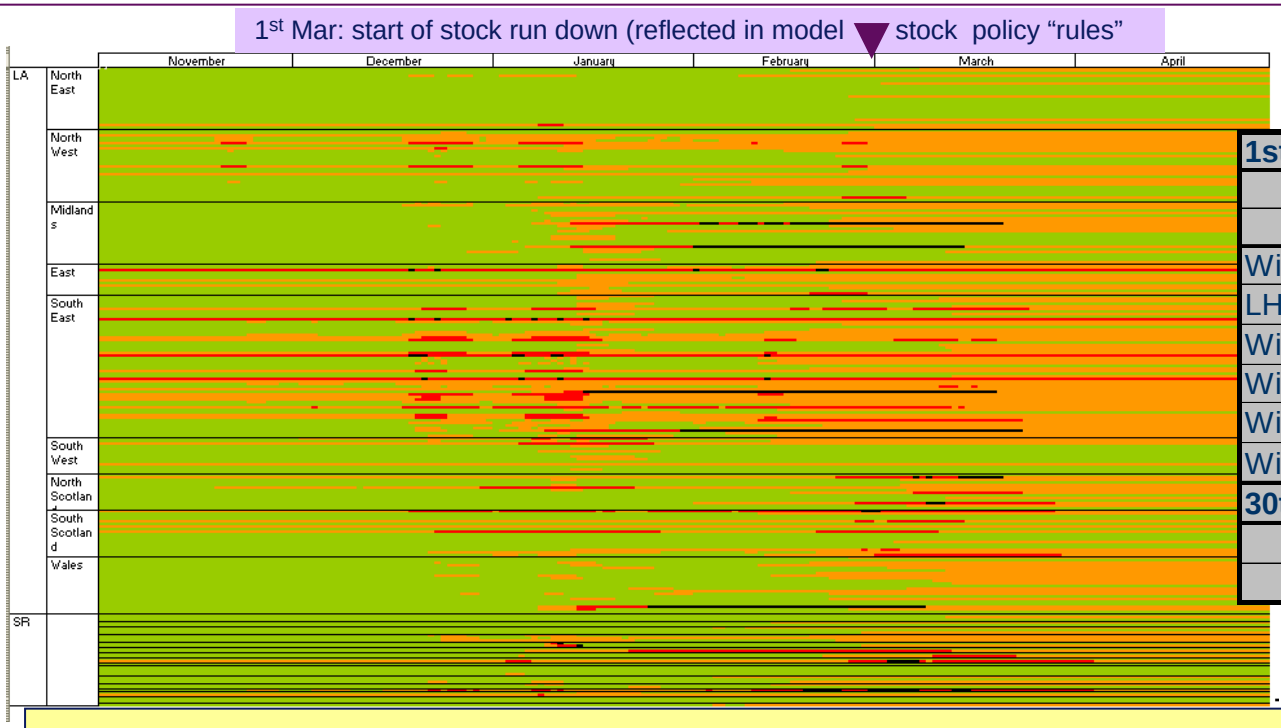
- Stock levels at end of Winter reduce the demand on summer restock supply
- Remaining shortfall could be alleviated through mutual aid and other local solutions

Note: no interventions modelled for Scotland and Wales

	kTonnes
1st November stock	**2,375**
of which highway authorities	*1,540*
of which buffer/reserves	*835*
Winter UK production	1,010
LHA supply from P'cocks / Salinity	60
Winter unconstrained demand	- 3,290
Winter constrained demand (salt savings)	- 3,290
Winter supply constrained usage	- 3,110
Winter imports	600
30th April stock	**930**
of which highway authorities	*715*
of which buffer/reserves	*215*

Improved spreading practice reduces demand considerably

HABA intervention scenario 3 – Nationally severe winter



	kTonnes
1st November stock	**2,375**
of which highway authorities	*1,540*
of which buffer/reserves	*835*
Winter UK production	1,005
LHA supply from P'cocks / Salinity	45
Winter unconstrained demand	- 3,290
Winter constrained demand (salt savings)	- 2,465
Winter supply constrained usage	- 2,365
Winter imports	-
30th April stock	**1,055**
of which highway authorities	*805*
of which buffer/reserves	*250*

- Salt spreading at 15g (25% saving) for whole of Winter reduces demand by 635 kTonnes – about the same as the volume of imports implied in the earlier scenario
- This results in a demand shortfall of 100 kTonnes – this could be met through mutual aid, production ramp-up and/or small (perhaps regionally arranged) imports
- The closing stock level at the end of Winter reduces the demand on summer restock supply
  - Next season restock supply requirement would be 1,300 kTonnes against capacity of 1,250 kTonnes (assuming same target starting levels totalling 2,375 kTonnes)

Region	Demand shortfall
North West	-
North East	-
Midlands	11,220
East	2,100
South West	65
South East	68,790
England total	**82,175**
North Scotland	1,975
South Scotland	7,545
Scotland total	**9,520**
Wales total	**11,070**
Total GB	**102,760**

Assuming a higher set of HABAs

- Starting Winter stock level assumptions
  - Highway authorities start winter with levels according

    to the following HABAs
    - Total highway authorities tonnes: 1,765 kT
    - Suppliers have their 'usual' buffer

      stocks at mine and port sites
    - Total starting stock: 2,599 kT
- Initial secondary fulfilment channels
  - Wales – ISS customers – Avonmouth stock pile; rest as primary
  - Scotland – ISS customers – Glasgow stock pile; rest as primary
  - England – direct from mine(s)
- Stock management rules as described previously

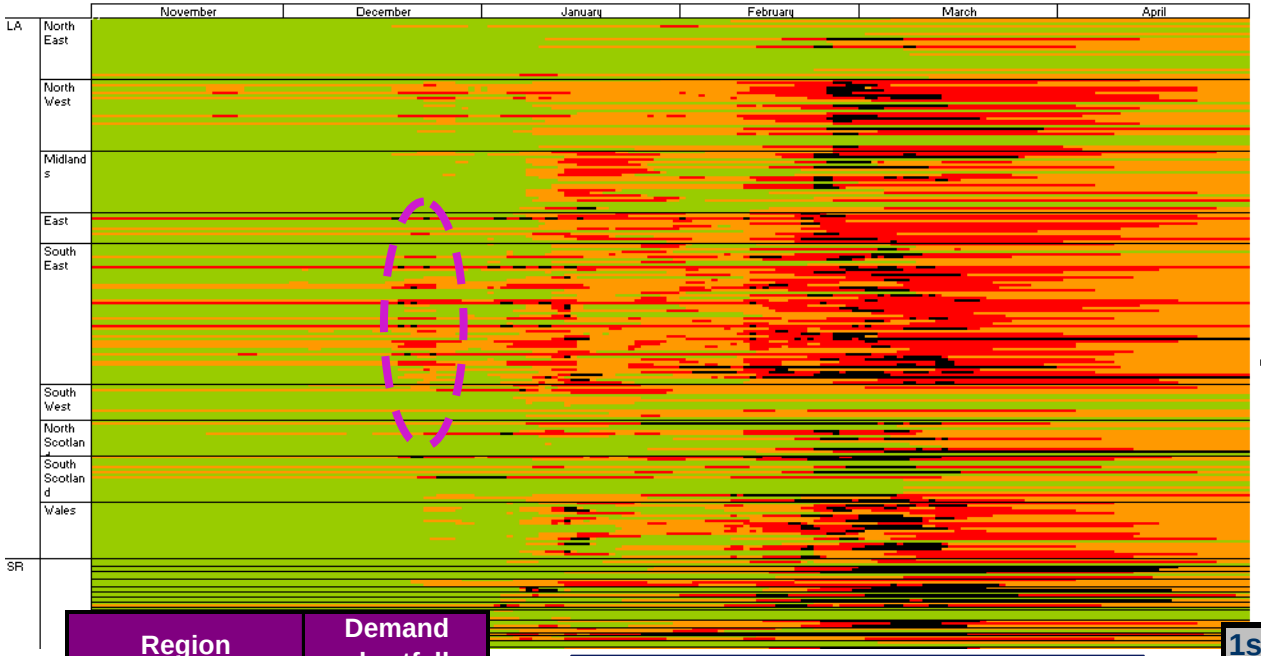
LHAs	SR authorities
If capacity below 48 runs then fill to capacity	If capacity below 72 runs then fill to capacity
If capacity up to 96 runs then fill to 48 runs plus 50% of remaining capacity	If capacity up to 144 runs then fill to 72 runs plus 75% of remaining capacity
If capacity 96 runs or over, fill to 96 runs	If capacity 144 runs or over, fill to 144 runs

Supplier site	Tonnes
SU - Winsford site	400,000
CP - Potash port	150,000
CP - Cobra rail terminal	200,000
ISS - Kilroot site	60,000
ISS - Avonmouth	6,000
ISS - Glasgow	18,000
Total supplier buffer	**834,000**

Date	Order Trigger Level	Order Up To
November	HABA	HABA
December	HABA	20% above
January	HABA	20% above
February	Days resilience: LHA 6, SR 12	Days resilience: LHA 6, SR 12
March	3 days resilience	3 days resilience
April	3 days resilience	3 days resilience

Higher starting stocks improves resilience

HABA (higher) base scenario – Nationally severe winter



- Mutual aid in South East required just before xmas
- Intervention required to increase resilience in January for South East and Midlands and in preparation for period of heavy demand in February
- Current demand shortfall: 335 kTonnes

Region	Demand shortfall
North West	13,735
North East	1,280
Midlands	16,095
East	7,360
South West	3,530
South East	165,905
England total	**207,910**
North Scotland	47,580
South Scotland	59,930
Scotland total	**107,505**
Wales total	**17,775**
Total GB	**333,190**

- Intervention is required to get

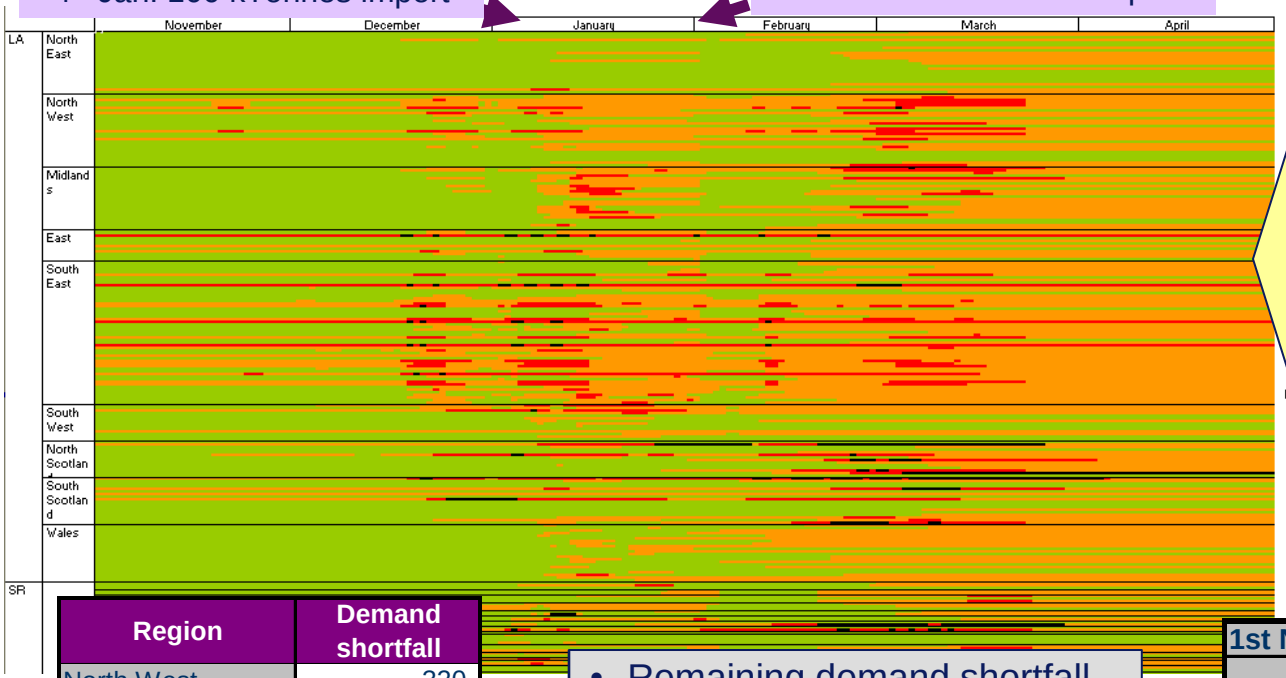
	kTonnes
1st November stock	**2,600**
of which highway authorities	*1,765*
of which buffer/reserves	*835*
Winter UK production	985
HA supply from P'cocks / Salinity	55
Winter unconstrained demand	- 3,290
Winter constrained demand (salt savings)	- 3,290
Winter supply constrained usage	- 2,955
Winter imports	-
0th April stock	**685**
of which highway authorities	*600*
of which buffer/reserves	*85*

Results of the intervention

HABA (higher) intervention scenario – Nationally severe winter

4th Jan: 100 kTonnes import

1st Feb: 300 kTonnes import



- In season imports of 400 kTonnes provide sufficient resilience levels (given no salt savings measures)
  - 4th Jan: 100 kT
  - 1st Feb: 300 kT
- Pre-Winter highway authorities stocks: 1,765 kT
- Pre-Winter supplier reserves: 835 kT
- In-season imported reserves: 400 kT

Region	Demand shortfall
North West	320
North East	-
Midlands	265
East	3,410
South West	590
South East	70,370
England total	**74,955**
North Scotland	37,870
South Scotland	33,895
Scotland total	**71,765**
Wales total	**-**
Total GB	**146,720**

- Remaining demand shortfall could be alleviated through mutual aid and other local solutions
- Closing stock will reduce pre-Winter restock demand for following winter

Note: no interventions modelled for Scotland and Wales

	kTonnes
1st November stock	**2,600**
of which highway authorities	*1,765*
of which buffer/reserves	*835*
Winter UK production	985
LHA supply from P'cocks / Salinity	55
Winter unconstrained demand	- 3,290
Winter constrained demand (salt savings)	- 3,290
Winter supply constrained usage	- 3,140
Winter imports	400
30th April stock	**895**
of which highway authorities	*700*
of which buffer/reserves	*195*

Higher HABA modelling summary
Against a nationally severe winter

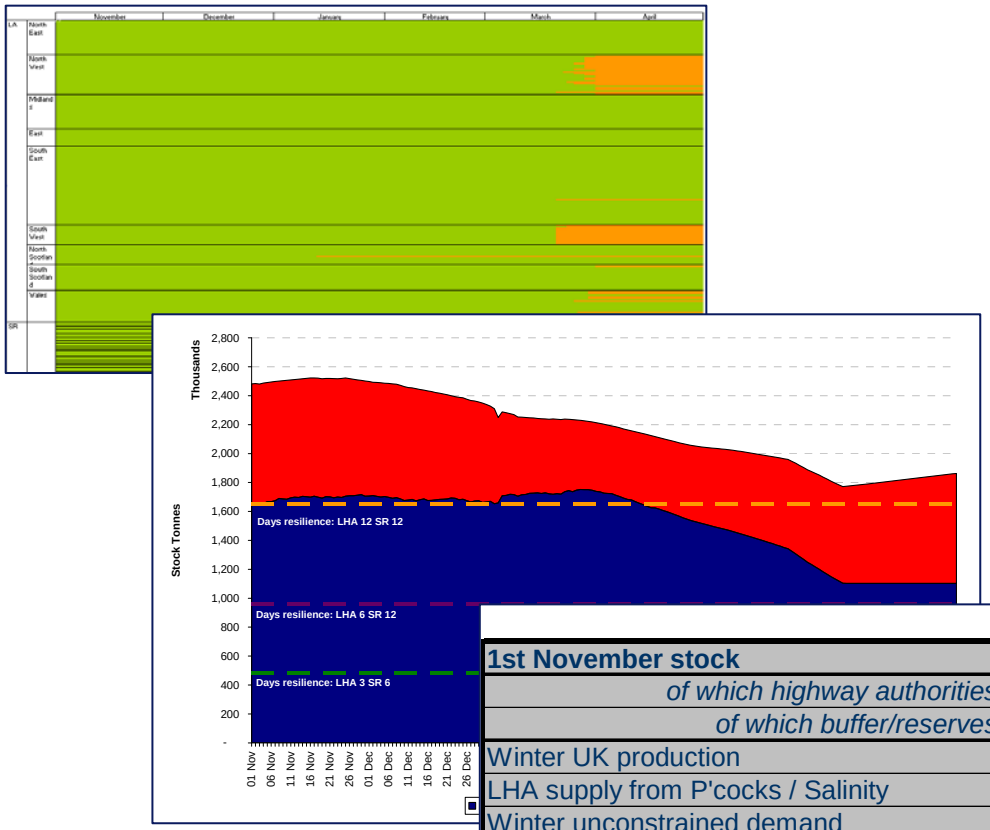
- Based on the minimum 24 runs stocking behaviour assumptions, the highway authorities starting stock is 1,540 kTonnes (and supplier reserves assumed to 'normal' at 810 kTonnes)
  - A combination of salt savings (20% across GB for Jan-mid Mar) and in-season imports of 250 kTonnes largely provides sufficient resilience – assuming that some mutual aid and other local actions will also occur
  - In-season reserves (in addition to supplier buffers) of 600 kTonnes are required to provide broadly the same level of resilience without the introduction of salt savings measures
  - Salt usage efficiency savings of 25% (for the whole Winter) improve the resilience significantly – and effectively remove the need for any large in-season imports (assuming "usual" supplier buffers are in place at the start of the season)
- Based on the minimum 48 runs stocking behaviour assumptions, the highway authorities starting stock is 1,765 kTonnes (and supplier reserves assumed to 'normal' at 810 kTonnes)
  - An in-season (imported) reserve of ca. 400 kTonnes is required to provide sufficient resilience through the season, and a reasonable closing stock

Planning for winter 2010/11

The modelling and analysis indicated some clear resilience measures and actions for 2010/11 which were discussed with the panel

- For the majority of highway authorities, the capacity of their depots is sufficient for an ‘average’ winter requirement and well in excess of the 6 days recommended
  - Setting the recommended days to 12 for all highway authorities (or filling their storage to capacity if insufficient in size) is the first winter resilience measure
  - This would give a total of 1.4 million tonnes available, so with supply from winter production, this would be sufficient for an ‘average’ winter
  - There is currently a storage shortfall at the local level of 250,000 tonnes (but only 60,000 at the regional level) to meet this 12 days recommendation
  - For highway authorities that have insufficient capacity, the second winter resilience measure is to increase capacity or make local arrangements with other authorities; through sharing of facilities with neighbouring local authorities or the Highways Agency, for example
- Subject to these actions, for more severe winters, the resilience of the salt supply chain is dependent on the levels of reserve stock at mines, ports or strategic storage locations
- Based on likely stock availability, it is clear from the macro analysis that recommendations are needed for both reduced usage and a level of imports

12 days resilience is sufficient for an average winter



	kTonnes
1st November stock	**2,485**
of which highway authorities	*1,650*
of which buffer/reserves	*835*
Winter UK production	885
LHA supply from P'cocks / Salinity	20
Winter unconstrained demand	- 1,505
Winter constrained demand (salt savings)	- 1,505
Winter supply constrained usage	- 1,505
Winter imports	-
30th April stock	**1,880**
of which highway authorities	*1,115*
of which buffer/reserves	*760*

- 12 days resilience at the start of Winter exceeds average winter demand
- There are significant supplier stocks at the end of the season – partly utilised and then replenished during the winter period
- The stock at the end of the Winter at HAs would reduce the summer re-stock demand on suppliers for the following Winter

Setting the resilience benchmark for highway authorities

- Based on the demand profiles, storage capacity analysis and modelling activity we proposed that the general benchmark of 12 days (12 x 4, 12 x 6 20g runs) should be used for all highway authorities – rather than the 6 days that was identified in the interim report
- As shown in the demand profiles, there are significant regional variations
- Highway authorities should make their resilience policy decisions based on the 12 days general guidance – AND by monitoring and analysing their local salt usage each year

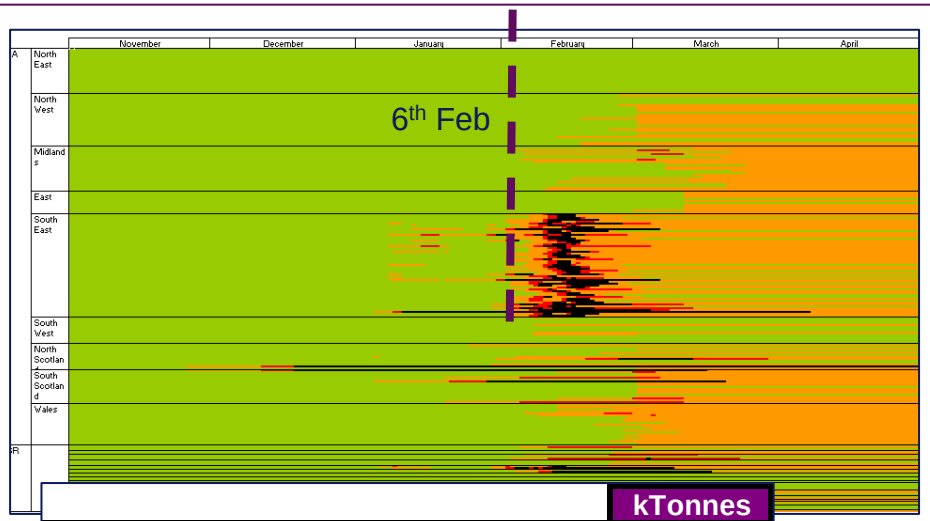
20g run equivalents made by LHAs

	Winter profile		
Region	Average	Regionally Severe	Nationally Severe
North West	64	48	75
North East	12	62	81
Midlands	45	80	79
East	9	55	72
South West	40	62	58
South East	64	141	127
North Scotland	37	87	101
South Scotland	42	81	101
Wales	67	105	143
GB Average	**42**	**80**	**93**
Conversion to days	**11**	**20**	**23**

20g run equivalents made by SR authorities

	Winter profile		
Region	Average	Regionally Severe	Nationally Severe
North West	82	75	103
North East	55	101	170
Midlands	55	94	107
East	26	56	83
South West	53	97	116
South East	164	296	386
North Scotland	70	86	131
South Scotland	70	86	132
Wales	55	94	107
GB Average	**70**	**110**	**148**
Conversion to days	**12**	**18**	**25**

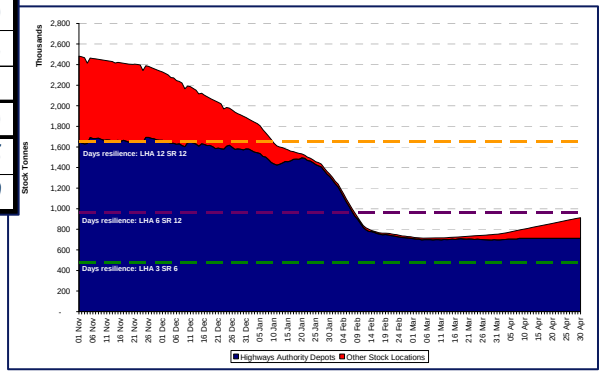
Resilience in a regionally severe winter



Resilience issue in South East from 6th Feb

Intervention decision required mid-Jan (to allow 3 weeks for import)

	kTonnes
1st November stock	**2,485**
of which highway authorities	*1,650*
of which buffer/reserves	*835*
Winter UK production	1,030
LHA supply from P'cocks / Salinity	75
Winter unconstrained demand	- 2,860
Winter constrained demand (salt savings)	- 2,860
Winter supply constrained usage	- 2,585
Winter imports	-
30th April stock	**1,000**
of which highway authorities	*795*
of which buffer/reserves	*200*



- Total demand is supply constrained by 275 kTonnes
  - of which South East constrained demand is 225 kTonnnes
- Scotland demand is constrained by 45 kTonnes – but could be resolved through mutual aid
- Central intervention is required
  - Mutual aid from neighbouring regions and salt saving measures could alleviate part of the problem
  - However a sizeable import for south east England – ideally arriving by 1st Feb – should have a more significant impact

But, with 12 day compliance there will still be a serious shortfall …

…in the face of unconstrained demand from a nationally severe winter

This table illustrates the total UK supply chain for a nationally severe winter	kTonnes
• Winter starting stocks of 12 days resilience for all highway authorities (assuming no capacity constraints)	1,650
• 'Usual' supplier mine and port holdings at start of Winter	810
◦ (SU: 400kT, CP: 350kt, ISS: 60kT)	
• Pre-Winter supply requirement	1,645
◦ Assuming around 410 kT (~3 days heavy spreading) is the ending position to the previous Winter for highway authorities and suppliers have exhausted 50% of 'usual' holdings	
• Pre-Winter UK supply capacity (assuming start of Apr to end Oct)	1,250
• Therefore the pre-Winter supply shortfall is	395
• Available stock entering Winter (assuming all demand met)	2,460
• Production in-season (start Nov to end Mar)	850
• The unconstrained demand experienced in 2009/10 was	3,300
• Closing stock assumption	410
• In-season shortfall	400
• **Total shortfall**	**795**

Filling that gap with additional storage …

- … can be supported by using more of the highway authority capacity than a standard 12 days
- More capacity is available and this high level view shows the total available salt given different starting resilience levels – as either a starting stock or mid season safety level
- Using the capacity of 2.1m tonnes will mean that stock will not always be in the right place and will require in season repositioning and mutual aid arrangements

Total GB tonnes

Number of 4x/6x 20g runs (Days of heavy spreading)	Constrained by local storage	Unconstrained by capacity
LHA: 6, SR: 12	898,198	962,403
LHA: 7, SR, 14	1,022,288	1,122,803
LHA: 8, SR: 16	1,138,820	1,283,204
LHA: 9, SR: 18	1,239,842	1,443,604
LHA: 12, SR: 12	1,396,302	1,648,607

Single day of heavy spreading	Tonnes
LHA 4x 20g runs	114,267
SR 6x 20g runs	22,777
Total	137,044

LHA: Local highway authority SR: Strategic road authority

Actual capacity is 2,100 ktonnes at all highway authorities which shows that there is a further 600 ktonnes of capacity in the chain beyond a standard 12 day resilience

The supply side of resilience…

- Although 12 days resilience could give 1,650 kT of salt, pre-Winter UK production cannot meet the highway authorities restock requirements AND replenish their own buffer stocks
  - At ‘normal’ levels UK pre-Winter production is around 1,250 kT with a further 500 kT possible if all suppliers “ramped-up” off-season
  - This additional supply clearly has significant commercial implications for the suppliers – particularly Cleveland Potash who are very unlikely to mine salt for an additional day / week at the expense of potash
- In the short-term, this supply constraint means pre-Winter imports are required to increase the available resilience going into the Winter
- And salt saving measures will also be appropriate
- In the long term, national reserve(s) should be built up and maintained – the lowest cost solution being at established supplier sites
- A series of mild winters and/or imports from sister mines will enable suppliers to re-build their own buffer stocks
- These national reserves and supplier stocks can then act as a resilience buffer for severe winters

Logistics costs and additional storage capacity

- Adding extra intermediate storage to supplement or replace capacity at either suppliers or highway authorities could add to cost significantly and it was important to find out by how much
- The cost waterfall charts and the detail on the following page provide therefore have significant cost impacts and an attempt was made to understand its potential impact
- Any additional stockholding costs require space and hence cost - at the rate of 2.5 acres per 100,000 tonnes and at an indicative cost of:
  - Outside sheeted - £4.70 per tonne including handling with a stock turn of once per year
  - In barns - £7.40 per tonne including handling with a stock turn of once per year
- In relation to the benchmark cost of £8 to £11.50 per tonne which takes advantage of highway authority or supplier storage, the cost of strategic depots cannot easily be justified
  - This is the case even when rail or short sea is introduced into the cost model
- However, we have been made aware the prices have risen to a range up to £40 per tonne and depending on the landed cost of imported salt, intermediate depots may be justifiable
  - Without access to imported salt prices, we have been unable to validate this benefit

Additional storage cost outweighs any rail saving

Example: supply route for Buckinghamshire – direct from Salt Union compared to via rail connected strategic stockpile nr Bicester