

**Review of Preparation Profile for IAEA Document: NS-G-3.6 Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants
(2004)**

COMMENTS BY REVIEWER				RESOLUTION			
Reviewer: Canadian Nuclear Safety Commission 2 Country/Organization: Canada		Page 1 of Date: May 31, 2021					
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	General	Change the title of the proposed revised document to reflect that other facilities, e.g. near surface disposal facilities, are also within the scope of the document.	The DPP seems to cover most geotechnical aspects that would need to be dealt with. It is also stated that it should cover all nuclear installations, e.g. near surface disposal facilities, with or without synthetic liners, and not only nuclear power plants and SMRs.	x			
2	General	Explicitly consider liquefaction in the document, by including this topic in the table of content.	Liquefaction is not explicitly considered in the proposed table of content of the IAEA tec doc (in press) detailing seismic soil-structure interaction. This document provides an opportunity to cover liquefaction, which is the dominant cause of structural failure due to earthquakes.			x	Liquefaction is obviously major issue so that is stated in OBJECTIVE. But is not the only subject in the individual sections.

3	General	<p>Consider covering permafrost, and frost heave and settlement in this document.</p> <p>Sensitive clays should also be considered.</p>	<p>Not aware of any IAEA document that addresses permafrost and sensitive clays and their impact on the design and assessment of nuclear facilities.</p> <p>This document provides an excellent opportunity to address both liquefaction (as in comment 2) permafrost, frost heave and subsidence and sensitive clays.</p>			x	It is not the only subject in the individual sections
4	General	<p>Include aspects on the construction method (of facilities), and their consequence, according to different types of below grade medium, soil or rock.</p>	<p>Construction plans for small modular reactors indicate that many SMRs are planned to be constructed below grade.</p> <p>According to the medium and the contact between the medium and the structure, the structural behavior will be very different.</p>		<p>Since the document supersedes NS-G-3.6, nuclear facilities below grade are out of scope of site evaluation of nuclear installation. The scope of the current DPP was ambiguous, so 'land based' is added in the scope</p>		

**ENISS comments on
IAEA draft DPP DS 531 *Geotechnical Aspects in Site Evaluation and Design of Nuclear Installations* (May 2021)**

COMMENTS BY REVIEWER				RESOLUTION ENISS			
Reviewer: ENISS		Page 1 of 2					
Country/Organization: ENISS		Date: 31/05/2021					
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	Section 6, page 3	The proposed Safety Guide falls within the thematic area of safety evaluation and will interface <u>and be consistent</u> with at least the following IAEA Safety Standards Series publications.	Consistency should be ensured and in priority with IAEA DS507 <i>Seismic Hazards in Site Evaluation for Nuclear Installations</i> (SSG-9 revision) & DS490 <i>Seismic Design of Nuclear Installations</i> (NS-G-1.6 revision), but also with DS498 <i>Design of Nuclear Installations against External Events Excluding Earthquakes</i> (revision of NS-G-1.5) & DS529 <i>Investigation of Site Characteristics and Evaluation of Radiation Risks to the Public and the Environment in Site Evaluation for Nuclear Installations</i> (revision of NS-G-3.2)	x			
2	Section 6, page 3	Text to be added at the end of section 6: <u>The revised guide should also take account of good practices as provided in relevant international standards (e.g. AFCEN RCC-CW</u>	It is deemed important to take benefit from all international consensus on good practices			x	“at least the following IAEA Safety Standards Series publications” does not

		<u>code, Edition 2020 (Rules for design and construction of PWR Nuclear civil works)).</u>					exclude any other relevant documents. But the comment reminded that the design itself is out of scope. To avoid inconsistency with the contents, title itself is revised to 'for Design basis' from 'and Design'. Thank you very much for your kind comment.

Japan NUSSC comments on DPP-DS531 “Geotechnical Aspects in Site Evaluation and Design of Nuclear Installations”

COMMENTS BY REVIEWER				RESOLUTION			
Reviewer: Japan NUSSC member Country/Organization: Japan/NRA			Page 1 of 1 Date: 31 May 2021				
No.	Para/Line No.	Proposed new text	Reason				
1	2. BACKGROUN ND/ 2nd sentence	In 2007, large ground settlements of the foundation induced by the <u>Niigataken Chuetsu-oki Earthquake</u> caused fire and damaged the function of the non-emergency in-house electrical transformer at the Kashiwazaki Kariwa NPP in Japan.	The official denomination for the earthquake named by Japan Meteorological Agency.	x			
2	2. BACKGROUN ND/Line 5	In 2011, a landslide of the slope collapse of an embankment induced by the <u>2011 off the Pacific coast of Tohoku Earthquake</u> fell down a transmission tower, resulting in the loss of off-site power to Units 5 and 6 of the Fukushima Daiichi NPP in Japan.	1) This event was caused by a collapse of an embankment, not ‘natural’ slope. However, the wording of ‘landslide of the slope’ in original text can be misleading with the collapse of ‘natural’ slope. 2) The official denomination for the earthquake named by Japan Meteorological Agency.		x		
3	4. OBJECTIVE/ Line 5	<ul style="list-style-type: none"> Methodologies on considering phenomena such as <u>settlement</u>, heave and slope failure 	Phenomena to be considered should include not only heave but also settlement as stated in NS-G-3.6.	x			
4	4. OBJECTIVE/ Line 9	<ul style="list-style-type: none"> Methods for soil/<u>rock</u> replacement in the case of unfavourable soil/<u>rock</u> condition. 	There is an example of rock replacement.			Based on the suggestion of USA, replaced with site improvement.	

DS531 DPP - Geotechnical Aspects in Site Evaluation and Design of Nuclear Installations (rev. of NS-G-3.6)

COMMENTS BY REVIEWER				RESOLUTION			
Reviewer: Aisha Abdelbasat Tantoush Page....1 of....2 Country/Organization: Libya (LAEE) Date:May 2021							
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	2. Paragraph (1)	In the last few decades, seismic induced geotechnical events affected several nuclear power plants (NPPs), and countermeasures were taken in response to these incidents. In 2007, large ground settlements of the foundation induced by the Chuetsu Oki earthquake caused a fire and damaged the function of the non-emergency in-house electrical transformer at the Kashiwazaki Kariwa NPP in Japan. In 2011, [...]	Improved grammar.	x			
2	2. Paragraph (3)	This revised Safety Guide will enhance and supersede NS-G-3.6 by incorporating the latest knowledge and experiences from the Member States and lessons learned from geotechnical events, and expand the scope from NPPs to all types of nuclear installation using a graded approach.	Improved grammar.	x			

3	3. Point (2)	<ul style="list-style-type: none"> • Consideration of lessons learned from recent geotechnical related events; nuclear build or existing nuclear sites and other relevant industries. 	Improved clarity.			x	Implicitly in the 'event'.
4	4. Point (4)	<ul style="list-style-type: none"> • Methods for soil replacement in the case of unfavourable soil conditions. 	Improved grammar.	x			
5	5.	<p>The scope of the revised Safety Guide will cover all types of nuclear installation as defined in the IAEA Safety Glossary (2018 Edition). It will be applicable apply to both existing and new installations, including small modular reactors. It will cover geotechnical engineering aspects that are important for the safety of nuclear installations. Although seismic aspects play an important role in this field, seismic aspects other than geotechnical aspects will be out of the scope of the revised Safety Guide and are covered by DS507.</p>	Improved clarity.	x			

DS531 DPP - Geotechnical Aspects in Site Evaluation and Design of Nuclear Installations (rev. of NS-G-3.6)

COMMENTS BY REVIEWER				RESOLUTION			
Reviewer: ONR		Page..1. of...9					
Country/Organization: UK/ONR		Date: May 2021					
Com ment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
<p>Headline technical comment – ONR’s view of DPP DS531 is that it provides a good basis for the revision of NS-G-3.6. Several key areas requiring updates are identified in the DPP, with reasonable justification and objectives outlined. However it would be beneficial to include further detail relating to the scope and ambition of the document revision.</p> <p>ONR would be interested in offering an expert to participate in the drafting of this updated guide.</p>				Thanks in advance and look forward to UK contribution			
1	Section 3, bullet point 2	Propose an expanded bullet: <i>“Consideration of lessons learned from recent geotechnical related events, nuclear new build, existing nuclear sites and other relevant sectors and industries;”</i>	Lessons learned should extend beyond recent geotechnical events. It is important to also capture geotechnical learning from new nuclear build projects, including GDFs etc., as well as other sectors and industries.			x	‘events’ consists of them.

2	Section 4	<p>The following text is suggested as minimum. The DPP would still benefit from more details on what is in and out of scope.</p> <p><i>“The main objective of the revised Safety Guide is to provide recommendations on how to meet the applicable requirements from SSR-1, SSR-2/1 (Rev. 1), SSR-3, SSR-4 and GSR Part 2, related to geotechnical aspects for nuclear installations. This will include expanding the scope from NPPs to all types of nuclear installation using a graded approach.”</i></p>	<p>Expanding the scope from NPPs to all types of nuclear installation using a graded approach is stated in Section 2 (Background). However, there are few details on what this will mean.</p> <p>It should be clear if SMRs or Geological Disposal Facilities are included in the update (noting IAEA has work underway for SMRs and SSG-14 already has a broad scope).</p> <p>If the approach is to mainly provide detailed guidance for large NPPs and cover other facilities in a single section, the requirement for a graded approach should be stated.</p>			x	It is obvious due to expansion from NPP to the nuclear installation.
3	Section 3, bullet point 4	<p>Suggested extra text:</p> <p><i>Evolution of the approach, methodology and techniques to assess the geotechnical aspects of nuclear installations. This will include, but will not be limited to:</i></p> <ul style="list-style-type: none"> • <i>Ground investigation rationale</i> • <i>Data collection and desk studies</i> • <i>Testing</i> • <i>Reporting of data</i> • <i>Development of a ground model</i> 	<p>It would be useful to include specific areas that are expected to be revised. This should provide greater clarity on the intended extent of the update. <i>It may be preferable to include this detail in Section 5 (Scope), as opposed to Section 3, bullet point 4.</i></p> <p>ONR is aware of advances in the specific areas highlighted in the proposed new text column. For example: <u>Ground Investigation rationale</u></p> <ul style="list-style-type: none"> • Development of a Ground Investigation Rationale document that describes the planned 			x	Thanks for the suggestions. They will be considered in drafting stage or supporting documentations for the technical detail.

			<p>investigations including objectives, requirements and tests.</p> <p><u>Data collection and desk studies</u></p> <ul style="list-style-type: none"> • How historical data should be considered and used to inform the ground investigation rationale. • How historical data should be sentenced and captured in the ground investigation. • The recommendations for regional, local and site-scale studies. <p><u>Testing recommendations</u></p> <ul style="list-style-type: none"> • Minimum number of boreholes and tests on site (possibly linked to overall site footprint as SMR's will have a substantially smaller footprint). • Expectations for wider geological investigation (regional and local scales) to understand any significant variations in the local area and geological features. • Identification of tests that should be conducted in conjunction with each other. • Test locations, i.e. reactor footprint. • Onshore and offshore ground investigation recommendations. • Tests in relation to re-use of excavated materials and/or modified re-used materials <p><u>Reporting of data</u></p> <ul style="list-style-type: none"> • How collected data feeds into interpretative and design reports. 				
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			<ul style="list-style-type: none"> • That the reporting (in addition to collection) of data should be suitable for end users. • Expectations for storage of data and samples for the facility lifecycle. <p><u>Ground model development and use</u></p>				
4	Section 5, new paragraph proposed, following existing text	<p>Suggested text to provide clarity to all on the scope and ambition of the planned updated:</p> <p><i>The scope of the revised Safety Guide will cover recent advances across geotechnical aspects. This will include, but will not be limited to:</i></p> <ul style="list-style-type: none"> • <i>Ground investigation specification and rationale</i> • <i>Surface (capable) faulting testing</i> <ul style="list-style-type: none"> - <i>Information on the methodology and relevant tests to determine the potential for a fault to rupture the surface.</i> - <i>Table 1 and/or 2 of the current NS-G-3.6 publication will be updated to include tests relating to capable faulting.</i> • <i>Comprehensive ground investigations</i> • <i>Independent review</i> • <i>Ground model</i> 	<p>The DPP could be clearer on the key areas planned for update.</p> <p>ONR is aware of advances in the specific areas highlighted in the proposed new text column. These areas are either covered in the current Safety Guide (NS-G-3.6) at a high level or not at all. For example, information provided in the revised standard could include:</p> <p><u>Ground investigation specification and rationale</u></p> <ul style="list-style-type: none"> • Recommendations for the production of a ground investigation specification and rationale are currently not outlined in detail. It would be beneficial to recognise the value of such documents and what they should contain. Ideally the rationale would describe the ground investigation scope and objectives, the end-user requirements and the range of tests that will be undertaken to 			x	<p>Thanks for the suggestions. They will be considered in drafting stage or supporting documentations for the technical detail, if it will be the scope without coverage by other documentations (e.g. Capable fault issue in SSG-9, management system in GS-G-3.1).</p> <p>Fully buried and offshore nuclear facilities are out of scope of site evaluation of nuclear installation. But the DPP was too ambiguous, so 'land based' is added in the scope</p>

		<ul style="list-style-type: none"> • <i>Geotechnical risk register</i> • <i>Ground investigation phasing</i> • <i>Cross-correlation of tests</i> • <i>Buried and offshore nuclear facilities and structures</i> • <i>Adjacent sites</i> • <i>Monitoring</i> • <i>Uncertainties</i> • <i>Temporary geotechnical features during construction</i> • <i>Ground remediation</i> 	<p>deliver the information needed to meet the requirements.</p> <p><u>Surface (capable) faulting</u></p> <ul style="list-style-type: none"> • In the current version of the publication there is a reference to Site Evaluation for Nuclear Installations (NS-R-3 (Rev. 1)). NS-R-3 provides information on capable faulting and the broad types of data that can be used to form a judgement. No detailed information of specific capable faulting tests/methodologies is included. Table 1 and/or 2 of the current NS-G-3.6 publication could be updated to include tests relating to capable faulting. <p><u>Comprehensive ground investigations</u></p> <ul style="list-style-type: none"> • Recommendations relating to spatially comprehensive ground investigations could be strengthened. For example, lateral and vertical extent of ground investigation, onshore and offshore requirements etc. <p><u>Independent review</u></p> <ul style="list-style-type: none"> • Information could be provided on the use, and benefit, of independent reviews of ground investigation related work. <p><u>Ground model</u></p> <ul style="list-style-type: none"> • Recommendations should be outlined for the production of a ground model, that captures the disposition and character of soil, 				
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			<p>rock and groundwater under and around the site. This should include update of the ground model, based on information from excavation/construction.</p> <p><u>Development of a geotechnical risk register</u></p> <ul style="list-style-type: none">• Guidance relating to the capturing of extant risks throughout the ground investigation process (e.g. possibility of unexploded ordinance or contamination based on site history etc. or unknown information). <p><u>Ground investigation phasing</u></p> <ul style="list-style-type: none">• Ground investigations for large projects often occur in phases. It would be beneficial for the revised publication to recognise that subsequent rounds of ground investigations should implement learning from the earlier phases and that later phases can be used to follow-up on outstanding issues from earlier phases. <p><u>Cross-correlation of tests</u></p> <ul style="list-style-type: none">• The value of test cross-correlation, rather than tests being considered solely independently, should be considered for inclusion in the revised publication. <p><u>Buried and offshore nuclear facilities and structures</u></p>				
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		<ul style="list-style-type: none">• Waste repositories (near-surface and/or geological disposal facilities) and SMR's present the possibility of fully buried nuclear facilities, if buried structures are included within the document scope it may require expansion to consider provisions for these instances (based on any existing facilities and similar structures in other industries). Offshore structures (marine, fluvial, lacustrine) should also be taken into account. <p><u>Adjacent sites</u></p> <ul style="list-style-type: none">• Consideration of learning available from adjacent sites – settlements, construction techniques etc. <p><u>Monitoring</u></p> <ul style="list-style-type: none">• The current NS-G-3.6 publication only discusses monitoring until operation. Expectations for monitoring of site evolution through the lifetime of the plant (e.g. groundwater, settlement etc.) should be given. Such monitoring is important to whether performance requirements are being met by the as-built design, understand how materials are changing and any impacts for nuclear safety. <p><u>Uncertainties</u></p> <ul style="list-style-type: none">• The current report is very brief on uncertainty. More detail on the				
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			<p>types of uncertainty (aleatory and epistemic), and how these are accounted for in geotechnical hazards and design.</p> <p><u>Temporary geotechnical features during construction</u></p> <ul style="list-style-type: none"> • Brief description of temporary works and geotechnical risks associated with them during construction. • Potential impacts of temporary works / structures on existing plant (e.g. subsequent construction and dewatering on existing foundations). <p><u>Ground remediation</u></p> <ul style="list-style-type: none"> • Techniques for localised ground improvement rather than wholesale replacement e.g. grouting to reduce groundwater flow / voidage etc. 				
5	Section 6 Interfaces with other relevant safety standards	Clarity/mention of “SSG-14 Geological Disposal Facilities for radioactive waste” to be added	We understand that this is the list in this section is not exhaustive but we consider that the scope of this DPP is very relevant to IAEA guidance in “SSG-14 Geological Disposal Facilities for radioactive waste” and could, if not considered carefully, impact adversely on the ability to construct, operate and close a Geological Disposal Facility. We would welcome specific mention of SSG-14 in the DPP to ensure any possible conflicts are explicitly addressed within the revision.			x	Geological disposal facilities are out of scope except the facility above surface. But thanks for this reminder and inconsistency should be avoided in the final documentation.

6	Section 7	It is suggested Section 7 provides some clarity on where Earth Structures & Buried Structures will be covered given that their omission is a change from the current standard.	'Earth Structures' and 'Buried Structures' are included in the contents list of NS-G-3.6. It is not clear from the DPP whether these topics will be included in the revised document. If they are included, it is not clear where they will be covered under the revised contents list.			x	As mentioned in 4, they are out of scope. To avoid this confusion, the scope of DPP has been revised. Your comment was kind reminder of ambiguous. Thank you very much and contributed to the improvement.
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TITLE: US Comments on DDP DS531, Geotechnical Aspects in Site Evaluation and Design of Nuclear Installations

COMMENTS BY REVIEWER				RESOLUTION			
Reviewer: USNRC							
Country/Organization: USNRC		Date: 06/10/2021					
Comment No.	Para/ Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	Page 2, Para 1	The revised Safety Guide will directly support Requirement 21 (paras 5.24-5.26) and Requirement 22 (paras 5.27-5.31) of SSR-1, as well as Requirement 17 (paras 5.15A-5.17, 5.19-5.21A) and Requirement 18 (para 5.23) of SSR-2/1 (Rev. 1), Requirement 19 (paras 6.45–6.57) and Requirement 18 (para 5.23) of SSR-3, and Requirement 19 (paras 6.45–6.57) of SSR-3, and Requirement 16 (paras 6.49–6.54) and Requirement 17 (paras 6.55–6.57).	In addition to mentioning SSR-2/1 (for nuclear power plants), We recommend to add the IAEA Safety Standards SSR-3 (for research reactors) and SSR-4 (for nuclear fuel cycle facilities) in the paragraph to reflect that all types of nuclear installation are considered. As stated in the DPP, the revised Safety Guide will cover all types of nuclear installation. One of the purposes for updating the current Safety Guide NS-G-3.6 is to address the revision of the applicable safety requirements including SSR-1, SSR-2/1 (Rev. 1), SSR-3, and SSR-4.			x	Unnecessary to refer all relevant paras in the requirements. Some of them are out of scope (e.g. design itself, internal hazards) or not exist, i.e. Requirement 18 (para 5.23) of SSR-3.
2	Page 2, Line 25	Methods for site improvement in the case of unfavorable soil condition.	We suggest replacing the soil replacement by site improvement which covers a broader range	x			

			of options to strengthen weak soils.				
3	Page 2, Line 21	Methodologies on considering phenomena such as settlement and heave, and slope failure;	We suggest adding settlement to pair with heave. Settlements and heaves are equally important for foundation deformation and connection between buildings. Settlements and heaves should be discussed in pairs.	x			
4	Scope Para 1/Line 2	The Scope as indicated in Para 1 indicated that this guidance <u>will be applicable to both existing and new installations</u> . Therefore, it is implicitly contemplated that certain design aspects may need to be modified or enhanced for existing facilities based on new geotechnical parameters evaluation. In this regard, we believe DS531 should address back-fit analysis and related geotechnical issues that could be <u>unfeasible or impractical to apply</u> for existing facilities but could be appropriate for new facilities. In this context, we recommend adding in Section 7 (Overview) an item on <i>“back-fit analysis and limitations on applicability to existing facilities.”</i>	Need to distinguish in site evaluation of geotechnical aspects between criteria and parameters applicable for new design of nuclear installations and those applicable for existing installation with inherited design and structures.		This document supersedes from NS-G-3.6 and design itself is out of scope. The title of current DPP was ambiguous, and revised to ‘for Design basis’ from ‘and Design’. Thanks for the comment to avoid confusion.		
5	Section 7 Overview	We recommend adding a section on graded approach for safety and risk analysis to enhance site performance based on revised geotechnical evaluation and site stability analysis.	The need and decision for applying or modifying design as related to geotechnical evaluation should be based on graded approach for risk			x	This is exactly in the bullet 8 of OVERVIEW.

			analysis including risk/cost benefit analysis				
6	Section 7	<p>2. Geotechnical site investigation</p> <p>3. Nuclear installation geotechnical site considerations.</p> <p>4. Geotechnical considerations for the foundations</p> <p>6. Assessing soil stability and design of mitigation measures</p> <p>7. Monitoring Geotechnical Parameters</p> <p>8. Site evaluation and design of nuclear installations other than nuclear power plants.</p>	Original titles are verbose and should be shortened.	x			
7	Section 7	Item 9: Geotechnical data management system	Item 9 states "Application of the management system regarding geotechnical systems." Is this a geotechnical data management system? If so, the proposed title is a better choice.			x	Not only data management, but also comprehensive geotechnical evaluation process.
8	Page 2, Section 4 Objective, bullet 2	Improved calculation methods evaluation methodologies for assessment of liquefaction hazard potential and consequences , and methodologies for determination of soil dynamic properties used for site response and soil-structure interaction evaluations ;	<p>1. The liquefaction assessment is not only involved calculation but also analysis;</p> <p>2. We need to improve methods on assessment of the liquefaction potential (triggering mechanism)</p>	x			

			<p>and consequences (settlement) at a site; and</p> <p>Improve SSI analysis methods is not the objective of this Safety Guide but for structure related safety guide. We need to improve methodologies on determination of the soil properties under seismic loading conditions for uses in site seismic response and SSI analyses.</p>				
9	Page 2, Section 4 Objective	Add a new (5 th) bullet: Guidance on geotechnical investigations for deeply embedded structures.	The deeply embedded structures used in SMR designs (can be as deep as 60 meters below ground) pose challenges to geotechnical engineers, such as the requirements for site investigation (small structure footprint, the need of more detailed soil property parameters along the embedded portion of the structure, etc.); the need for an adequate analysis method for static and dynamic earth pressures as the current methods are suitable for shallow foundation analysis		The comment reminded that the scope of the document was ambiguous, so the 'land based' is added at front of SMR.		