Centre for Sustainable Delivery

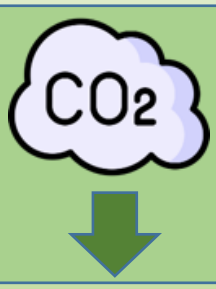
NHS SCOTLAND

National Green Renal Programme

Dialysis Concentrate Switch from 1:34 to 1:44 Concentration

Opportunity for Change

January 2026



26.8

T CO_2e

£ 175,900

Cost Reduction

1. Description of action

1.1 This action aims to support renal colleagues across NHS Scotland to implement a change from using a dialysate concentrate which requires a 1:34 dilution with water, to a higher concentrate which requires a 1:44 dilution.

2. Background

2.1 Dialysate solution is used in haemodialysis (HD) machines in a counter-current system against the blood to allow removal of salts, waste products, and water. Dialysate can be available either from a central tank or single-patient canisters. The choice between these two sources is based on whether there is a central tank on site or if the patient requires a specific electrolyte composition different from the composition in the tank.

2.2 In Scotland, dialysate is purchased almost exclusively from Fresenius, who supply the concentrate in tanks of 500 or 1000 litres as well as canisters, 6 litres for the 1:34 concentrate and 5 litres for the 1:44 concentrate. These canisters are made of High Density Polyethylene plastic (HDPE), 292g and 250g, respectively. Production, transport, and disposal are the main contributors to the carbon footprint of a dialysate canister[1.] Life cycle analysis (LCA)[1] data estimates that per haemodialysis session, the carbon footprint of a 6L canister is 6.18 kgCO2e, compared to 2.469kgCO2e for a 4.2L flexible bag, and central storage tanks 1.54 kgCO2e. This is supported by 2024 UK government BEIS conversion factors for greenhouse gas (GHG) emissions for HDPE manufacture.

3. Who needs to be involved in this change locally?

3.1 Engaging relevant stakeholders early in this process to ensure broad support for this action is vital. These groups will include:

- Renal Technical Staff
- Clinical Staff
- Procurement colleagues, liaising with suppliers
- Finance colleagues (if there is a desire to track financial spend/savings)

3.2 The below points may be helpful for communication with relevant stakeholders when discussing this change:

- Although the exact date has yet to be determined, Fresenius has confirmed it will cease production of all 1:34 dialysate in 2026, adding weight to the need to shift to 1:44.
- The How-To Guide (Appendix 2) has detailed considerations of running down tank supplies, managing remaining residual concentrate, and an example Standard Operating Procedure (SOP) for technicians overseeing the switch.

4. Boundaries

4.1 The table below identifies the boundaries for this action:

In scope	Out of scope
• Manufacture of dialysate fluid • Canister HDPE manufacture • Freight transport	• Bulk acid container and LLDPE plastic liner, as these are re-used many times • Differences in waste management GHG emissions of 5L versus 6L HDPE canister; clinical, domestic, or recycling*

* Note: an 'OfC: Dialysis Canister Recycling' will be published which sets out to remove all canisters from the clinical and domestic waste streams and redirect them into the recycling waste stream.

5. What is the change and how will it be implemented?

5.1 This change involves switching from ordering and using a dialysate concentrate that requires 1:34 dilution with water to a high concentrate that requires a 1:44 dilution. This document aims to empower staff across NHS Scotland who have not yet explored the implementation of this change.

Integral to the implementation of this action will be tailoring the approach to local context:

1. Ensure that your HD machine fleet in the target clinical area can be reconfigured to allow 1:44 dilution.
2. Estimate the time and staffing needed to undertake the reconfiguration.
3. Not every 1:34 concentrate has a direct 1:44 equivalent so check availability of 1:44 concentrates and the formulas required. If any concentrate changes are needed these need to be approved by the clinical team and communicated in advance to the technical team and the wider Multi Disciplinary Team (MDT.) (Appendix 2 provides equivalent formulations)
4. Take an inventory of weekly use of the range of 1:34 acid concentrates (canisters and bulk) used in each site to determine the volume of 1:44 concentrate that will be required after the switch.
5. Communicate your 1:44 requirements to your supplier(s) and agree a provisional date to switch and delivery dates for new stock.

6. What are the potential benefits of this change?

6.1 This change will deliver carbon savings and financial savings as well as benefits to staff experience as a result of lighter canisters. Below are the estimated carbon and financial savings. These will require validation at a future measurement meeting. The detailed estimated savings data breakdown per health board is shown under Appendix 1.

Outcome	Potential Benefits
Carbon Savings	26.81 tCO2e
Cost Savings	£ 175,900 per year
Staff Experience	Lighter canisters to handle, reducing risks of musculoskeletal injuries
Patient experience	Neutral

6.2 Some potential co-benefits from the implementation of this action may include:

- Using the opportunity to flag the high financial and carbon cost of canisters and prompt reviews of patients to consider if they could be switched to central acid instead. In turn, this could lead to sites (re)considering installing a central acid tank where these are not already available.

7. Risks and Issues

Description of risk or issue	Mitigation / Action Plan
Residual lower concentrate remaining in tank after maximal use / drainage.	See How To Guide Appendix 2 highlighting that 5% residual does not constitute a clinically relevant difference.
Dialysis machine not set up / recalibrated for higher concentrate, risking constituents being at wrong concentrations and potential for patient safety concern.	Machines in each Renal Dialysis Unit (RDU) will be switched over all at once, each machine visibly labelled when done. Conductance alarms on machine will add second level of assurance. After setting and recalibrating the machines, Renal Technicians should run and test the new 1:44 solutions and send dialysate samples to the biochemistry labs to ensure all the levels are within specifications.
Precise equivalent dialysate not available in 1:44 concentrate.	Look at the nearest equivalents and consider what differences in composition would be acceptable

8. Implementation Guidance

8.1 This document highlights how the opportunity for change will help each site and NHS Scotland achieve net-zero emissions by 2040, as stated in NHS Scotland's Climate Emergency & Sustainability Strategy 2022-2026.

8.2 The National Green Renal Programme has provided guidance on how to implement this change. For further information or guidance, please contact the National Green Renal programme team: cfsdghs@nhs.scot.

Local Sustainability or Green Renal Group:	
1.	Review opportunity for change and validate what this means locally.
2.	Provides National Green Renal Programme Team with validated information / local targets.
3.	Convene a discussion with the staff who need to implement it and those who are involved in the action.
4.	Understand what the opportunity is for implementing the action locally: work already undertaken and challenges.
5.	Agree a local implementation plan.
6.	Implement local plan.
7.	Provide data as per measurement plan.

8.	Monitor implementation of action.

9. Measurement

9.1 Volume of concentrate ordered from suppliers will allow for calculation of GHG emission reductions.

9.2 Shown below are the calculations outlining the methodology and data used to estimate the potential savings.

Calculation example

FINANCE

In the 2024/2025 tax year, the Health Boards collectively ordered 1,276,693 litres of 1:34 concentrate which can make 44,684,255 litres of dialysate. To achieve the same volume of dialysate, only 992,983 litres of 1:44 concentrate would be required. Because the products are charged at approximately the same price per litre (£0.62/L) that difference of 283,710 litres translates to a financial saving of **£175,900**.

CONCENTRATE PRODUCTION

Although the higher concentrate comes with a slightly higher carbon cost than the lower concentrate, 0.154g/L[1, 2] and 0.121g/L, respectively, it also dilutes further so provides more final dialysate fluid per litre concentrate which also brings with it a carbon saving.

The carbon cost of producing the 1:34 concentrate that was ordered in 2024/25 was 154.48 tCO2e (1,276,693 x 0.121tCO2e/L). As mentioned above, to make the equivalent amount of dialysate from the 1:44 concentrate would require 992,983 litres of 1:44 concentrate which would have a carbon cost of 152.92 tCO2e (992,983 x 0.154tCO2e/L). This means that the higher concentrate emits **1.56 tCO2e** less.

HDPE PRODUCTION

In the 2024/2025 tax year, the Health Boards collectively ordered 90,054 6L canisters of the 1:34 concentrate which, when diluted, makes 18,911,340 litres of dialysate. To produce the same amount of dialysate from the higher concentrate, the HBs would need to order 84,050 5L canisters of the 1:44 concentrate. (see Appendix 1 for details).

Each canister of the higher concentrate weighs 33 grams less than the canister for the lower concentrate. This difference in weight multiplied by the difference in the number of canisters, 90,054 x 292 gr and 84,050 x 259gr, respectively, could result in avoiding the use of 4.53 tonnes of plastic.

The embodied carbon in HDPE plastic as a result of manufacture of 3.095tCO2e per tonne.
Therefor the avoided carbon through the reduction in HDPE plastic is 4.53t x 3.095[III] = **14.01t**.

TRANSPORT

Transporting 283.71 tonnes of concentrate less, over a distance of 384 km, at a conversion factor of 0.10163[3] per tonne per km, means that there will be **11.07t** CO2e less expelled.

Transporting 4.53 tonnes of plastic less, over a distance of 384 km, at a conversion factor of 0.10163[III] per tonne per km, means that there will be **0.17t** CO2e less expelled.

HDPE WASTE

There will be additional carbon savings from the reduction of the volume of plastic going into waste streams, be that clinical waste, domestic waste, or recycling. Unfortunately, calculations of the reduction in carbon emissions cannot be provided at the time of writing due to a review of the emission factors for these waste streams.

However, NGRP is also preparing a document on canister recycling, which should remove all canisters from both clinical and domestic waste streams and redirect them exclusively into a recycling waste stream, thereby reducing the carbon footprint of the canisters even more.

TOTAL 26.81t

10. Appendices

10.1 Appendix 1: Health Board Breakdown of Indicative Financial and Carbon Savings

2024/25	Litres of 1:34 concentrate ordered	Litres of 1:44 concentrate needed	difference in litres	financial saving (Litres x cost price per litre (£0.625))		1:34 canisters ordered	1:44 canisters needed	difference in HDPE plastic in tonnes	embodied carbon in HDPE (3.095 tCO2e per tonne)	avoided carbon emissions (emission factor per tonne of clinical waste 0.271 tCO2e)	Total carbon savings
Ayrshire	128,149	99,671	28,478	£ 17,656		5,139	4,796	0.26	0.80	0.07	0.87
Borders	29,638	23,052	6,586	£ 4,083		2,273	2,121	0.11	0.35	0.03	0.38
Dumfries & Galloway	59,676	46,415	13,261	£ 8,222		9,946	9,283	0.50	1.55	0.14	1.68
Forth Valley	97,460	75,802	21,658	£ 13,428		160	149	0.01	0.02	0.00	0.03
Highlands	41,604	32,359	9,245	£ 5,732		1,434	1,338	0.07	0.22	0.02	0.24
Fife	129,888	101,024	28,864	£ 17,896		13,148	12,271	0.66	2.05	0.18	2.22
GG&C	374,524	291,296	83,228	£ 51,601		31,504	29,404	1.58	4.90	0.43	5.33
Lanarkshire	use	only	1:44	£ -		use	only	1:44	-	-	-
Lothian	189,308	147,240	42,068	£ 26,082		10,209	9,528	0.51	1.59	0.14	1.73
Western Isles	24	19	5	£ 3		4	4	0.00	0.00	0.00	0.00
Ninewells	156,270	121,543	34,727	£ 21,531		4,545	4,242	0.23	0.71	0.06	0.77
National Services	70,152	54,563	15,589	£ 9,665		11,692	10,913	0.59	1.82	0.16	1.98
TOTAL	**1,276,693**	**992,983**	**283,710**	£ 175,900		**90,054**	**84,050**	**4.53**	**14.01**	**1.23**	**15.24**

10.2 Appendix 2:

How-to Guide: Implementing the Switch from 1:34 to 1:44 Dialysis Acid Concentrate

Project: Sustainable Kidney Care – Implementing Best Practice

Author: Centre for Sustainable Healthcare / Centre for Sustainable Delivery / UK Kidney Association

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Although this guide has been developed by experts in sustainability and sustainable kidney care, local teams should use their discretion in its implementation according to local context and requirements

Introduction

Transitioning from a 1:34 to a 1:44 acid concentrate dilution in haemodialysis can reduce environmental impact without compromising patient care. Recent studies highlight the benefits of this change, including reduced packaging waste and lower greenhouse gas emissions [1].

Benefits of Switching to 1:44 Acid Concentrate

- **Reduced Packaging Waste**: Higher concentration requires less volume, leading to less packaging waste [2]
- **Lower Transport Emissions**: Decreased volume translates to less weight for deliveries, reducing carbon footprint [2][3]

- **Improved Storage Efficiency**: Less storage space needed due to reduced volume.
- **Reduced staff Manual Handling:** Each 1:44 canister is approximately 1 kg lighter.
- **Cost Neutral**: Lower packaging and transport costs over time [4]
- **Clinical Equivalence**: No difference in patient outcomes when properly implemented and no initial start-up costs.

Step-by-Step Implementation Guide

Central acid delivery : The switch from 1:34 to 1:44 needs to be carefully planned with the renal technicians and suppliers, as any residual acid concentrate preparations still delivered by canister (these are usually the less commonly used ones) will need to be switched at the same time.

Central acid delivery reconstituted from dry powder: provided this is the main source of acid concentrates to the unit, we do not recommend that a conversion from 1:34 to 1:44 is made. Where 1:34 canister delivery still makes up a substantial (e.g. > 20%) proportion of the acid concentrate used, we suggest that the potential environmental and cost savings of a conversion are calculated to inform the decision to proceed.

Where acid concentrate is wholly delivered by canister, we strongly recommend that the conversion is made for a whole clinical area at a single point in time to minimise the patient safety risk.

We suggest a timeline for conversion as follows:

1. Ensure that your HD machine fleet in the target clinical area can be reconfigured to allow 1:44 dilution.
2. Estimate the time and staffing needed to undertake the re-configuration.
3. Take an inventory of weekly use of the full range of 1:34 acid concentrates to determine 1:44 concentrate requirements after the switch. This should include all preparations delivered by both canister and through central delivery.
4. Not every 1:34 concentrate has a direct 1:44 equivalent so check availability of 1:44 concentrates in the formulas required. If any concentrate changes are needed these need to be approved by the clinical team and communicated in advance to the technical team and the wider MDT. (Appendix 2A)
5. Communicate your 1:44 requirements to your supplier(s) and agree a provisional date to switch and delivery dates for new stock. Where like-for-like conversion of acid concentrates cannot be undertaken, pause and discuss rationalisation of the suite of available acid concentrates, to include the clinical team.

Once the provisional date for the switch has been confirmed:
Ensure sufficient renal technical staff availability to convert the machine fleet for the target unit in one (non-dialysing) day – this will usually be a Sunday. If insufficient staff availability, this may require staggered conversions.

2. Engage Stakeholders

- **Technical Staff**: Verify compatibility of dialysis machines with 1:44 concentrate. If feasible, get a sample of the new concentrates and run some workshop tests possibly with samples of dialysis fluid being analysed to verify the electrolyte composition. It is also advisable to also test that the HD machines with the new settings will no longer run up on 1:34 dilution concentrate. If successful, and in conjunction with the MDT, develop a plan for the changeover, one unit at a time starting with a smaller unit.

For guidance on managing residual concentrate in tanks, please see Appendix 2B, for the change-over SOP see Appendix 2C.

- **Clinical Team**: Discuss the patient safety implications of the switch from 1:34 to 1:44. Failing to change the dialysis machine settings can result in patient acid base and electrolyte imbalances.
- **Procurement**: Inform suppliers of the intended switch for the availability of 1:44 acid concentrate and negotiate a changeover date to allow completion of machine re-configuration and staff engagement before delivery of new stock which will be determined by your local inventory.

3. Staff Training

- **Educate**: Advise staff the same process is required for 1:44 concentrate on handling and preparing as 1:34 concentrate.
- **Update Documentation**: Revise any relevant protocols or standard operating procedures to reflect the change.

4. Full Implementation

During the implementation project it is vital that all staff are aware of the need to physically separate the new and old concentrates. The plan must include the two dilutions being stored in different areas.

Conclusion

Switching to a 1:44 acid concentrate dilution is a practical step towards sustainable dialysis care. The transition promises environmental benefits and operational efficiencies, aligning with global efforts to reduce the carbon footprint of healthcare services [1-4]. In conjunction, your audit results of concentrate waste may also highlight the need to install concentrate acid delivery alongside 1:44.

References

[1] Jiménez MDA, Audije-Gil J, Martínez R, Martín Vaquero N, Gómez M, Portillo J, Pereda G, Gascueña DH, Duane B, Sanjuan M, Martín JLF, Dapena F, Ortiz A, Arias M. How to improve the environmental impact in haemodialysis: small actions, big changes. Clin Kidney J. 2024 Dec 20;18(2):sfae407. doi: 10.1093/ckj/sfae407. PMID: 39927256; PMCID: PMC11806634. https://doi.org/10.1093/ckj/sfae407

[2] Murcutt, G., Hillson, R., Goodlad, C., & Davenport, A. (2024). Reducing the carbon footprint for a 30-bed haemodialysis unit by changing the delivery of acid concentrate supplied by individual 5 L containers to a central delivery system. *Journal of Nephrology*, 37, 1949–1955. https://link.springer.com/article/10.1007/s40620-024-02073-9

[3] Cadenas RM, Audije-Gil J, Arenas MD, Vaquero NM, Portillo J, Larkin J, Fehintola A, Ortiz A, Duane B. Impact of the Type of Dialysate Acid Concentrate Container on the Environmental Footprint of Hemodialysis Centers. Am J Kidney Dis. 2025 Jul 28:S0272-6386(25)00965-5. https://doi.org/10.1053/j.ajkd.2025.06.009

[4] Choo S.M.Y, et al (2025). Sustainable health care in a renal centre - carbon saving is coupled with cost-efficiency | Journal of Nephrology J Nephrol (2025). https://doi.org/10.1007/s40620-025-02354-x

Appendices

Appendix 2A. Summary Acid replacements when amending prescriptions

(for full version follow link: Full list acid formulations for 1 44 switch)

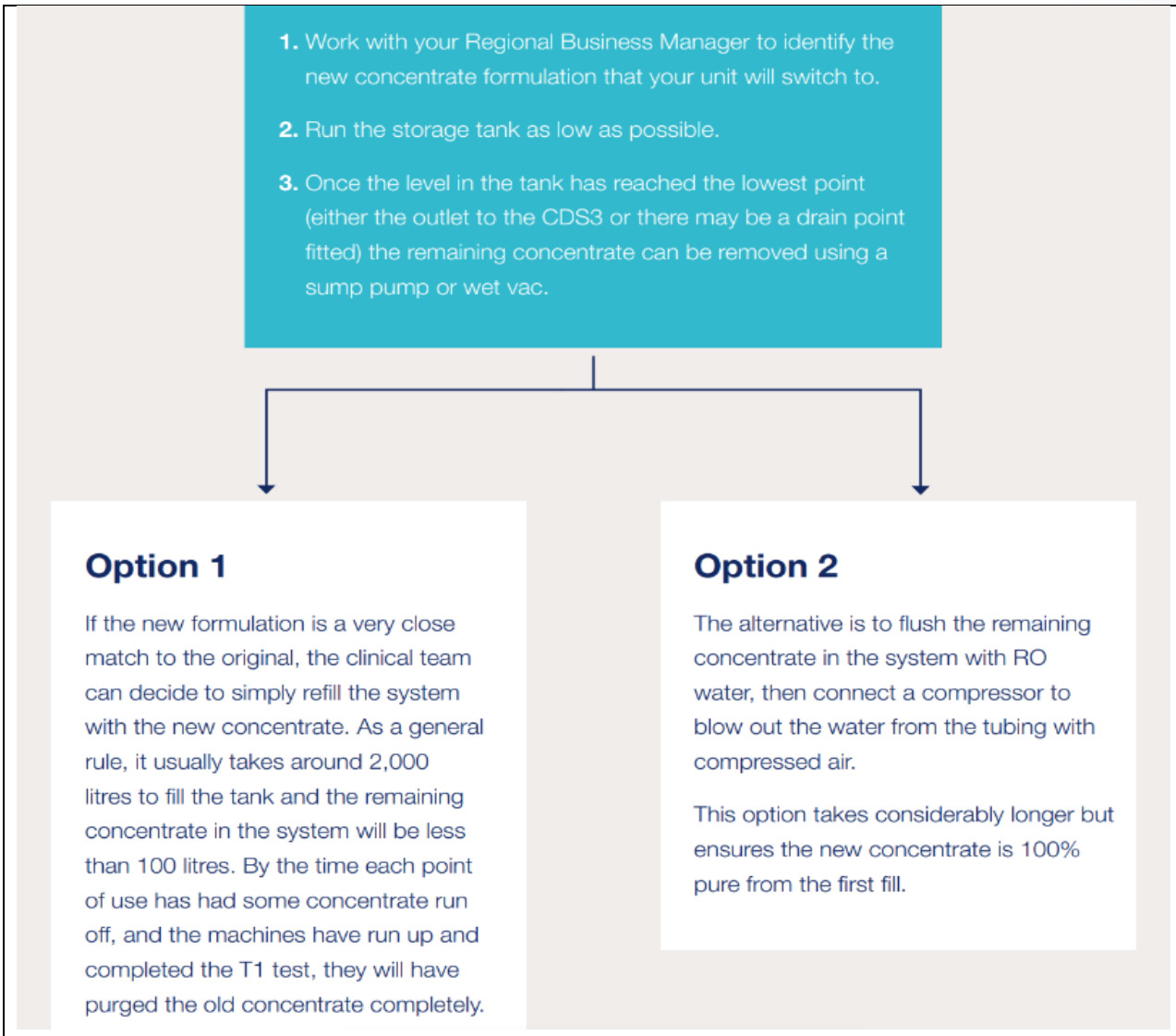
Original Acid 1:34	Ca (mmol)	K (mmol)	Replace with 1:44	Ca (mmol)	K (mmol)
A231	1.50	2	AC-F 213/4#	1.50	2
A232	1.50	1	AC-F 119/5	1.25*	1
A333	1.75	2	AC-F 213#	1.75	2
A335	1.25	2	AC-F 219/1	1.25	2
A453	1.25	3	AC-F 313/2	1.25	3
A336	1.00	2	A27	1.00	2
A253	1.50	3	A313/2	1.25*	3
A511	1.75	3	A26	1.75	4*

*No direct conversion available. Clinical team to monitor calcium or potassium levels.
#Please note that AC-F 213/4 and AC-F 213 have different calcium levels

Appendix 2B. Managing the residual in a tank at the time of switch

Summary Table for Clinicians (Including 5% and 10% residuals)

Electrolyte Dialysate Examples	Pure 1:44	Blend 5% 1:34	Blend 10% 1:34	Absolute Difference (5%)	% Difference (5%)	Absolute Difference (10%)	% Difference (10%)
Sodium (mmol/L)	138	136.5	134.93	-1.5	-1.10%	-3.07	-2.22%
Potassium low (mmol/L)	1	0.99	0.978	-0.01	-1.10%	-0.022	-2.22%
Potassium high (mmol/L)	3	2.97	2.93	-0.03	-1.10%	-0.07	-2.22%



Full version available at: FLOW CHART CDS RATIONALISATION.pdf

Appendix 2C. SOP for switchover

Ahead of time - look through recent orders and estimate time taken / number of HD sessions to use up dialysate in tank. Confirm lead time on orders of 1:44

Day 0 - Business manager to submit new purchase order for new 1:44 bulk concentrate (volume dependent on tank) for day 14 delivery

Day 0 - Contact procurement to order 1:44 canisters to be delivered ahead of 1:44 bulk concentrate, in case the tank runs out quicker than expected

Day *** - Stop bulk 1:34 orders (Cancel deliveries) based on estimated time to use up existing supply

Continue using the central A231 supply until it is fully drained. Monitor tank levels. Named Person tasked with notifying Fresenius to stop bulk orders.

Day 7 - 1:44 cannisters delivered, stored separately until required. SCN to remind RDU staff of timetimes for change

Once the 1:34 central acid has been fully drained, techs to fully drain tank and pipes as far as possible.

Use 1:34 canisters in the interim to use up current stock.

Email Fresenius 1 week before to confirm new bulk delivery

Day 12 - Prescribers to change dialysate prescriptions day before changeover.

Day 13 - techs to switch over machines (Fresenius easy, Nikkiso more labour intensive). Clearly label as 'READY'

Day 14 - once tech checks completed, can start dialysing using central acid

By the end of the process - Date: __/__/__

Materials management team to move any remaining 1:34 canisters to the other dialysis units

11. Acknowledgements

- Iain Jack – Project Support Officer, Green Healthcare Scotland, CfSD
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- David van der Zalm – Project Manager, Green Healthcare Scotland, CfSD
- Green Healthcare Scotland Programme Team
- National Green Renal Programme Specialty Delivery Group Members

12. References

1 Cadenas, R.M., Audije-Gil, J., Arenas, M.D., Vaquero, N.M., Portillo, J., Larkin, J., Fehintola, A., Ortiz, A., Duane, B. (2025). Impact of the Type of Dialysate Acid Concentrate Container on the Environmental Footprint of Hemodialysis Centers, *Am J of Kidney Diseases*, 86(5), pp.616-623. https://doi.org/10.1053/j.ajkd.2025.06.009. https://www.sciencedirect.com/science/article/pii/S0272638625009655

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13. Version Control

	Name	Title	Date
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