Nanotechnology for contaminated land **Rem**ediation

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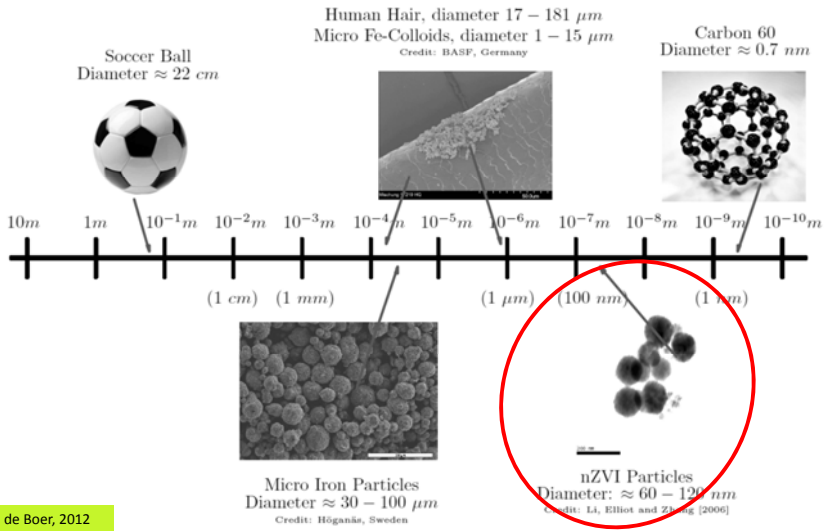
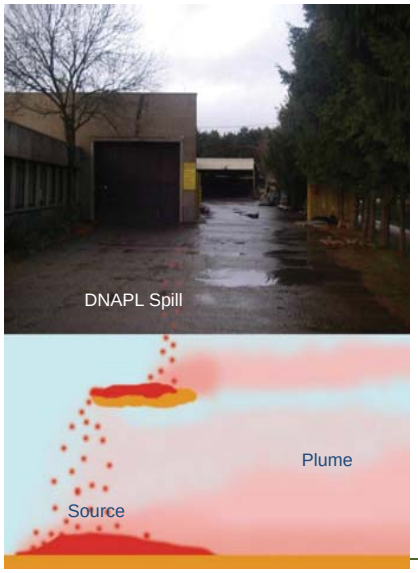
What does „nano“ means ?



de Boer, 2012

Nano particles for *in situ* remediation



- Small size
  ➔ higher surface area
  ➔ more reactive
- NPs (in a carrier fluid) injected into saturated zone via wells
- Focus on source treatment
- Applicable below buildings
- “independent” of application depth
- „semi-passive“ technology
- particles e.g. nZVI
- innovative technology

Overall Goals (1)

“NanoRem - Taking **Nano**technological **Rem**ediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment”

- Identification of the most **appropriate nanoremediation technological approaches** that could achieve a **step-change** in practical remediation performance.
- Development of **lower cost production techniques** and production at **commercially relevant scales**, also for large-scale applications.
- Determination of the **mobility and migration potential** of nanoparticles in the subsurface, and their **potential to cause harm**, focusing on the NP types most likely to be adopted into practical use in the EU.

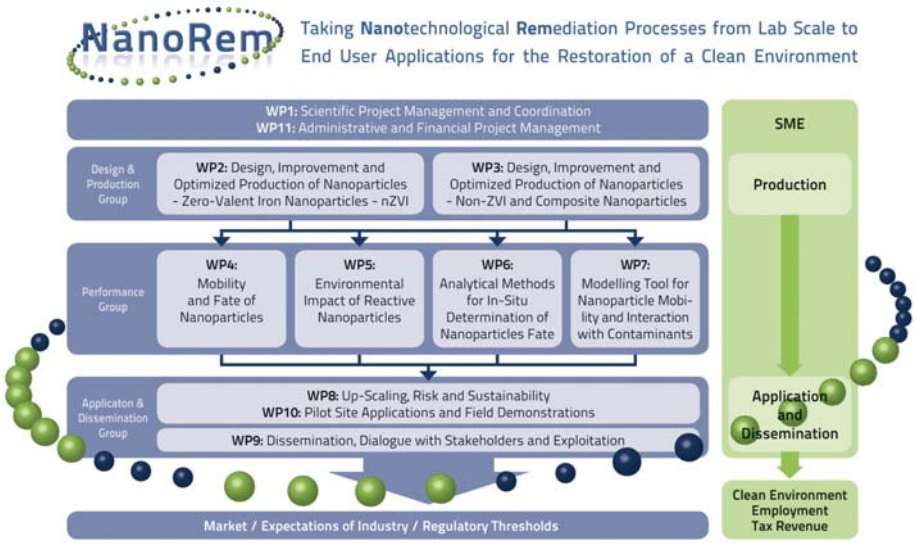
Overall Goals (2)

- Development of a comprehensive **toolbox** for the design of nanoremediation operations, **field scale nanoremediation performance** and **determination of the fate of NPs** in the subsurface.
- **Dissemination and stakeholder dialog** to ensure that research, development and demonstration meets end-user and regulatory requirements.
  - Pre-deployment **risk assessment** - regulatory requirement,
  - **sustainability,**
  - **market niche**
- Provision of **tests at representative scales** to validate cost, performance, and fate and transport findings.

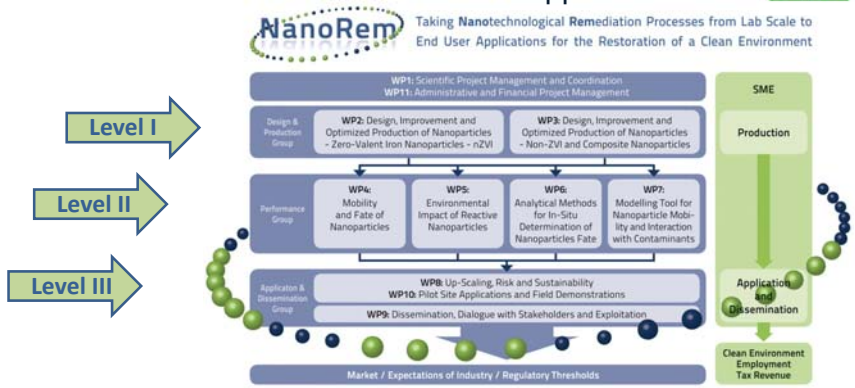
Numbers and Facts

- **11 Workpackages**
  - Coordination
  - Production
  - Application
- **28 Partners from 13 countries**
  - AT 1, CH 1, CZ 4, DE 8, DK 1, ES 2, FR 2, IL 1, IT 1, NL 1, NO 1, PT 1, UK 4
- **Partner Background**
  - Higher Education (9) - SME (8) - Multinational Industry (1)
  - Non-Profit Organization (1) - Research Instituts / Organizations (9)
- **Project Advisory Group PAG**
  - Stakeholders from EU, USA, Asia

NanoRem Structure

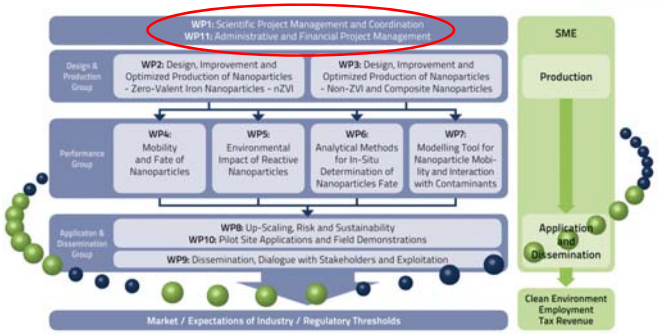


NanoRem´s three level approach



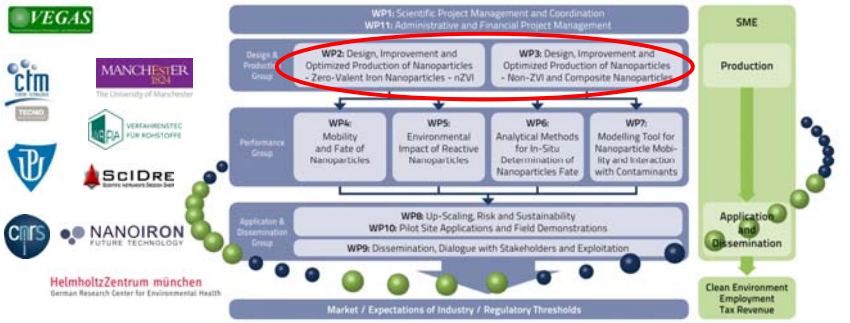
I	Development and production: **WP2** and **WP3**
II	Properties and behavior in the environment: **WP4** to **WP7**
III	Application, permission (approval) and promotion • Large scale experiments and pilot sites: **WP8** and **WP10** • Dissemination, communication and exploitation: **WP9**

Coordination



- **Time management and monitoring of deadlines, milestones, and deliverables**
- **Chairmanship of the Coordination Team and the Project Management Group** (PMG)
- **Web site editorial** control
- Leadership for **science strategy and publication**
- Controlling of project **finances and budget**, financial and administrative processing
- **Conflict resolution, risk management and contingency plans**
- **Report to the European Commission**

Production

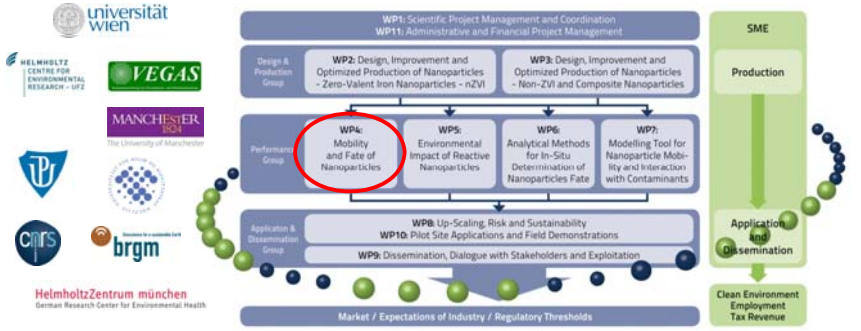


- **Production of new types of nZVI particles** with surface stabilization
- Production and improvement of **nZVI based on grinding/milling.**
- **Optimization** and property adjustment **of particles**
- Chemical and physical **characterization of particles**
- Particle supply and **upscaling of particle production for field application**
- **Identification and expansion of the range of potential applications.**

Production

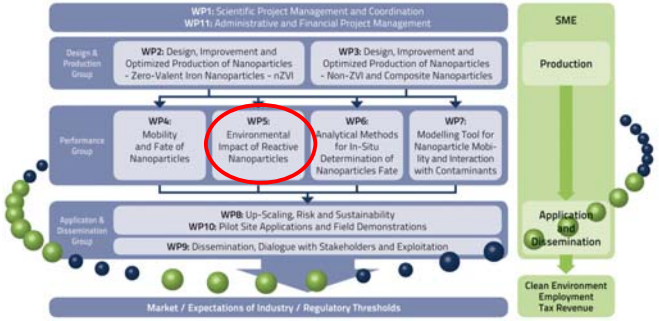
Particle name	Manufacturer	Comment / used in NanoRem
NANOFER 25s	NanoIron	Reference particle, WP10: Large Scale Flume , Pilot sites CZ (DNAPL)
NANOFER STAR (air stable)	NanoIron	WP4: Cannot be transported To be optimized
NANOFER STAR* (air stable)	NanoIron	Modified NANOFER STAR Needed in WP 10: Large Scale Flume Pilot site IS
Milled Fe(0)	UVR-FIA	Needed in WP 10, Pilot site Zurzach, CH
Carbo-Iron (lab)	UFZ	Needed in WP10: Large Scale Flume
Carbo-Iron (industry)	SciDre Dresden	Pilot site HU
Fe-Oxide	HMGU	Needed in WP 10 : Large Scale Container, Pilot Site CZ (LNAPL), PO, ES
Bio-Fe-oxides	UMAN	Research status
Fe-Zeolites	UFZ	Research status
Nano-Metals (Mg, Al)	USTUTT	No final product available yet
Ferrates	USTUTT	No final product available yet

Transport / Reactivity



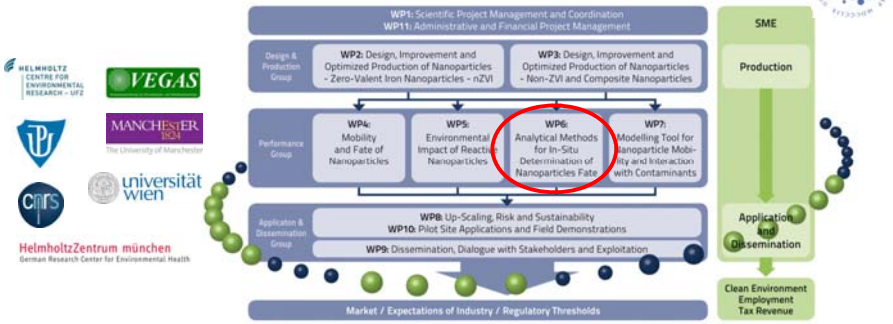
- **Standardized experimental protocols** to facilitate comparison of NP mobility and fate
- **Optimization of NP delivery** and derivation of the effective **NP transport**
- Provision of field-relevant information on **NP reactivity**
- **Transport and reaction kinetic parameters for numerical modelling.**
- **Provision of field relevant information on chemical and size transformations, decomposition, performance, and long-term fate of NPs.**

Ecotox



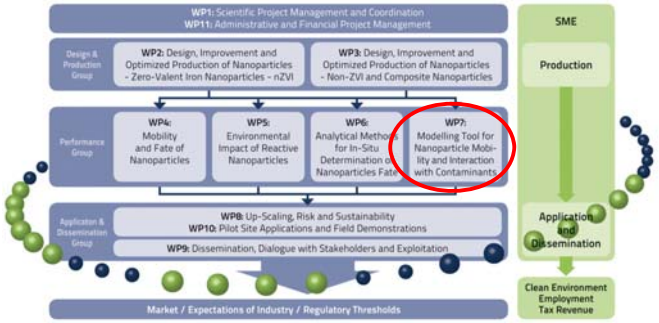
- Establish a **base-line for potential (maximum) toxicity** in aqueous suspensions
- Assess **ecotoxicity of NPs, NP transformation products and pollutant metabolites** under lab and field conditions
- Describe time-course of ecotoxicity and **quantify the potential for toxicity alleviation after migration, oxidation and ageing** of NPs in contact with soil
- Describe **NP-microbial interactions** during and after remediation with NPs

Monitoring



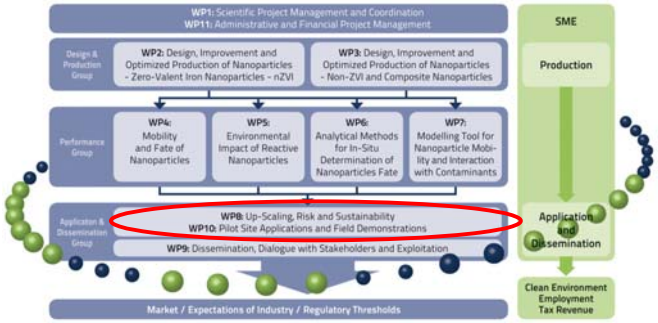
- **Optimisation of monitoring and tracing tools.**
- Application of modern high performance analytics for **on-site measurements and *in-situ* characterization** of natural and engineered nanoparticles
- **Laboratory and field tests of the methods** developed will be conducted, providing documentation of "fit for purpose", **detection limits and costs**

Numerical Model



- Development of a **user-friendly simulation tool** (RT3D module) for the design and interpretation of laboratory tests and for **predicting the fate and transport of nanoparticles and their effectiveness at the field scale**.

Upscaling and Sustainability

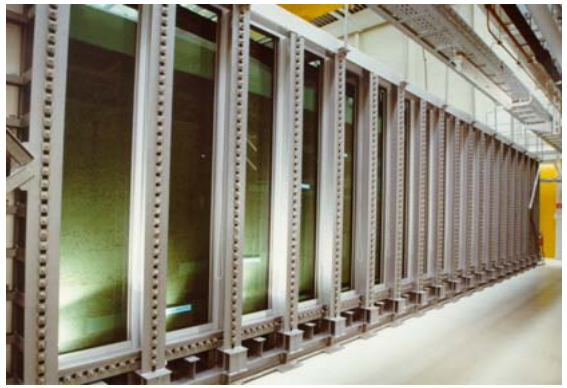


- **Upscaling and testing at representative scale** of emerging NP applications in contained facilities.
- **Feedback for optimisation of NPs and tools**.
- **Provide knowledge on degradation products** under controlled large scale conditions.
- Testing of **appropriate injection technologies** for varying subsurface conditions.
- **Risk model, sustainability appraisal and life cycle assessment** (LCA) considerations.

Large Scale Container (LSC)

- Stainless steel walls
- Length: 18.5 m
- Width: 9 m
- Height: 4.5 m
- Division into 3 compartments (9m x 6m x 4.5m)
- 378 sampling and measurement ports in each compartment

Large Scale Flume (LSF)



- Stainless steel walls
- Glass front
- Length: 18 m
- Width: 1 m
- Height: 3 m
- **Division into two compartments,** 9m x 1m x 3m each
- 32 sampling and measurement ports in each compartment

WP 8.4 Large Scale Experiments

Large Scale Container (LSC)

Plume Remediation (Toluene, LNAPL) using FeOx NP (Goethite)

Large Scale Flume (LSF) ZVI NP

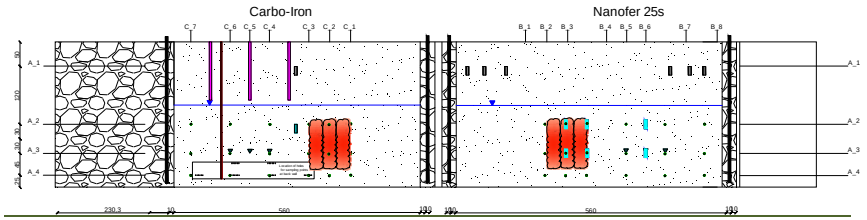
Source Remediation (PCE, DNAPL) using NANOFER 25s

Large Scale Flume (LSF) composite NP

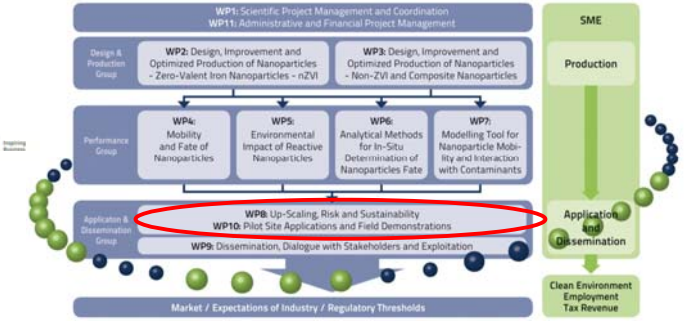
Source Remediation (PCE, DNAPL) using Carbo-Iron

LSF – Sand Emplacement



Pilot Site Applications



- Testing of emerging NP applications on **pilot field sites**.
- Optimisation of NPs and tools via **feedback from pilot sites** and field demonstrations.
- **Determination of degradation products at field conditions**.
- Application of **appropriate injection technologies** for varying hydrogeology
- Alleviating the current lack of **validated field scale performance data for end-users and regulators**.

NanoRem Pilot Sites

Site	Country	Site Primary Investigator	Target Cont.	NP-Type	Reaction Principle	Aquifer
Zurzach	CH	Solvay	CHC	milled nZVI	Reduction/ Sorption	porous / unconfined
Spolchemie 1	CZ	Aquatest	CHC	NANOFER 25s	Reduction	porous / unconfined
Spolchemie 2	CZ	Aquatest	BTEX	Iron-Oxide	Oxidation/ microbial Enhancement	porous / unconfined
Barreiro	PO	GeoPlano	HM	Iron-Oxide	Immobilisation	porous / unconfined
Besor-Secher Neot Hovar	IS	Negev, BGU	CHC	air-stable nZVI NANOFER STAR*	Reduction	fractured
Balassagyarmat	H	Golder	CHC	Carbo-Iron	Reduction / Soption	porous / unconfined
Bizkaia	ES	Tecnalia	HM	Iron-Oxide	Reduction/ Immobilisation	porous / unconfined

Pilot Sites

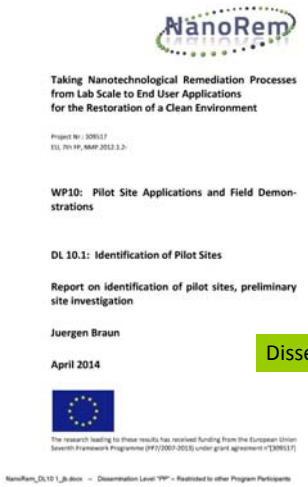

Balassagyarmat, Hungary


Besor –Secher, Israel


Portugal

Spolchemie DNAPL, CZ

Pilot sites


Taking Nanotechnological Remediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment

WP10: Pilot Site Applications and Field Demonstrations

DL 10.1: Identification of Pilot Sites

Report on identification of pilot sites, preliminary site investigation

Juergen Braun

April 2014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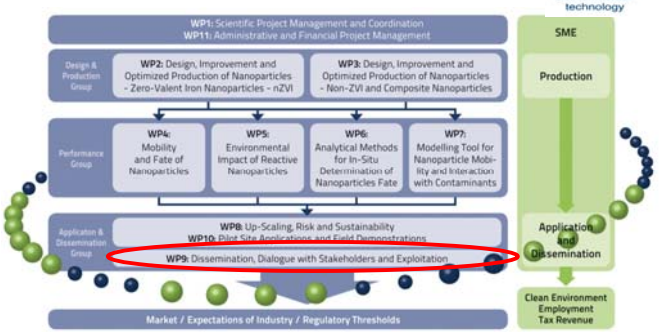
Dissemination Level "PP" (Program Participants) CONFIDENTIAL

Dissemination / Steakholder Dialogue



- Facilitate **dissemination, dialogue and exploitation**, transmitting the results of NanoRem widely amongst user communities,
- Support dialogue to **collect of "soft" information from a broad range of stakeholders** internationally and
- **Provide a risk-benefit based identification of key exploitation opportunities**.

Dissemination: some interim results

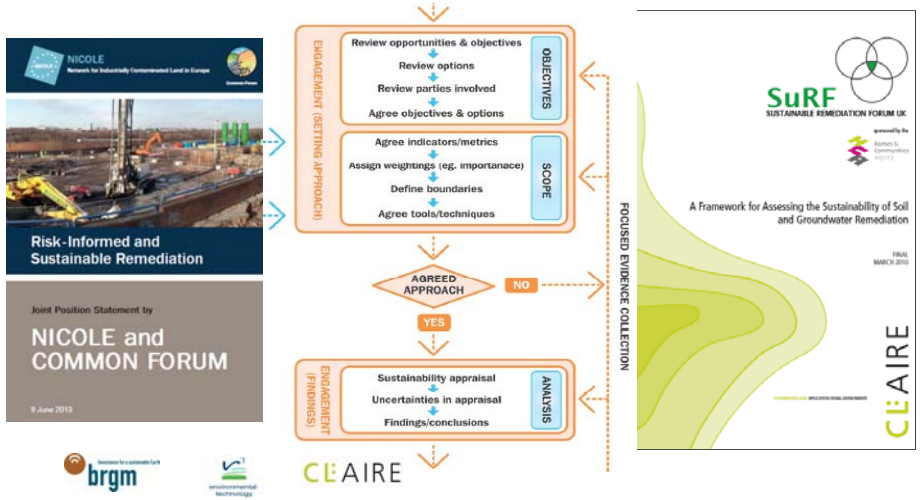
- Stakeholder engagement
  - LQM Predeployment Risk Assessment Nottingham Workshop 16-17 July 2013
    ➔ Deliverable: Potential Environmental Risks of Nanoparticle Deployment (under discussion)
  - Oslo Workshop 2-4 Dec. 2014
    Sustainability and market research
    ** SustRem 2014, Sept. 17-19, Ferrara as a "dry run"*

- Project web site and Newsletter
  www.nanorem.eu

WP8.3 Sustainability assessment and preliminary LCA approaches

- Determining most appropriate system boundaries (link with WP10 pilot studies);
- Applying one or more of the existing sustainable remediation tool (e.g. NICOLE? SuRF-UK) and determining most important impacts and benefits of practical remedial use;
- Investigating how quantitative tools (LCA, carbon footprint) best used to support decision making;
- Testing on a pilot study (comparison with alternative remediation techniques).

Sustainability assessment



Project Advisory Group: Contact for WPs

PAG contact for WPs									
PAG Member	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10
Daniel Elliott	X		X	X					X
Dominique Darmendrail							X	X	X
Cathrine Leaf							X	X	X
Rolf Gerhardt					X		X	X	
Pierre Matz	X				X	X			
Mark Wiesner		X	X	X		X			
Greg Lowry		X	X		X				X
Mengfang Chen				X		X	X		X
Chih C. Chao	X							X	X

www.nanorem.eu

Nanotechnology for contaminated land **Rem**ediation

Thank **you for your interest**
and
the **EU for the funding**

This project received funding from the European Union Seventh Framework Programme (FP7 / 2007-2013) under Grant Agreement No. 309517.

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