

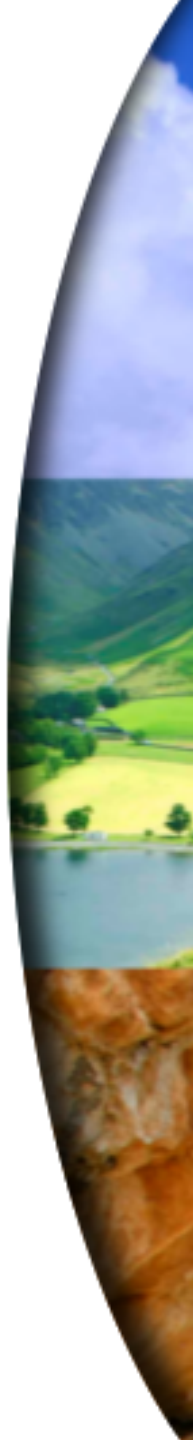
# Review of the MARFA Code

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Quintessa



# Reports Reviewed

Reviewed report	Reviewed sections	Comments
TR-11-01 (Main Report)	13.4, 13.5, 13.7	Aspects covering MARFA only
TR-10-50 (Transport Report)	3.6, 4.5, 6.4, Appendix C, Appendix H, Appendix I	Aspects covering MARFA only
TR-10-51 (Model Summary Report)	3.10	
R-09-56 (MARFA Report)	Whole Report and supporting references	Reviewed in 2010 for SSM, published in SSM-2011-11
TR-10-47 (Buffer, Backfill and Closure Processes Report)	Searched	Pessimistic colloid density not located
TR-10-52 (Data Report)	5.3	For colloid Kd

# Background

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- MARFA is a new code for geosphere transport
  - Allows spatial heterogeneity and time dependency
  - Can link directly with DFN output and work with network paths
- A previous SSM project in 2010 reviewed the MARFA Report (R-09-56)
  - Undertook detailed review of algorithms
  - Developed additional verification tests
  - Published as part of SSM 2011-11

# Approach to Current Review

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- Confirm that 2010 Review is relevant (✓)
- Recap issues found there
- Consider how MARFA has been used in SR-Site to see what the key issues are
- Check the approach to modelling colloidal transport

# Key Points from 2010 Review

- Basic algorithms sound, but some issues in implementation
- Decay chain handling not demonstrated
  - Short-lived nuclides\* cannot be properly handled
- Test cases limited and report is full of errors
- Some inaccuracies after changes in flow rate
- Input syntax error-prone – uses derived parameters
- Quintessa semi-analytic code can be used for verification in simple cases (few time switches, single flow path – i.e. sequence of legs)

*\*No definite limit, but number of particles that arrive for short lived nuclides is in proportional to half-lives, so not enough for accurate results*

# Strengths and Weaknesses

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- Strengths
  - Can handle large networks in practical times
  - Fine for single nuclides or short chains without rapid decay rates
  - Accurate for advective systems where matrix diffusion is dominant
  - Dispersion handled well (for high Peclet numbers)
- Weaknesses
  - Unable to handle long chains with short-lived nuclides
  - Memory limitations restrict number of particles that can be followed
  - Cannot handle diffusive systems
  - Poor when matrix diffusion is not dominant
  - Inaccurate after flow changes
  - Short spikes can only be handled with difficulty
  - Technical documentation dispersed and hard to follow

# Findings From Current Review

# Verification and Documentation

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- This is a major finding of the review.
- Documentation, particular for Verification, is poor
  - R-09-56 full of errors
  - Verification does not cover range of usage
  - Key weaknesses are not identified
  - QA process appears to have been inadequate

# Versions

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- Version 3.2.2 is used in SR-Site
- It is indicated that a new version to undertake fully transient calculations (i.e. including changes of flow direction) is still being developed
  - But R-09-56 includes an appendix for version 3.3 which already does this.

# DFN Linkage

- MARFA links directly (via ptv files) to ConnectFlow
- Verification of this usage is not reported
- Channel factor is now not used
  - F was reduced by 10 to account for channels in SR-Can
  - Check on this in RNT review
  - Possible implications for MARFA conceptual model should have been discussed
- Uncertainties in DFN feed through to transport
  - And further uncertainties added
  - Not properly discussed

# Varying Flow Conditions

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- Lots of sudden flow rate changes, some with short duration
  - Potential inaccuracies
  - Would smooth transitions be worse? (Links to use of LDFs in biosphere)
  - Flow change in near-field is ignored
    - Is this justified? No calculation shown to support this.

# Retention in Tunnels and Soils

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- MARFA used to analyse retention at both ends of geosphere path
- Some results not properly explained
  - E.g. factor 5 increase when tunnels and soils omitted
  - Possibly many path stagnate in tunnels? In which case, is MARFA usage appropriate? (diffusion dominated)
- The strong impact of assumptions about the near-field merit more discussion

# Colloid Facilitated Transport

- MARFA used for this as it can be parameterised appropriately (not a specific colloid capability)
- Rapid Reversible Sorption onto Colloids
  - Equations seem ok but explanation is rather brief
- Irreversible Sorption onto Colloids
  - Explanation hard to follow
- Application
  - Some questions over choice of data
  - Some data could not be traced
  - Uncertainty covers range from no effect to effective bypass of the geosphere

# Relevance of MARFA Weaknesses

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- Decay chains not relevant (doses dominated by single nuclides and Ra226 ingrowth in the near-field with no decay in geosphere)
- Some lack of convergence due to limitation on number of samples but not a big effect
- Diffusion dominant in some tunnels? MARFA results may be incorrect
- Inaccuracies due to flow changes and short spikes might be important

# Recommendations to SSM

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- QA concerns – seek clarification from SKB
  - Possible follow up with full review/audit
- Technical issues – lists of questions to SKB
- Possible further review work
  - Depends on responses to questions, but inter-disciplinary issues need to be looked at:
    - Linkage to DFN modelling
    - Linkage to Biosphere Modelling (and Climate/Flow Assumptions)

# Draft List of Questions to SKB

Is this the sort of thing SSM are expecting?

To be presented if required.

# Draft Questions - I

- 1) Are SKB aware of the limitations of MARFA identified in SSM-2011-11? Were these taken into account in deciding how to use MARFA in SR-Site?
- 2) Are SKB satisfied that the verification tests reported in R-09-56 are adequate? Were further (unreported) verification tests carried out?
- 3) How have the results for MARFA when linked to the DFN code output been verified?
- 4) Please clarify the status of MARFA versions. What plans exist for further MARFA development – TR-11-01 Section 13.4.2 says the details are given but they do not seem to be. Why was version 3.3 not used in SR-Site?
- 5) Are there any implications for MARFA from the implied change in conceptual model in relation to channelling as described in Appendix A of TR-10-50?
- 6) Is there a potential for higher doses during transitions between the various climate states? Are the sharp transitions used in modelling obscuring these?
- 7) How has the accuracy of MARFA in handling short-duration changes in flow rate been verified?
- 8) Have near-field (COMP23) calculations been made to demonstrate that flow rate changes can be ignored in the near-field, to support the claim made in Section 4.5.7 of TR-10-50 that fuel dissolution is the dominant process?

# Draft Questions - II

- 9) Are tunnels the dominant factor in the effects shown in Figure 6-53 of TR-10-50 (pink versus green lines)? What is the main cause of the factor 5 change in peak dose?
- 10) Are the soil properties used in Section 6.4.4 of TR-10-50 consistent with those assumed in biosphere modelling?
- 11) Is the major cause of the lack of impact of having multiple release pathways (Figure 6-52 of TR-10-50) the averaging over all deposition holes? Would the same effect been seen with a single deposition hole calculation as presented in other scenarios?
- 12) Is the parameter  $R_C$  equal to  $1+K_C$  in Appendix I-1 of TR-10-50?
- 13) Please give a fuller explanation of the model presented in Appendix I-2 of TR-10-50, setting out the conceptual basis for what is described and indicating how Ra226 sorption is treated.
- 14) Is using the same  $K_d$  for both intact and colloidal bentonite (Section 4.5.6 of TR-10-50) conservative?
- 15) Where in TR-10-47 (or elsewhere) is the pessimistic 10 g/l colloid figure described? It is given as the reference in the 2<sup>nd</sup> paragraph of Section 4.5.6 of TR-10-50.
- 16) How do the parameter values given in Table H-2 of TR-10-50 relate to those given in the Data Report (TR-10-52)?