



**The Ninth International Symposium on
Naturally Occurring Radioactive Material**
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“25 Years of NORM Oilfield Worker & Public Radiation Monitoring”



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Introduction



- ❖ **With controlled protocols and procedures, NORM injection disposal demonstrates safe radiological doses to the workers and the public.**
- ❖ The dose to the general public did not exceed 10% of a permissible dose ($< 100 \mu\text{Sv}/\text{year}$).
- ❖ The dose to a licensed NORM worker did not exceed 1% of a permissible radiation worker dose ($< 500 \mu\text{Sv}/\text{year}$).
- ❖ An overview of monitoring methods, practices, measurements and data is presented.

NORM Operations Monitored



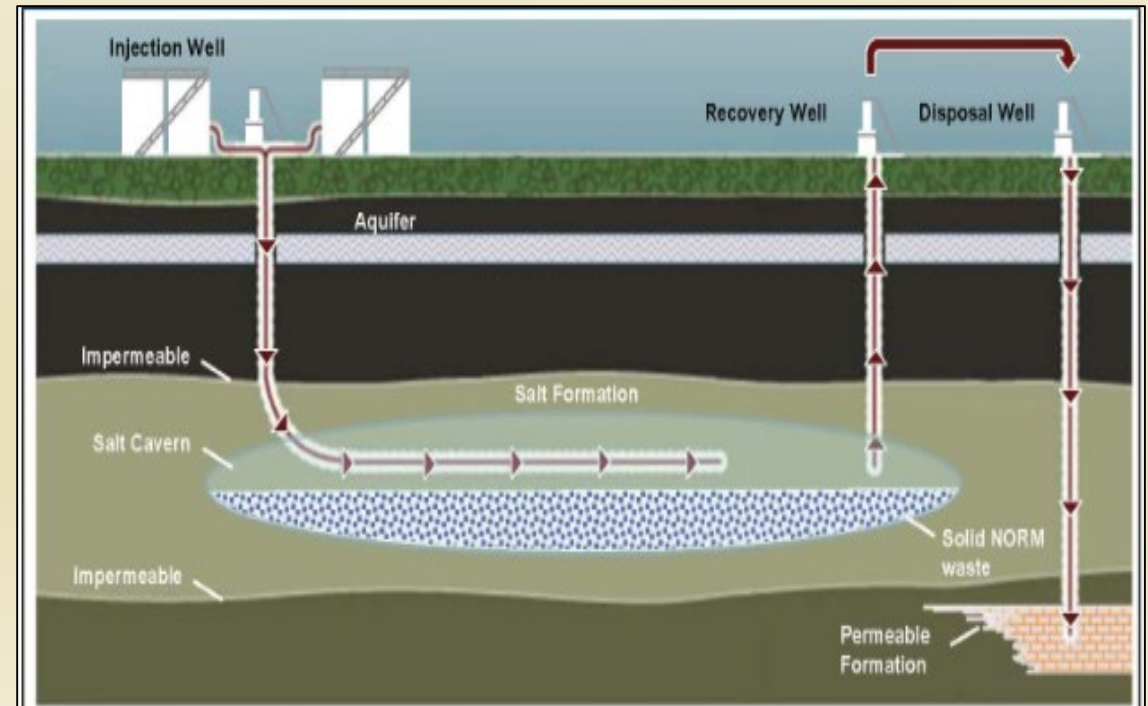
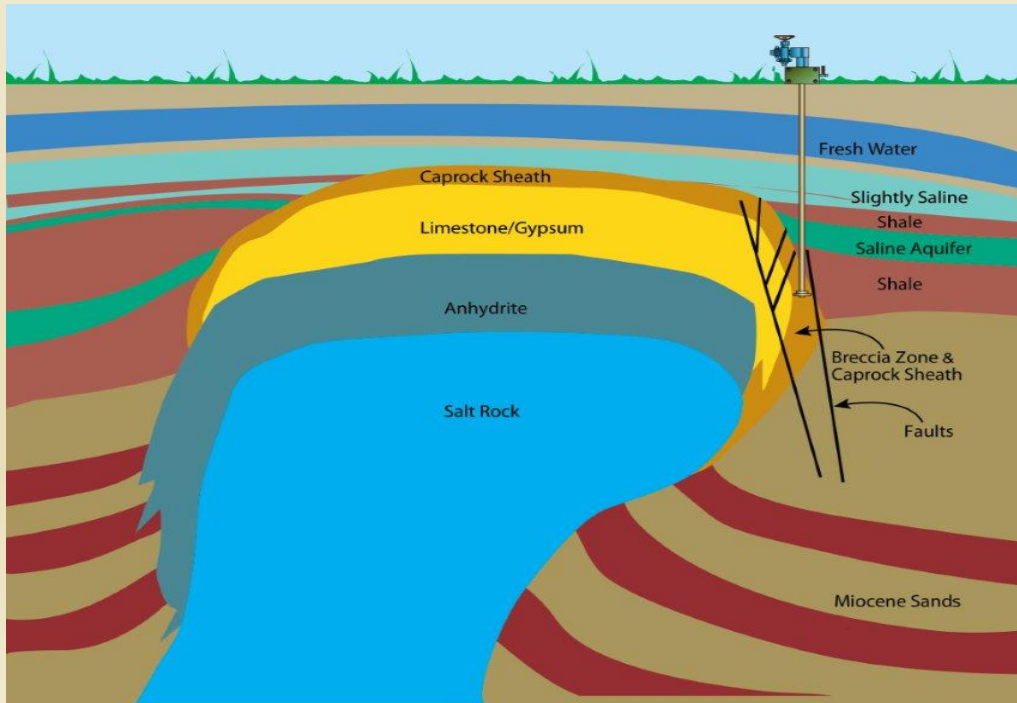
- ❖ 25 Years of Radiation Monitoring at Licensed NORM Disposal Facilities.
- ❖ Facilities received bulk regulated NORM waste & equipment.
- ❖ Waste was particle sized & processed into a slurry solution.
- ❖ The slurry solution was injected into permitted disposal wells.



NORM Injection Disposal



- ❖ Cap-Rock/Sub-Fracture Injection & Cavern Well Injection
- ❖ Commercial NORM Injection in the US – (1994 to Present)
- ❖ AVG Activity of waste = ~ 300 pCi/g (11 Bq/g) Ra-226
- ❖ Receipts - Commercial Disposal = 1.5M BBLS (238 ML)



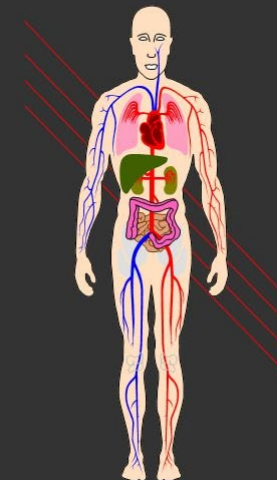
NORM Radiation Monitoring



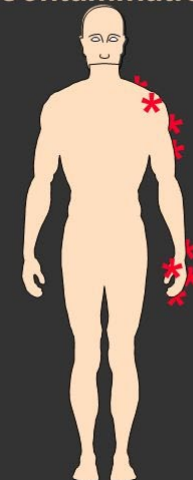
- Radiation Monitoring
 - ❑ External Gamma Exposure – Surveys & Dosimetry
 - ❑ Contamination Monitoring – Surveys
 - ❑ Air Monitoring – Worker & Public monitoring
 - ❑ Radon Exposure – Verification

Radiation Exposure Types

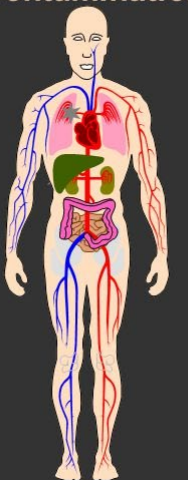
Irradiation



External Contamination



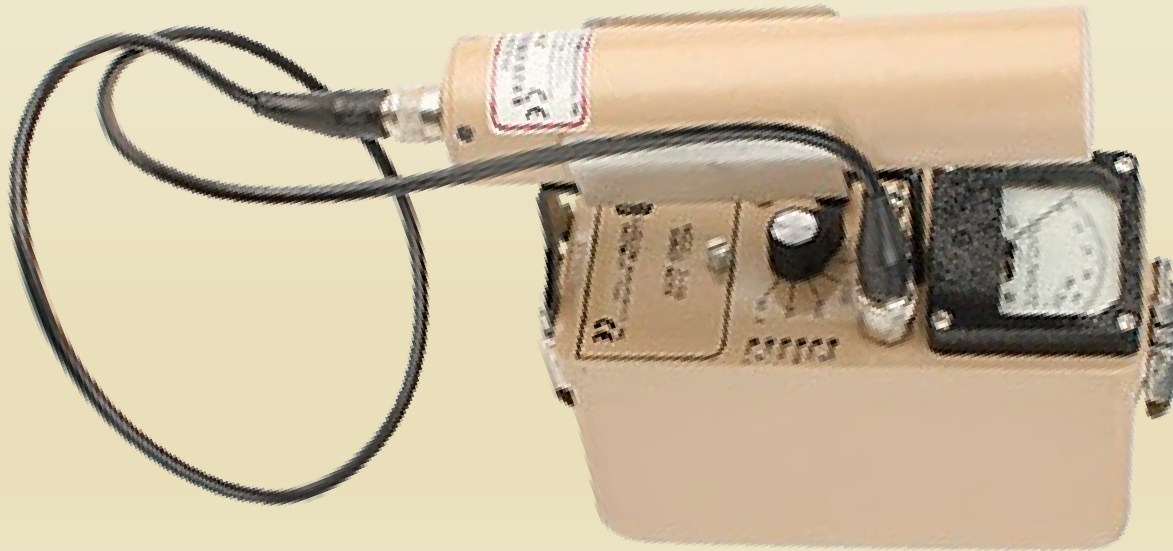
Internal Contamination



Data Collection



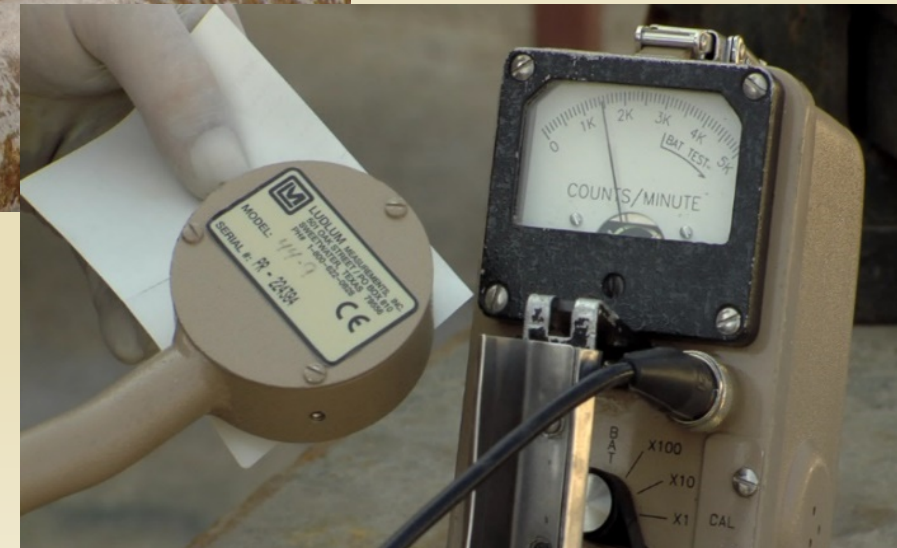
- External Gamma Exposure Monitoring
 - ❑ Gamma surveys using scintillation detectors
 - ❑ Passive Dosimetry (TLDs, OSLs) for personnel and public





Data Collection

- Contamination Monitoring
 - ❑ Frisking of personnel & equipment
 - ❑ Smear samples





Data Collection

- Air Monitoring
 - ❑ Worker “Breathing Zone” Sampling
 - ❑ Public Effluent “Boundary” Sampling



Data Collection



- Radon Exposure Measurements
 - ❑ Activated Charcoal
 - ❑ Alpha Track
 - ❑ Electret





Total Effective Dose Equivalent (TEDE) for the General Public

External Radiation Exposure Calculation – DDE:

- Boundary Radon Monitoring
- Boundary Gamma Exposure Surveys
- Boundary TLD Exposure

+

Internal Radiation Exposure Dose Calculation – CEDE :

- Downwind “Boundary” Air Monitoring



Public Dose Calculations (TEDE):

- ❖ Limited to less than 100 mrem/year (1.0 mSv/year)
- ❖ Actual Calculated Dose < 10 mrem/year (0.1 mSv/year) to the public at the fence-line, downwind of the operation, 24 Hrs/day, 365 days a year.





Total Effective Dose Equivalent (TEDE) for NORM Workers

External Radiation Exposure Calculation – DDE:

- External Gamma Exposure – Surveys
- External Gamma Exposure – TLDS

+

Internal Radiation Exposure Dose Calculation – CEDE:

- Worker “Breathing Zone” Air Monitoring



Worker Dose Calculations (TEDE):

- ❖ Limited to less than 5000 mrem/year (50 mSv/year)
- ❖ Actual Calculated Dose < 50 mrem/year (0.5 mSv/year) to NORM workers.

