SAFETY EVALUATION REPORT

On

SITE PARAMETERS REPORT for AKKUYU NUCLEAR POWER PLANT

ANS.GDR02E.SPR

February 2017
Version 1

Department of Nuclear Safety
Turkish Atomic Energy Authority

SAFETY EVALUATION REPORT

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SITE PARAMETERS REPORT for AKKUYU NUCLEAR POWER PLANT

INSTALLATION	
Name	Akkuyu Nuclear Power Plant
Code	ANS
REPORT	
No	ANS.GDR02E.SPR
Date	09.02.2017
LIST OF DOCUMENTS REVIEWED:	
1. Akkuyu NPP Site Parameters Report, AKU-BDD0132 Rev B01 2. Akkuyu NPP Site Parameters Report, AKU-BDD0132 Rev B02 3. Akkuyu NPP Site Parameters Report, AKU-BDD0132 Rev B04	

Executive Summary

The Akkuyu NPP project has been started with an intergovernmental agreement signed between the Republic of Turkey and Russian Federation to build and operate a nuclear power plant in Akkuyu site. A project company, Akkuyu NPP Electricity Generation JSC has been established by the end of 2010 to implement the provisions of the agreement. Akkuyu NPP Electricity Generation JSC has been registered as Akkuyu Nuclear JSC, changing its name. The agreement ordains building of four units of AES 2006 design VVER 1200 nuclear reactors in Akkuyu site located in Gülnar township of Mersin province.

Akkuyu site had been licensed in 1976 by the Atomic Energy Commission. Akkuyu Site License had been issued to Turkish Electricity Authority, and its ownership had been assumed by the Electricity Generation JSC upon restructuring of the electricity authority. Site License has been allocated to the project company in accordance with the provisions of the agreement. Upon allocation, the Authority requested an update of the site report which established the basis for the site license, and Updated Site Report has been endorsed by the Authority in December 2013.

Second stage of the site activities for nuclear power reactors, according to the Decree on Licensing of Nuclear Installations, is consist of determination of site related design parameters with detailed site investigations and submission for them to the approval of the Authority. To establish a basis for this approval, the applicant was requested to submit a report containing the detailed site investigations and their results, and the values of the site related design parameters. Chapter 13 of the Site Parameters Report includes the definitive values of the site related design parameters.

Site Parameters Report has been submitted for the first time in November 2014, and based on the review and assessment findings, the project company was asked to perform some additional investigations and analysis and provide absent information. During the process, two more versions of the report, addressing the findings, were submitted to the review and assessment of the Authority. Consequently, the fourth version including all amendments agreed upon were submitted in January 31st, 2017 and it was reviewed and assessed.

According to the findings of review and assessment, the information provided with the fourth version were found adequate, the data, methodology, assumptions and analysis used for determination of site parameters were found acceptable, and the site related design parameters provided in Chapter 13 can be approved.

Additionally, issues that need further attention during the continuing process after the approval were also identified and given among the conclusion of evaluations.

Abbreviations

ACNS: Advisory Committee on Nuclear Safety
ANS: Akkuyu Nuclear Power Plant
APC: Akkuyu Project Company, namely Akkuyu Nuclear J.S.C.
DNS: Department of Nuclear Safety
IAEA: International Atomic Energy Agency
NPP: Nuclear Power Plant
SPR: Site Parameters Report
URAP: National Emergency Response Plan
VVER: Water Cooled Water Moderated Reactor

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Section 1 Introduction

1.1. General

Akkuyu Nuclear Power Plant (ANS) project has been started by an Intergovernmental Agreement signed between the governments of Republic of Turkey and the Russian Federation in order to build and operate a nuclear power plant in Akkuyu site. To implement the mandates of the Agreement, a project company, namely, Akkuyu NPP Electricity Generation JSC has been established by the end of 2010. Akkuyu NPP Electricity Generation JSC has been renamed and registered as Akkuyu Nuclear JSC (APC, Akkuyu Project Company) in September 2014.

According to the Agreement, four units of AES 2006 design VVER 1200 shall be built in Akkuyu site in Turkey. Akkuyu is a site within the Gülnar county of Mersin, located 140 km west of Mersin and 37 km south southeast of Gülnar. Closest settlement is the Büyükeceli town. The Atomic Energy Commission Akkuyu issued the Site License to Akkuyu in 1976. The site license has been awarded to Turkish Electricity Authority, public electricity producer by 1970's, transferred to Electricity Production JSC upon reorganization, and allocated to APC by the Agreement.

The Decree on Licensing of Nuclear Installations [1] defines the site stage in two steps. First step is the Site License issued based on the Site Report demonstrating that a nuclear installation can be built in the site. Second step is the determination of exact values of site related design parameters to be used in proposed design of the nuclear installation and submit these values to approval of the Authority.

Upon request of APC on determination of License Conditions for the Akkuyu Site License, the Site Report, which established a basis to the license, has been reviewed. Since the report was prepared in accordance with the project considered at that time based on the site investigations performed earlier, it has been assessed that the report was not reflecting existing project and conditions, and became outdated in terms of current nuclear safety principles. Based on this assessment, the "License Conditions for Akkuyu Site License" [2] has been prepared, requiring APC to update the Site Report. APC updated the site report by performing all requested site investigations. The Updated Site Report has been submitted to the Authority for review and assessment on May 22, 2012. The Authority found some inadequacies in the report. APC submitted revised Updated Site Report [3] on June 24, 2013, which was found adequate and approved by the Authority in December 2013. Together with the approval, "License Conditions for Akkuyu Site License" [4] have been revised, including additional issued that is expected to be addressed in Site Parameter Report stage.

According to the Decree and License Conditions for Akkuyu Site License, upon approval of the Updated Site Report, APC was expected to submit the results of detailed site investigations and exact values of the site parameters that will be used in design to the approval of the Authority. APC was requested to submit a Site Parameters Report (SPR), which also includes the results of detailed site investigations, for the approval mentioned above.

The Authority is utilizing a project management approach in its regulatory oversight activities. To ensure employment of similar approaches to different activities, groups have been established to perform activities in different areas, and procedures for inspection, review and assessment have been prepared.

Table 1 Responsibilities of Site Group of ANS Licensing Project

PROJECT MANAGERS		
Mehmet Ceyhan	Head, Dept. of Nuclear Safety	
Serhat Alten	Project Manager, ANS Licensing Project	
Ali Erkan Soyer	Deputy Project Manager, ANS Licensing Project	
SITE GROUP OF PROJECT		
EXPERT	**MAIN RESPONSIBILITY**	**CONTRIBUTION**
Arif Kara	Group Leader	
Barış Güner	Deputy Group Leader Section 8 *Human Induced External Events*	Section 6*
Serhat Köse	Section 1 *Introduction*	Sections 5, 6
Gürdal Gökeri	Section 2 *Geography and Demography* Section 10 *Emergency Planning*	Section 9
Berke Sayın	Section 3 *Important facilities and Activities on Site Vicinity*	Sections 5, 6, 8
Özge Ünver	Section 4 *Meteorology* Section 9 *Radiological Effects of the Facility*	
Batuhan İşcan	Section 5 *Hydrology*	Section 6
Ayhan Altınyollar*	Section 6 *Geology, Geophysics and Seismology*	
Sibel Ünlü	Section 7 *Ecological Effects*	Section 5
Mahmut Doğan	Section 11 *Electrical Systems*	Sections 3, 8
Yusuf Gülay		Sections 2, 9, 10
Meltem Nihan Aksoy		Sections 2, 4
Burak Uçak		Sections 2, 6, 8
Rauf Terzi**		Section 5
Kevser Öney		Section 5, 6
Ezgi Tanrıkul Demir		Section 9
Tüm saha grubu	Section 12 *Additional Information*	
Tüm saha grubu	Section 13 *List of Site Related Design Parameters and Exact Values*	

*Responsibilities of Ayhan Altınyollar have been taken on by Barış Güner

** Rauf Terzi left the DNS prior to completion of review and assessment

In this respect, regulatory control of the siting activities prior to construction license application were performed by the Site Group of the project, in accordance with responsibility distribution given in Table 1. This group also constitutes to the working group for communicating siting issues with APC. The expectations of the Authority and the relevant requirements on siting have been communicated with the APC in this working group.

Regulatory activities of the Authority have been supported by procurement of external expert services as advisors, and by independent review of the submission by international experts under the coordination of International Atomic Energy Agency (IAEA).

Table 2 Advisors and Contribution Areas

ADVISOR	UNIVERSITY	CONTRIBUTION AREAS
Prof. Dr. Mehmet Ekmekçi	HU	Hydrogeology, Hydrology, Dispersion of radioactive materials
Prof. Dr. Nuretdin Kaymakçı	METU	Geology, Seismology
Prof. Dr. Selahattin İncecik	ITU	Meteorology, Atmospheric dispersion
Prof. Dr. Kemal Önder Çetin	METU	Seismic hazard analysis, Geotechnics
Assoc. Prof. Dr. Zeynep Gülerce	METU	Seismic hazard analysis

First version of the Site Parameters Report has been submitted on November 26, 2014. A control on sufficiency of the application have been performed on the report by the site group members. The submission has been found inadequate in format and content [5], and APC is requested to resubmit the report by providing the missing information and references and emending the non-compliances to

format requirements, for initiating the detailed review and assessment. Additionally, APC has been notified that the site parameters shall not be approved unless hydrogeological studies are completed to the satisfaction of the Authority.

APC has resubmitted the first version of Site Parameter Report (SPRv1) [6] on December 23, 2014, emending the format non-compliances. Even though some additional information has been provided in this version, it has been found deficient in some information and references, but decision was made to initiate the detailed review and assessment, expecting that deficiencies in information shall be solved during the review and assessment process.

Findings of review and assessment of SPRv1 have been managed by a database, which was shared with APC in working group meetings and by electronic means. Answers to findings were also managed using the same database. The second version of SPR (SPRv2) [7] has been submitted to the Authority at the end of December 2015 revised based on the findings. Further revisions were found necessary in various chapters upon review and assessment, and they were implemented into the SPR without increasing the version number. The third version of SPR, submitted on December 30, 2016 prior to full implementation of revisions, was not reviewed, and this revision is not referenced in following sections of this report on review, assessment and evaluation. Instead, the Authority preferred to continue with working group meetings for developing solutions to findings. The review and assessment of fourth version of SPR (SPRv4) [8], submitted on January 31, 2017 after implementing all revisions, has established the basis for evaluations given in this report.

1.2. Regulatory Basis for Review and Assessment

The main provisions regarding the siting of an NPP are in the Decree on Licensing of Nuclear Installations [1]. Second section of first chapter of the Decree includes the provisions on licensing of sites in which an NPP will be built. Fourth paragraph of Article 12 of the Decree, titled “Issuance of the site license”, states that:

> *“Following the receipts of the site license, the applicant … may perform the detailed site investigations and submit their results and the final values of the site related design parameters to Authority for approval prior to the application for construction license.”*

The second paragraph of Article 5 of the “License Conditions for Akkuyu Site License”, notified to APC with the approval of the Updated Site Report of Akkuyu site, states that the license holder:

> *“a) Shall continue with the detailed site investigations to determine the site related design parameters in accordance with fourth paragraph of Article 12 of the Decree, taking into account the experience gained in nuclear safety including the lessons learned from the Fukushima accident occurred on March 11, 2011 in Japan,*
>
> *“b) Shall determine the results of the detailed site investigations on NPP site and exact values of the site related design parameters, and submit the Site Parameters Report to approval of the Authority. It is ensured that the report contains the additional information (App. 1) listed in Site Evaluation Report of DNS and requested to be included in SPR.”*

The additional information to be included in SPR in accordance with the License Conditions are:

1. Detailed information on estimation of population changes, and on gaseous and liquid discharge points during normal operation,
2. Estimations on industrial development in site vicinity,
3. Results of the determination and analysis of land-sea breezes,
4. Probability calculations and impact analyses of external events,
5. Information on petroleum transport on sea routes beyond 10 km radius,
6. Determination of releases during normal operation of radioactive waste facility to be built on site, and discussion of doses from this source, and
7. Utilization of an atmospheric dispersion model, which takes into account the topographical conditions, breeze effect and wet deposition in detailed analyses of radiological consequences.

The general provisions on NPP sites, on the other hand, were laid out in the Regulation on NPP Sites [9]. Format and contents of the report to be prepared by an applicant for implementation of the Regulation have been given in a guideline [10].

In addition to these regulatory documents, two regulations from the Russian Federation [11, 12], IAEA safety requirements NS-R-3 “Site Evaluation for Nuclear Installations” [13], and Guideline on Specific Design Principles [14] were considered during the review and assessment.

Based on necessities, IAEA, Russian Federation or a third-party country guideline were also utilized for specific issues or analyses, and such documents were referenced in relevant sections.

1.3. Objective and Scope of Site Parameters Report

The Authority reviewed and approved the Updated Site Report, which establishes the basis for Akkuyu Site License. As the next step, the Authority expects APC to determine the site related design parameters and their definitive values through detailed site investigations, and to submit them to the approval.

As an international approach, design of an NPP is ready in general and this design is customized with the site characteristics and requirements laid out by the owner. APC proposed the Novovoronezh 2 as generic design for Akkuyu NPP and the Authority accepted this proposal. However, this design needs considerable customization for it was built in a respectively low seismic area along a river. To perform this customization, seismic, meteorological and geological characteristics of site need to be determined with certain precision.

In this respect, APC shall prepare the SPR to contain much more details, introducing the characteristics of site that may affect the design of NPP and including the explanations with justification on measurement or calculation methodology, and definitive values of these parameters. In this respect, the Authority determined the expected format and content of the SPR based on the relevant guidelines [10] to contain all necessary information to perform the review and assessment, and communicated to APC.

Site related design parameters displays a spectrum from numerical data to tables or to issues to be followed during the design and construction. Relevant chapters of the SPR covers the calculations and/or analyses to derive the definitive values of these parameters, and Chapter 13 of SPR compiles the definitive values.

Section 2 Site Visits and Inspections

Since the submission of the updated site report in May 2012, APC performed various site investigations under the regulatory control of the Authority. Within the scope of approval of site parameters, the Authority carried out eight inspections and nine technical visits to the site (Table 3).

Objectives of the inspections are to monitor and determine that the site investigations are performed within the scope of a quality management system, and activities are in line with the provisions of the regulatory basis. On the other hand, the Authority arranged technical visits to site in order to be informed about site activities that are not important for safety, in accordance with the project schedule of the APC. During technical visits, experts of the Authority monitored the activities on site and informed APC representatives about expectations of Authority, if needed.

Table 3 Inspections and Technical Visits within the Scope of SPR

Date		Subject
2012	June 27-29	2012-ANS-01: Inspection on meteorology, hydrology, hydrogeology, geoteknik, geodesy, geophysics and quality management
	Sept. 17-20	2012-ANS-02: Inspection on hydrology, hydrogeology, boring, ecology and quality management
	Oct. 05-06	Technical visit, terrestrial and marine ecology investigations
	Oct. 18-19	2012-ANS-03: Inspection on boring, meteorology, emergency planning and quality management
2013	May 16	Technical visit, site activities
	June 27-28	Technical visit, seismology, layout and site preparation
2014	April 17	Technical visit, site activities
	May 20-21	2014-ANS-NG.01: Inspection on Akkuyu Nuclear JSC office in Ankara
	Oct. 1	Technical visit, Hydrogeological conceptual model development
2015	March 19	Technical visit, site activities
	April 16-17	2015-ANS-01: Inspection on hydrogeological investigations and tests
	April 28	2015-ANS-02: Inspection on meteorology
	April 28-29	Technical visit, site activities
	May 13-14	Technical visit, site activities
	May 25-28	2015-ANS-03: Follow-up inspection on hydrogeological investigations and tests
	July 13-14	2015-ANS-04: 2nd follow-up inspection on hydrogeological investigations and tests

2.1. Inspections and Visits in 2012

In 2012, after the submission of Updated Site Report, the Authority inspected the Akkuyu site activities three times and performed a technical visit for regulatory oversight.

First inspection, carried out in June 27-29th, was on the meteorology, hydrology, hydrogeology, geotechnical, geodesy, geophysical activities and quality management [15]. A team of seven experts of the Authority and three advisors inspected the site activities, found discrepancies in quality management, inadequacy in hydro chemical sampling methods and in works on level determination and sampling for groundwater, and insufficient sampling in meteorology. Team did not file non-compliance report, but notified the APC representatives about the findings in closure meeting of the inspection.

Second inspection, carried out in September 17-20th, was on hydrology, hydrogeology, borings, ecology and quality management [16]. A team of five experts from the Authority and two advisors carried out the inspection, including the follow-up of findings of previous inspection. The inspection team has identified that the corrective actions for findings has been carried out. Additionally, team identified further inadequacies in calibrations and precision in hydrologic and hydrogeological

measurements, in records of terrestrial borings, in procedures for marine borings, and inadequacies and mistakes in preservation of ecological samples, but did not file any non-compliances. The team notified the APC representatives about findings in closure meeting of the inspection, and requested corrective actions.

Authority experts visited the site in October 5-6th, to gather information about the activities on data collection regarding the terrestrial and marine ecology. Main objectives of the study was to identify the flora and fauna and reference levels. Team has gathered information on sampling methods, measurements, and parameters used in the study. Team recorded their observations in the mission report [17].

Third inspection of the year, carried out on October 18-19th by a team of four experts from Authority, was on borings, meteorology, emergency preparedness and quality management [18]. The team found out that the boring activities were completed and samples were stored, and discussed the storage conditions and durations with the APC representatives. Team also found out that the meteorological data collection was completed, and inform the APC representatives that they need to initiate the analyses. Team identified that there is no need to approach the facility to evacuate the housings of the workers in case of an emergency as stated in the Updated Site Report, and notified the APC representatives.

2.2. Inspections and Visits in 2013

The authority experts visited the site in 16th of May regarding the site activities. Main objective of the visit was information exchange on current site activities and planned activities for near future. The team observed the environmental monitoring, seismic measurements and paleo-tsunami studies currently going on, and identified inadequacies in notification of the Authority about and quality management of the activities [19]. The team communicated these observations with the APC representatives in working group meetings, requesting better management of notification process.

Similarly, the Authority experts visited the site in 27-28th of June regarding the site activities [20], determining continuing studies such as environmental monitoring, seismic monitoring, and studies related to layout and roads and fresh water within the scope of site preparation.

2.3. Inspections and Visits in 2014

The Authority experts visited the site in 17th of April regarding the site activities [21] gathering information on continuing monitoring activities and studies on fresh water supply within the scope of site preparation.

In May 20-21st, six experts from the Authority inspected the headquarters of Akkuyu Nuclear JSC in Ankara [22]. Main objective of the inspection was to audit the quality management system of the APC. The team has filed non-compliance reports for nonexistent procedures of the management system and for not implementing any self-assessment of the management system.

In 1st of October, a team of three experts from the Authority visited the site for observing the studies on hydrogeological conceptual model development [23]. The team has exchanged of information on current activities on the subject, and determined the status of the hydrogeological studies and related conceptual model development.

2.4. Inspections and Visits in 2015

The objective of the technical visit of two experts on March 19th was to determine the status of site activities. Observations made on fire roads within the site and status of other activities [24].

In April 16-17th, five experts from the Authority and two advisors inspected the hydrogeological studies on site. Based on the findings of the inspection, non-compliance reports were filed on [25];

1. Lack of contract with the company which performs the hydrogeological studies and tests,
2. Incomplete quality plan of the subcontractor
3. Insufficient details on procedures and implementation of work non-compliant with referred standards,
4. Lack of monitoring and inspection of APC, and
5. Lack of quality plan of second subcontractor.

Additionally, no APC representative were present on site to liaise regarding the findings of previous inspection, and 16 more issues that may cause complications with respect to results were identified. The team notified the APC representatives about findings and non-compliances in closure meeting of the inspection and with an official letter, requesting the corrective actions.

A team of two experts from the Authority inspected the meteorological data collection activities on 28th of April [26]. Team visited the meteorology stations and audited the quality procedures. Team has identified that the ownership of the stations belongs to the subcontractor and quality documents and procedures for stations and data collection were not on site. The team did not file any non-compliance but notified the APC representatives about findings in closure meeting of the inspection.

A team composed of two Authority experts visited the site on April 28-29th regarding follow-up of hydrogeological studies [27]. The team determined the status of the hydrogeological studies, inquired about the corrective actions of previous inspection, and observed the ongoing activities. The team identified that the hydrogeological studies are on schedule and some findings of the inspection were already remedied.

On the other hand, another team of two experts found out in a technical visit on May 13-14th, that there are some delays on studies because of the signature of contract between the APC and the subcontractor [28].

A team of five Authority experts and an advisor performed first follow-up inspection on hydrogeological studies on May 25-28th [29]. The team inspected the ongoing processes and audited the corrective actions on con-compliances identified in previous inspection. Inspection team found out that APC properly addressed all non-compliances, except the corrective action regarding fourth non-compliance listed above needs further arrangements. The team agreed on closure of non-compliances and found the remediation of APC regarding other findings of previous inspection adequate.

A team of three experts and an advisor performed the last inspection on hydrogeological studies on July 13-14th [30]. Based on inspection findings, the inspection team identified six suggestions mainly on issues regarding reporting of the results, and did not file any non-compliance. These suggestions were later notified to APC in writing.

2.5. Evaluation and Results

The Authority ensured the regulatory oversight on site preparations and detailed site investigations for determining definitive values of the site related design parameters carried out by APC through inspections and technical visits. The main concern arose in these activities was the preparation of quality documentation towards the end of the activity, in accordance with the Russian regulatory approach. Since our regulatory system envisages the implementation of an activity in accordance with a quality plan prepared prior to the implementation, inspection teams identified several findings and filed non-conformances regarding this issue, notifying APC to comply with the our system. Even though APC took corrective actions and remedied the non-compliances, a general solution by APC is yet to be developed.

Section 3 Review and Assessment Activities

According to the DNS procedures, the review and assessment activity is composed of two stages. Firstly, application is controlled for sufficiency. The purpose of this control is to identify if there is a missing application document, and if the documents comply with the relevant format and content requirements. The detailed review and assessment is initiated only if the application is found to be sufficient.

3.1. Sufficiency Control of the Application

The first version of the Site Parameters Report, submitted on November 26th, 2014, controlled on sufficiency of the application based on the format and content determined by the Authority. The submitted documents have been found inadequate in format in the level that would require resubmission [5]. APC has been requested to resubmit the report by emending the non-compliances to format requirements, and providing the missing information and references and for initiating the detailed review and assessment. Additionally, APC has been notified that the site parameters shall not be approved unless hydrogeological studies are completed to the satisfaction of the Authority.

APC has resubmitted the first version of Site Parameter Report (SPRv1) on December 23, 2014 [6], emending the format non-compliances. Even though some additional information has been provided in this version, the report has been found deficient in some information and references, but decision was made to initiate the detailed review and assessment, expecting that deficiencies in information shall be solved during the review and assessment process.

3.2. Review and Assessment

Upon accepting the SPR, the project team has initiated the planned activities. SPR has been communicated to the members of the ACNS and to the IAEA experts for reviewing against the IAEA safety requirements and guidelines. Concurrently, the in-house review and assessment has been initiated in DNS. Members of the ACNS has reviewed the SPR and reported their findings to the Authority.

SPR has been reviewed and assessed by the site group of the ANPP licensing project and independently by the IAEA experts. Details of these review and assessment activities are given below.

3.2.1 Review of ACNS

The project team has provided the SPRv1 to the ACNS members, requesting their opinion on the report. The members of the committee reviewed the report, had a meeting on March 16th, 2015 to discuss their findings and reported them to the Authority [31].

ACNS reported that the SPRv1 has not have minimum quality that a report must have, difficult to read, understand and follow, and hard to reach to information sought. ACNS stated unanimously that an effective review and assessment of the report is very difficult and it should firstly be emended in accordance with their comments to improve the readability and understandability.

ACNS stated that the APC need to be notified about expectations on reporting quality, consistency and assiduity, and pointed out to the difficulties to rectify inadequate and inconsistent reports, prepared by different people for different chapters without due diligence. ACNS also

mentioned that they had identified and reported the same problem in Updated Site Report and the problems listed for that report were repeated in SPRv1, exceedingly.

ACNS noted that, in their opinion, the report need to be elaborated considering the comments provided by the committee, emending the mistakes and providing for the absent information. ACNS also noted that the Committee, having a report of almost 1300 pages without any appendix, could not perform a thorough review, and that each member reviewed the chapters relevant to their expertise to the extent possible only. Additionally, ACNS emphasized that the Committee did not perform any verification on parameters and findings, and hence, implementing the comments would not mean acceptability of the report, but only means resolution of some generic problems.

ACNS provided general inconsistencies, deficiencies and mistakes as appendix 1, their opinion on specific chapters as appendix 2, and some examples of issues given in appendix 1 as appendix 3 of their report, stressing that the list for corrections in appendix 3 is not exhaustive.

The opinion of ACNS, particularly the ones given in appendix 2, were addressed in Section 4 of this report under relevant subheadings.

3.2.2 IAEA Review

The Authority cooperated with IAEA for an independent review of submission against compliance with the IAEA safety requirements that are in the licensing basis.

A SEED (Site and External Events) Review mission was requested from IAEA Seismic Safety Center within the scope of technical cooperation for review of SPR. SPRv1, together with its appendices and references, were shared with IAEA, and reviewed by an IAEA team of six experts.

IAEA experts shared and discussed their findings with Authority's experts in a meeting held in Vienna on February 18-20th, 2015, which are mainly concentrated on:

a) Meteorology and dispersion of radioactive materials in air and water,

b) Hydrogeology including meteorological and flood hazards,

c) Geology, seismology and seismic hazard analysis,

d) Geotechnical hazard analysis, and

e) External events and industrial facilities and activities in close vicinity.

The findings and suggestions of IAEA team were in-line with the findings of site group review and detailed information was provided in IAEA mission report [32]. Site group has incorporated these findings and suggestions in their review and assessment.

3.2.3 Review and Assessment of DNS

The site group (Table 1) of the project team carried out the review and assessment on behalf of the Authority. Within the scope of the project, external advisory services of academicians (Table 2) were provided for the site group. Advisors worked together with the Authority experts during review and assessment, and participated in working group meetings with APC and in site inspections and technical visits of the authority. Since the advisors are directly involved in the review and assessment process, they were not expected to report their findings separately. Review and assessment reports of the site group members were prepared with due consideration to the Advisor's suggestion.

The team communicated their findings and results to the APC through working group meetings and via electronic mail, instead of formal additional information requests used in previous stage, reckoning that it would lead to faster solution.

In first working group meeting on January 20-21st, 2015, the team shared approximately 500 preliminary findings on SPRv1 [6] that would improve the efficiency of the review and assessment. These findings were, in general terms, on:

a) Shortfalls from the objective of the report – inadequate demonstration, absence of a system, and absence of graded approach,

b) Non-consideration of regulatory hierarchy,

c) Inconsistencies among the chapters and with the Updated Site Report,

d) Illegibility, inconsistency of with the text and untraceable presentation of non-text elements such as maps, cross-sections and figures, etc., and

e) Low quality English and use of non-standard terminology.

The team held many working group meetings with the APC representatives and experts, details of which were given in Section 4 of this report regarding the review and assessments.

The site group reviewed and assessed the SPR to identify:

a) The sufficiency of provided information,

b) Compliance with the regulatory documents listed in licensing basis,

c) Adequacy of detailed investigations in terms of model, methodology, measurements and analyses,

d) Acceptability of parameters and their definitive values, and

e) Compliance of the Report with the findings of inspections carried out during the site activities and License Conditions of Akkuyu Site License.

The site group requested an update of the SPR from APC based on the findings of review and assessment. The group also reviewed and assessed the second [7] and forth [8] versions of SPR in similar manner.

During the review and assessment process, inspection reports, minutes of working group meetings and mission reports of technical visits were the records kept. Review and assessment activity has been documented in three levels. Site group members prepared a Review and Assessment Report for each chapter of the SPR using a predefined format. Group leader prepared a compilation report on activities, attaching the Review and Assessment Reports.

This report, Safety Evaluation Report on SPR, was prepared based on the group report [33] and its attachments, and mission and inspection reports, for establishing the basis for the approval of the Authority.

3.3. Problems Encountered in Review and Assessment Process

Similar to the Updated Site Report stage, unavoidable translations in communication, and information and document exchange with the APC led to considerable loss of information and time. All documents/information produced by the Authority were translated to Russian, and all documents/information prepared by subcontractors such as designer, etc., were translated to English from Russian. Considerable amount of valuable information and detail were lost during these translations.

Opting for the communicating the findings and developing solutions in working group meetings led to two problems. First problem was the discontinuity in participation of APC experts directly responsible from the issue under discussion to the working group meetings. The same issue had to be communicated to different experts of APC, repeatedly, and while expecting a solution to an issue, finding a new counterpart in meeting caused considerable time losses. Second problem was the official recording of the findings and solutions proposed by APC.

Section 4 Site Parameters Report and Its Review and Assessment

For the Authority, Site Parameters Report shall contain the detailed site investigations carried out by APC, the results of these investigations and the definitive values of the site related design parameters, demonstrating that these values sufficiently reflect the parameters taken into account in design of the proposed installation. In this respect, the Authority notified the APC at the site report stage about its expectations on submission of site parameters in an additional chapter of the Site Parameters Report in accordance with the relevant guideline [10].

Site parameters are used for the customization of generic design, ensuring the consideration of impact of the site in design and safe construction and operation of the installation at this specific site. For this reason, the site group reviewed and assessed the SPR comprehensively in the light of current regulations and nuclear safety principles. The review and assessments given in this section includes all relevant activities starting from first version of SPR. The evaluations and conclusions are based on the review and assessment of the SPRv4 [8] submitted on January 31, 2017, and given in subsections organized according to the chapters of SPR.

4.1. Introduction

Information on description of site and installation to be built on site, alternative layouts, and APC and its subcontractors should be provided in this chapter.

4.1.1 Information Provided in SPRv1

SPRv1 [6] states that four units of VVER-1200 reactors based on AES-2006 design shall be built on site, and Novovoronezh-2 NPP (V-392M design of VVER-1200) is the reference plant for ANPP, and provides general information on ANPP design as V-509 design of VVER-1200.

The report states that the Akkuyu Nuclear JSC is the project company, and shall procure all services, including scientific, research, design, engineering and equipment manufacturing services from main Russian companies Rosatom, Atomstroyexport and InterRAO. The report identifies the Atomenergoproekt as main service provider on design, scientific research and inspection activities for ANPP, also coordinating the site activities, managing and inspecting these activities and monitoring the site activities carried out by Turkish subcontractors such as ENVY. Additionally, it is stated that Worley-Parsons and InterRAO-WorleyParsons companies are utilized as advisors to the APC in site activities since 2011.

APC explained two alternative layouts in the report, identifying the chosen one with justification. Additionally, APC provided general technical characteristics of site and the installation under subheadings of the chapter.

4.1.2 Review and Assessment of SPRv1

Based on the review and assessment, the team determined that the layout alternatives and final layout are consistent with the information given in updated site report. However, the team also determined that some information was absent, such as total area of site, maximum heights of some structures, etc. as requested in guidelines [10], and that there are inconsistencies in information provided in this chapter with the rest of the report and/or with the updated site report [34].

Team communicated the findings on this chapter in working group meetings with APC, and requested providing of necessary information, and resolving of inconsistencies. There was no suggestion from IAEA mission or inspection findings on this subject.

ACNS has pointed out general format and language problems regarding this chapter, and their comments were communicated with APC.

4.1.3 Review and Assessment of SPRv2

The team has reviewed and assessed the SPRv2 [7], and found that the absent information were provided while the inconsistencies were resolved, and the chapter complies with the regulatory requirements.

4.1.4 Conclusion

The team has found this chapter acceptable after the inconsistencies and format problems were resolved. The team also reviewed the final version, SPRv4, determining that there is no further amendments to the chapter after SPRv2. Hence, the team evaluated the chapter as sufficient without any unresolved issues.

4.2. Geography and Population

Information on the location and ownership of the site, emergency planning zones, and population and land use around the site should be given in this chapter.

4.2.1 Information Provided in SPRv1

APC described the location of site providing maps showing its near and distant vicinity in SPRv1 [6]. Geographical description of site was given in regional and local maps, identifying the facilities in close vicinity. The only highway was identified as D400 around the site.

Regarding the land use, agricultural, husbandry and fishery activities were introduced with a land use map. The villages focused on husbandry and number of livestock were given, stressing that the preference was breeding sheep and goat. It is stated that there are 10 fishery centers and cooperatives, and that they provide for the approximately half of the demand of the township, while providing information on 2011 yield, and species that are fished or produced most.

APC provided information on the paths of exposure to radiation from the radioactive effluents released during the normal operation. It is stated that the main sources of potential exposure would be the gaseous releases during normal operation or accidents, asserting that the radioactivity levels in discharge water to sea shall not exceed the standards for drinking water.

Information on population around the site and development predictions were provided regarding the emergency planning zones, zone with 20 km radius and population centers. The radius of the emergency planning zones, referencing the chapter nine of the report, was given as approximately 5.4 km, stating that there are Büyükeceli, Koçaşlı ve Yanışlı villages in addition to settlement for the installation personnel. The total permanent population of the zone is given as 1290, providing information on sectorial population distribution. It is predicted that the population may reach to 8100 with the construction and operation personnel.

Regarding the 20 km zone, the land is shared by Gülnar, Aydıncık ve Silifke townships, and it is stated that approximately one eighth of the total population of these townships live in this region,

providing predictions on population growth. Additionally, nomadic population were provided based on Yörük tribe. While Yörüks live outside of 20 km zone, they might increase the population by at most 1200 in the zone if they migrate.

4.2.2 Review and Assessment of SPRv1

Upon review and assessment of the SPRv1 [35], the APC has lost the authority of use of site since the duration of authorization was expired.

Inconsistencies were identified by the team in information provided in this chapter with other chapters of this report and the updated site report. The team queried the deliberation of wheat as most yielded agricultural product in the region, while citrus fruits are expected to be the one. Additionally, team identified that of some information on population and predictions are absent, some schools, health centers and dairies were not shown in maps, and locations of releases in normal operation were not given.

ACNS pointed out the inconsistent information on radii of emergency planning zones in different chapters of the report. They also called attention to the issue of additional population increase by doctors, barbers, butchers, waiters, etc. that would migrate in to the zone with the increase in population by installation staff and their families.

IAEA has not laid a suggestion regarding this chapter, and no inspection findings was recorded. Team communicated the findings on this chapter in working group meetings with APC, and as a table in electronic form in early 2015.

4.2.3 Review and Assessment of SPRv2

With SPRv2 [7], APC provided the extension on authorization of use of site, closing the finding. The inconsistencies regarding the dimensions of emergency planning zones were resolved by addressing the dimensions given in chapter nine of the report. Additional information provided on population and predictions as requested, resolving inconsistencies and ambiguities, hence the team closed this finding.

APC also provided estimated locations of gaseous and liquid releases in normal operation and predictions on population growth as requested by findings and in License Conditions for Akkuyu Site License, and as given information found satisfactory, the issues were closed.

4.2.4 Conclusion

Team determined that all issues raised regarding this chapter have been closed, and concluded that the information is satisfactory and in compliance with the regulations. The SPRv4 reviewed to ensure no further information were given for assessment, and team determined that the information provided in this chapter is satisfactory [35].

4.3. Nearby Industrial Installations and Activities

The all industrial installations and activities that may affect the NPP including pipelines, sea routes and air corridors, their potential impact on the NPP and predictions of nearby industry are expected to be given in this chapter.

4.3.1 Information Provided in SPRv1

In SPRv1 [6], APC provided information on sea routes, railways and highways in close vicinity, stated that there were no industrial installation or oil pipeline within 10 km radius, or no plans of such. APC also stated that there are no civil or military airports in the vicinity, or air field or air traffic stations. It is stated that there are 13 mining site with exploration/production permit with one in production, and a stone quarry in Koçaşlı. In three mining sites, activities were planned for exploration. It is stated that there are two gas stations in Büyükeceli and Yanışlı, and being behind the hills, they would not affect the site.

Closest airports were given as Adana at 180 km east and Gazipaşa at 110 km west of site. Information was provided for civil air corridors within 100 km, and flight altitudes, and types of plane using these corridors. Additionally, it was mentioned that there are military air corridors within 39 km radius. According to the information provided, there are W84 and UW84E routes at 1.34 km, T38 and UT38 routes at 6.8 km, N135 and UN135 routes at 7.5 km and A-5 and A-6 corridors within 8 km.

APC stated that there is no sea transportation or transport of dangerous goods by sea within 10 km from the site. It is stated that there is no coastal facility other than fishery bays in Yeşilovacık at 11/8 km east and at Aydıncık at 19.5 km west. Boats were moored at Yeşilovacık fishery harbor.

4.3.2 Review and Assessment of SPRv1

In review and assessment of this section, the IAEA safety guide NS-G-31 (App. I) on human induced external events has been used in addition to general reference regulatory documents.

The team has determined [36] that there is not enough explanations regarding the mining sites, are inconsistencies and non-compliances with the regulations in given flight routes and is not enough predictions on industrial development as required by the License Conditions of the Akkuyu Site License.

There are no IAEA or ACNS opinion or suggestion, or inspection finding regarding this chapter.

Findings were communicated with APC in working group meetings and in electronic table form.

4.3.3 Review and Assessment of SPRv2

Upon review and assessment of SPRv2 [7], the team determined that the maps provided for further explanation of mining site is adequate, inconsistencies in flight routes were resolved and industrial development predictions were made based on the Environmental Plan (1/100 000 scale), and given in the report. The team evaluated [36] that the information provided complies with the regulations except one issue on flight routes.

4.3.4 Conclusion

The review and assessment of this chapter has been finished with SPRv2, and provided information was found adequate. SPRv4 has also been reviewed [36] to identify any further issues, and found satisfactory, except a non-conformance about flight routes.

Regarding the flight routes, in contrary to Article 10.1.b of Guidelines on Specific Design Principles [14], the W84 and UW84E routes are passing at 1.34 km of the site. APC could only receive an agreement on no further flight routes shall be planned on the 5 km radius from the reactor, as it was requested in the above mentioned guideline. It is understood from the information provided that the issue could only be addressed in time. Since the changing the routes of these flight corridors need

to be implemented prior to the fuel loading, the Authority will follow the activities of APC on this issue at later stages.

4.4. Meteorology

The meteorological data, short and long-term atmospheric dispersion analyses, extreme values of meteorological parameters and potential meteorological events were expected to be provided in this chapter based on the regional, local and on-site scale, with more in details for the latter.

4.4.1 Information Provided in SPRv1

In SPRv1 [6] regional macro climate properties were given based on the 30 year long data gathered from Anamur and Silifke stations, and 30 years average and extreme values of meteorological parameters based on the Mersin station. Additionally, site-specific data were provided from the on-site station. Based on this information provided from these sources, local data on primary wind directions and speeds, humidity ratios, precipitation types and amounts, cloudiness, air temperature and pressure were given.

Meteorological characteristics of site were based on the data collected from 60 m station, 10 m stations of İnceburun and of one by gate, and SODAR-XFAS system. İnceburun station was moved to Kocaşlı, 2 km inland from NPP on June 16, 2014, to represent the local meteorological conditions and initiation of preparatory activities where the station was located. From the information gathered from this station, site specific solar radiation, wind, mixing layer height, atmospheric stability, vertical temperature profile and humidity values.

Describing the region and introducing the calculation methodology, parameters of the short and long-term atmospheric dispersion analyses were derived, and calculation results were provided for dispersion of normal operation effluents and short-term dispersion.

Regarding the extreme meteorological events, fog, hail, icing, thunderstorms, sand storms and tornados were considered, and detailed investigations were carried out taking into account the occurrence frequency and the importance of the event.

Considering all meteorological data, studies for determination of extreme values of the meteorological parameters were carried out and results are presented.

4.4.2 Review and Assessment of SPRv1

During the review and assessment of this chapter, IAEA guidelines SSG-18 on meteorological hazards, NS-G-3.2 on population and dispersion of the radioactive materials and a few regulatory documents of Russian Federation. A list of these regulatory documents was given in Appendix I.

Based on the review and assessments, the team determined [37] that the given climate classification of Turkey based on the Russian standard GOST 15150-69 does not reflect our country properly, quality of local meteorological data was not studied enough, the data from Tarsus meteorology station are not used even though stated in the report, and data on solar radiation and wind are not sufficient.

The team also determined that the site-specific data are not up to date and the pressure and precipitation data are absent. The on-site data have been compared with the data from nearby stations to determine the representation of the long-term characteristics only for the temperature but not for

the other parameters used in dispersion models. The team identified various inconsistencies in information provided and discrepancies in comparison durations of meteorological parameters.

It is determined that the topography was not sufficiently considered in atmospheric dispersion analyses. Reference data for the flat terrain given in guidelines were used, and topographical effects considered only for the wind. The deposition and breeze effects were not considered as requested in the License Conditions for Akkuyu Site License. Additionally, inconsistencies were identified between the information provided in this chapter and chapter nine, and while three alternative calculations were provided, APC has not stated which one is preferred and why.

The software used for calculations for normal operation has been found inadequate for predictions, and different from one used in chapter nine, where they were expected to be the same regarding that they serve the same purpose. Models without dose calculations were used for the normal operation and dispersion calculations of non-radiological effluents were given in the report.

The information provided about the hail, icing and sand storms were found to be not complying with the SSG-18 of IAEA, justification of tornado scale was found insufficient. Tornado based design parameters were found to be not complying with IAEA with insufficient justification.

The team determined that no correlation was performed on long-term data for representation of site in calculations of extreme values of the meteorological parameters, and that there are inconsistencies between the Russian Federation regulation referenced for calculation method for the extreme values and data duration with the relevant Turkish regulation [9] and SSG-18 of IAEA.

Team also identified considerable amount of data inconsistencies, absence of textual description of data provided in tables, and grammatical errors causing misunderstandings.

Within the scope of this chapter, ACNS pointed out that the wet deposition was not considered in atmospheric dispersion models, and that it should be taken into account.

The findings were communicated with the APC in various working group meetings and provided to APC in electronic table form as usual approach.

4.4.3 Review and Assessment of SPRv2

Results of review and assessment [37] on SPRv2 can be discussed in three groups. Some of the findings were resolved by the APC and issues were closed. However, there were still some findings yet to be resolved and there are new findings on new information provided by APC.

Climatic classification of Turkey, most of the findings regarding the local meteorology, justification of tornado scale and having out of date meteorological data of site were among the important issues that were resolved and closed. Findings regarding the short and long-term atmospheric dispersion analyses were among the issues that are yet to be solved.

By review and assessment of SPRv2, the team determined that long-term data from Mersin station were listed in the report to support local meteorological data, even though Mersin station is not acceptable because of being at a long distance from the site. Mersin station is not among the stations that represents the site.

The team determine that the references of the meteorological conditions of the site were not provided yet, and the information provided were not the justified. In addition, the discussion on site-

specific data representing the long-term characteristics, and discrepancy in data collection periods of data set compared with each other are not resolved. The APC has not identified which methodology of two provided for the determination of the atmospheric stability characteristics of the site that they chose and why.

Discrepancies in atmospheric dispersion model used in this chapter and chapter nine still need to be explained.

APC has not clarified why the maximum velocity of hail is not among the site related design parameters of meteorological events.

Regarding the extreme values of the meteorological parameters, the issues that remain open are inconsistent information on the use of gust velocity as maximum wind in accordance with SSG-18 of IAEA, updating of statistical analyses with longer data period, description of reliability for derived extreme values, and justification of information provided for persistence of extreme temperature values. Additionally, it has been determined that finding on correlations regarding long-term data representing on-site characteristics were not reflected to the report even though it was resolved during the working group meetings.

4.4.4 Review and Assessment of SPRv4

Since the some of the findings were not resolved during the interim revisions of the chapter, SPRv4 was subjected to additional review. With SPRv4, most of the remaining issues were closed.

During the process, unused information given in short and long term atmospheric dispersion analysis were removed from the text, information provided was restructured as requested with due consideration to chapter nine. Furthermore, inconsistencies on data and information with chapter nine were emended and extreme velocity for hail was given in relevant section. Since it was specifically stated that the hail is not a design parameter for the plant, the issue was closed.

On the other hand, APC shall develop atmospheric dispersion models for accident conditions with plant parameters and better representation of site, including the re-determination of χ/Q values further away from 5 km. The team has identified discrepancies in daily changes of mixing level height.

4.4.5 Conclusion

Team has evaluated that the information provided in chapter four of SPRv4 is adequate for this stage and complies with the regulations [37]. Additionally, team agreed that some information can be provided with PSAR for they are not site related design parameters or used for derivation of such a parameter, which are:

- Provision of daily change of mixing level height, and
- Developing atmospheric dispersion models for accident conditions with plant parameters and better representation of site, including the re-determination of χ/Q values further away from 5 km.

The Authority will follow up these issues at later stages.

The team also determined that the site related design parameters developed or derived in this chapter are consistently reflected in chapter 13 of the report.

4.5. Hydrology

APC is expected to provide information on general hydrological characteristics of region, site and its environs, dispersion of radioactive materials in groundwater, sufficiency of water sources, hydrological events such as land or marine based flood, and water basins around the site.

4.5.1 Information provided in SPRv1

With SPRv1 [6] APC provided information on groundwaters, groundwaters, water sources for use and drinking, and defined the water need of ANS project for use and drinking, and as cooling water.

Information provided on five dry creeks as temporary streams of Akkuyu site, and fresh water sources in close vicinity of Akkuyu site. Sipahili creek is the closest permanent stream to Akkuyu site. Total groundwater capacity of closest streams, the Büyükeceli and Sipahili creeks as were calculated. It has been stated that the Sipahili creek would not affect the site since its basin is separate from the site in terms of physical and hydrological characteristics. On the other hand, Sipahili creek was not considered for use in ANS due to its distance (7 km) to construction site. Mediterranean Sea was considered as the source for technical usage. Total cooling water taken away from the sea and discharged back is around 1,090,000 m^3/hr. Sipahili creek and a desalinization facility is considered as drinking water source.

Within the scope of dispersion of radioactive material in marine environment, information is given regarding the water sources containing radionuclides, characteristics of waste water and properties of neutralization system. Additionally, information provided on gaseous and aerosol releases to groundwater in normal operations, models on dispersion of radionuclides in groundwater, radionuclide content analyses of different mediums, such as filtered water, suspended particulates, sediments in seabed, and coastal sand, and radiation effects of ANS on wetlands.

Changes in sea level were also studied, estimating a 7.2 mm raise per year based on the observations. Extreme value analyses were performed for minimum and maximum sea level after determining the reference level. For exceeding probability of 1 %, 0.1 % and 0.01 %, the maximum sea levels are given as 0.97, 1.14 and 1.31 m, and minimum sea levels as -1.08, -1.47 and -1.86 m, respectively.

Regarding the extreme values of sea temperature, 29.84 °C and 15.57 °C were given as maximum and minimum sea temperatures based on the historical measurements. Additionally, temperature in Akkuyu bay was studied, warmest sea temperatures were found to be from end of August to mid-September for various depths.

Calculations for design basis extreme values was performed using a statistical approach based on the historical data provided from the General Directorate of Meteorology. Annual extremes were calculated based on the daily data from 1970 to 2011. According to the analyses, for 0.01 % exceeding probability, the maximum monthly average temperature is 31,95 °C, and maximum daily temperature is 32,13 °C.

In order to assess the water pollution and pollution levels in Akkuyu bay, organic and inorganic pollutants in sea water and sediments were investigated by chemical analyses. The measured values, detection thresholds of methods and regulatory limits were tabulated. It has been determined that all measured concentration values for all measurement points and depths are below the regulatory limits.

Regarding the flood scenarios, extreme precipitation, flooding from streams, nearby dams, seiche and storm waves, tsunami and derivation canals were considered. Based on the meteorological data, it has been stated that the maximum precipitation in a 24 hr period was 688.5 mm, and further stated that the flood levels are effected potentially from tide levels, storm waves and waves from the wind.

Due to the insufficient information on flowrate of Zeytinçatağı and Çamalanı-Sarp dry creeks around the site, only deterministic approach was used for flood, stating that the water levels of land based floods will remain below the site base level.

APC stated in the report that there is no close by dams threatening the site, Gezende Dam is at 53 km far as closest, and other dams were not even considered being so far.

For determination of probable maximum storm surge, simplified deterministic, simplified deterministic-empirical and numerical deterministic approaches were used together, in accordance with the suggestions of IAEA.

Based on the investigations performed on frazil ice effects on water intake systems, APC stated that such an effect is negligible, and such a scenario may not lead to contamination or blockage of the water intake.

Regarding the wave regime, effective fetch, extreme wave statistics, near-shore bathymetry, wind calculations, and wave set-up and run-up computations for the selected scenarios of storm events are given in tabulated form. APC considered the global warming and Coriolis effects in wave studies.

APC stated that the seiche oscillations can be expected in Anamur-Cyprus channel, and that the seiche induced wave heights at site will remain under tsunami event even though it may lead to amplification of 2-2.5 times at site according to the numerical simulations.

APC introduced the possible earthquake sources that may lead to tsunamis in eastern Mediterranean and provided information on fault regions in the area including Hellenic arc, North Anatolian fault zone, East Anatolian fault zone, Cyprus arc and Dead Sea fault, and historical tsunami information based on literature.

APC prepared a source catalogue for tsunami analyses including historical earthquake information. For the deterministic tsunami analyses, 17 of these sources were selected by estimating that their effects would be bigger on site. According to analyses, three of these 17 sources cause to larger water level and stronger currents, the source RUN-7 and its derivatives determined as the worst-case scenario.

While investigating the worst-case tsunami scenarios, the initial sea level was assumed as 2.3 m above normal, considering 1 m for global warming and 1.3 m for other reasons. According to the deterministic calculation of probable maximum tsunami, maximum near-shore tsunami height is 6 m including the combined effects of 2.3 m for RUN-7 source and its derivatives.

In probabilistic calculations, all earthquake sources that may lead to 1.5 m or higher tsunami levels were considered. In this respect, eight more sources were included in the analyses together with RUN-7 and its derivatives. APC calculated the annual rates of exceedance of different possible tsunami

heights based on the weighted average annual rates for Akkuyu specific tsunami sources. Based on these calculations, RUN-7c has been found as worst-case scenario, as in deterministic analyses.

For probabilistic calculations, 0.15 m for tidal changes, 0.6 m for storm wave setup, and 0.15 m for seasonal variations were considered as additional effects, taking not into account the effects of global warming. In these conditions, the possible maximum tsunami was calculated as 10.1 m and the grading elevation of Akkuyu NPP has been determined as 10.5 m.

Within the scope of paleo-tsunami studies, APC has worked on total of 33 trenches in 50 km radius in 2013, from Gözce to Aydıncık on west and Taşucu, Kurtuluş ve Arkum on east of the Akkuyu site. Only at Arkum, 50 km east of Akkuyu, studies revealed evidence potential tsunami after an earthquake occurred circa 1036-1037. A three to four meter tsunami evidence was identified in this trench.

4.5.2 Review and Assessment of SPRv1

In review and assessment of this section of SPR, IAEA guidelines SSG-18 on hydrological threats and NS-G-3.2 on population and dispersion of radioactive materials, and Russian Federation regulation on external events were considered in addition to general regulations. The list of these regulatory documents was given in Appendix I.

With the review and assessment performed on this section [38], team has identified absence of information on Sipahili (Babadıl) creek and location, capacity and technical information on desalination facility, which were proposed as sources for drinking water. Additionally, it has been found that technological terminology used was not standard, that there are discrepancies in information provided on water usage with other chapters of the report, and that some regulatory documents, not included in the licensing basis, were referenced.

The information provided on dispersion of radioactive materials were found insufficient, unreferenced or unjustified, and data used were inadequate and were not site specific.

Similarly, information provided for the extreme values of sea level was based on inconsistent data, and unreferenced.

It has been found that non-valid IAEA guideline NS-G-3.5 was used for studying the water level changes due to tsunami and runoff. This information need to be reconsidered regarding the SSG-18 which superseded the NS-G-3.5.

Regarding seiche oscillations, the studies, analyses and description of all possible sources were found inadequate.

Within the scope of tsunami studies, team found that the source list is not properly justified, source parameters used for analyses, such as depth, magnitude, seismic moment, focal mechanism, and rupture zone parameters, were not explained sufficiently. APC did not define which bathymetric data or map were used for tsunami. Additionally, bathymetric and topographical information did not include the potential changes due to coastal structures.

There was insufficient information on methodology used in tsunami analyses, boundary conditions, regional models, and assumptions.

Team found verification studies of software used for the tsunami analyses are adequate but additional information would be needed on structure of software, models, correlations, solution techniques, etc. Expected explanation and justification on selection of finite element dimensions, due to its importance as model nears the coastal area, were not given.

It has been found that selection from the source list did not considered all sources and selection process and results were not explained.

Explanations on determination of worst-case scenario were inadequate, establishing an opinion on reviewers that there was no parametric study on this issue. For determination of the worst-case scenario, a parametric study would be needed for quantification of the uncertainties. Lastly, not enough information was provided for completion of review and assessment of the probabilistic methods.

Regarding this subject, there were no IAEA suggestion, ACNS opinion or inspection finding. The findings of review and assessment were communicated to and discussed with APC in the working group meetings and in electronic form.

4.5.3 Review and Assessment of SPRv2

With SPRv2 [7] the information on fresh water sources and technical information on desalination facility were provided. Regarding the dispersion of radioactive materials, results of radioecological monitoring performed from 2011 to 2013 were given, other requested information is provided and format irregularities were remedied. Similarly, format problems were remedied for other subsections also. Biggest amount of information provided in this chapter was on the seiche and tsunami issues.

Additional information was provided for water sources for technical use, stating that the additional information shall be provided based on the new studies on Sipahili creek and desalinization facility at later stages. Some of the inconsistencies regarding the water sources were remedied, while it is determined that some inconsistencies were yet to be addressed, particularly on fresh water sources.

APC claimed that some information on radioactive material dispersion in marine environment can only be provided after relevant design information becomes available, explaining the use of reference data instead of site specific data as adoption of conservative approach based on the estimation of lower site specific data than the reference values.

The APC provided the chemical and physical characteristics of waste in tabular form together with the allowable limits defined in regulations. APC need to provide explanations for some parameters that are higher that the allowable limits for release.

Corrections were made on extreme values of sea level, sea temperature and floods. Since some of these parameters are depend on the design, they were noted as follow up issues for later stages.

As requested, the information provided for the tsunami and seiche were combined.

Additional information was provided in the scope of deterministic analysis of the design base tsunami height, but they were not addressing or providing solutions to the findings on the first version of the report. The same findings were communicated to the APC.

Regarding the probabilistic approach, the explanation provided on derivation of some parameters considered in seismic model was found inadequate. While APC claimed that the all sources which lead to 1.5 m high tsunami on site were considered in the study, reviewers identified that the S42_ECEMIS and RUN-6 sources were not considered even though their effects exceeds this limit.

Failing to provide the report prepared by RIZZO [39], despite multiple requests made in the working group meetings, impeded the review and assessment process. Inadequacy of the information provided on methodology used led the review team to have the opinion that there are inconsistencies in seismotectonic models and there is a need for recalculation of some parameters and weight factors used in models because of the inconsistencies in zoning and the disregarding the Ecemiş fault line.

Team also stressed that additional explanation would be needed on justification of use of average of two approaches in estimating the 10000-year return period by extrapolation in the probabilistic analyses, while one of the approaches does not use all available data and the other which make use of all available data gives more conservative result, and on the use of different additional effects in this version of the report.

Regarding seiche oscillations, seiche analysis were provided for Anamur-Cyprus channel, showing that it may amplify the wave height 2 to 2.5 times at site. It was determined that the seiche waves remain lower than the tsunami waves.

Findings on SPRv2 were discussed with the APC in nine working group meetings, particularly focusing on the tsunami issue. During this process, additional information was provided by APC with interim versions of the report to be included in full submission later, they are reviewed and assessed by the team until all findings reach to some solution.

These interim revisions provided additional information mainly on tsunami and seiche, providing format remedies for other information. Seiche oscillations were provided for Anamur-Cyprus channel based on numerical simulations, demonstrating that the seiche wave heights are below the tsunami waves.

It has been determined that the tsunami catalogue was further developed to include the parameters of reference earthquakes, such as date, center, magnitude, etc., and information on historical tsunamis, and finding was closed based on the adequacy of the additional information provided.

Similarly, additional information on topography and bathymetry was found adequate and finding was closed.

Information on software used in analyses, and on initial and boundary conditions were found adequate and the issue was closed.

APC provided the results of the numerical calculations, information on justification of selection of critical sources and information on the sensitivity analyses based on the quantification of the uncertainties, and this information has been found adequate.

Based on these studies, the RUN-4 has been identified as most critical scenario among all sources, and maximum tsunami height has been calculated as 6.4 m while the lowest calculated as -6.79 m for this scenario. From the deterministic analysis of the source scenarios, maximum tsunami height has

been calculated as 7.36 m with 0.95 reliability level, including uncertainties, and minimum height as -7.77 m. The calculation methods and justifications provided have been found adequate.

Additional information on issues, of which probabilistic calculations based on, were provided. Annual exceedance probability of the probabilistic tsunami heights at coastal areas were calculated by correlating them with the values calculated from the deterministic analysis. Calculated values were linearly extrapolated to 10000 years return period and the maximum tsunami height was calculated as 7.97 m for this return period.

As additional effects, 1.0 m from global warming, 0.15 m from tidal changes, 0.6 m from storm surge, 0.08 m from wind surge, 0.15 m from seasonal changes and 0.1 m barometric effects were considered, taking the maximum tsunami height calculated by deterministic analysis as 9.44 m and by probabilistic analysis to 10.05 m. APC stated that the grading elevation of 10.5 m for the ANS shall provide enough protection for the flood.

4.5.4 Conclusion

The review and assessment of this chapter could only be finalized through interim revisions of the report and provided information has been found satisfactory. Within this scope, SPRv4 also controlled to ensure that all issues were satisfactorily closed [38], except an issue to follow at later stage, by provision of adequate information. Maximum tsunami height was determined as 10.5 m. It has been determined that all site related design parameters derived or determined in this chapter were reflected consistently in thirteenth chapter.

It has been assessed that the maximum water height is based on the current topography and bathymetry of the coastline and might change with the coastal structures. This issue shall be reevaluated at review and assessment of the Preliminary Safety Analyses.

4.6. Geology, Geophysics and Seismology

Information in this chapter is expected to be provided for three different scales. In regional scale, structural characteristics were to be provided with stratigraphic and tectonic data. For the near vicinity of the site geological and geomorphological characteristics, local faults, groundwater, and historical depressions and landslides, and for the site geological, geotechnical and hydrogeological characteristics need to be provided in detail. Additionally, seismologic, surface faults, and slope stability characteristics of the site should be explained clearly.

4.6.1 Information Provided in SPRv1

With SPRv1 [6], data gathered for regional, near regional and site vicinity scales were provided, presenting the regional geotechnical structures in maps. In near regional scale, results of the field reconnaissance and analyses were provided. For the site vicinity, information provided on geological, geomorphological and stratigraphic studies and geophysical investigations.

Regarding the hydrogeological characteristics of the site, hydrogeological structure, geological setting, undersurface characterization and hydraulic tests, artificial and environmental tracer techniques and modelling studies were presented with relevant evaluations. The regional hydrogeological setting studied and evaluated for the development of conceptual hydrogeological model of the site, boundary conditions of the settings, and recharge-discharge mechanisms of the site for regional and local scale were described.

The regional hydrogeological map developed by detailed investigations, including karstic depression features, regional conceptual hydrogeological model characterizing the groundwater circulation system and its structural relations were provided. Hydrological settings of Akkuyu site, Sipahili basin and Sipahili Dam area and their relationship with water bearing formations were provided in three-dimensional form.

The hydrogeological setting of the Akkuyu site described by using the information obtained from subsurface geology, drilling, geophysical surveys, and hydraulic test studies are presented together with the hydrogeological maps of the Akkuyu site and its vicinity. The location map of the bore holes with lithological descriptions and the cross-section profiles and the tree dimensional subsurface geological model of the Akkuyu site are given.

The physical and chemical properties of groundwater were given. The groundwater temperature and electrical conductivity values measured in the monitoring wells at Akkuyu site and Sipahili plain, and radiological composition of groundwater were presented describing the change in inventory of the groundwater in time. It has been stated that the general flow direction of the groundwater in both Akkuyu site and Sipahili plain were towards the Mediterranean Sea.

The Hydraulic properties of Büyükeceli aquifer and Sipahili plain coastal aquifer were given. Akkuyu site groundwater flow and transport models including the conceptual hydrogeological model of the site, numerical model and model for dispersion of radionuclides were described.

Information were provided on the borehole studies conducted to determine the geotechnical parameters and seismic soil-rock properties of the Akkuyu site. Shear wave velocities were provided based on the analyses and properties determined by study on physical-mechanical properties of soil and rock. Mean shear wave velocity (V_{s30}) up to 30 m depth from surface is given as 1038 m/s with 266 m/s standard deviation. Additionally, the system for monitoring of the micro-seismic activities was described together with the information on seismic activities occurred during the measurement period by comparison with data from other seismic networks. Micro seismic earthquakes in 2014 were summarized.

Methods used for preparing the regional earthquake catalog compiled for the seismic hazard analyses of the Akkuyu site were explained. Information was provided on completeness of the catalog for seismic hazard analyses, describing the elimination of dependent activities such as fore and aftershocks and homogenization of the catalog parameters. Five different seismotectonic models developed by Envy-KOERI (2 models), Paul C. Rizzo Associates Inc. (2 models) and Worley Parsons (1 model) for the seismic hazard analyses were introduced together with the estimation on maximum magnitude expected from seismotectonic regions of the models.

Two groups of ground motion estimation equations were used in ground motion model of the consolidated seismic hazard analyses, providing a hazard input document containing main information on calculations of probabilistic and deterministic seismic hazard analyses.

Within the scope of deterministic analyses, information and studies were provided on all sources and sub-sources in seismic source models, consolidated deterministic seismic hazard analysis performed by logic tree and applicable ground motion estimation equations, 5 % damped free field response spectra, and sensitivity analysis explicitly including the variation in V_{s30} in analyses.

Within the scope of probabilistic analyses, results were provided in graphical form for 5 % damped mean, median and quantile Uniform Hazard Spectra for return periods of 1000, 10 000, and 100 000 years, calculated by using five models, eight ground motion estimation equations, and seven logic tree levels. Regarding the dependency of peak ground acceleration to location and magnitude for these return periods, results of the seismic hazard deaggregation were provided together with a sensitivity analyses explicitly incorporating the variation of V_{s30} in analyses.

Based on the results of the consolidated seismic hazard analyses, design basis ground motion is given in the form of design basis S1 and S2 acceleration response spectra for horizontal and vertical directions, enveloping the uniform seismic hazard for 10 000 year return period of probabilistic analyses with 5 % damping, while Peak Ground Acceleration is given as 0.3875g. Additionally, S2 values for critical damping of % 0.5, % 1, % 2, % 3, % 7, % 10, and % 20, derived from the 5 % damped S2 spectrum were provided. Also, acceleration response spectra of S1 and S2 for horizontal and vertical direction were presented.

Site investigations and morphological studies performed for 5-10 km radius were provided regarding the surface faulting. Based on the results of geological, geophysical, seismological and paleo-seismological studies, APC stated that the Akkuyu site has no potential for surface faulting.

Results of the tests and analyses regarding of soil liquefaction were presented. APC stated that design may provide complete replacement of fine-grained soil of Akkuyu site because lithology and physical properties of the site is heterogeneous and the static and dynamic mechanical properties of fine-grained soils do not meet the requirements for foundations of NPP buildings and structures.

APC further stated that there is no slope instability risk in Akkuyu site since the site is bordered with hills of 200-250 m high formed by folded and faulted rock, with average 35˚ slopes covered with dense pine trees and thin topsoil.

4.6.2 Review and Assessment of SPRv1

The review and assessment of this chapter based on, in addition to general regulatory documents, the IAEA guidelines SSG-18 for hydrological hazards, NS-G-3.2 for demography and dispersion of radiological materials, SSG-9 for seismic hazards and NS-G-3.6 for geological issues were used. The list of these regulatory documents was given in Appendix I.

Upon the review and assessment [40] of the SPRv1 important findings were reached regarding the hydrogeological studies of site and determination of seismic hazard.

It has been determined that the regional databases were provided with maps of very low decipherability, and some faults given in maps were not considered in later stages of the chapter. Additionally, information provided was not homogenized and standardized, and some recently moved faults were not considered at all.

It has been determined that near regional investigations are satisfactory other than lacking a map indicating the geological features that may influence the facility to be built on site, and non-consideration of some new faults such as fault at north of Cyprus Kyrenia Range. APC were asked about needing simplification since the readability and understandability of this chapter is very low.

Important insufficiencies in databases for site vicinity, and inconsistencies with information provided in other parts of the chapter were found.

Information provided for regional hydrogeological features need to be updated, having considerable uncertainties in mathematical model based on the conceptual hydrogeological model and hydraulic characterization. Despite some comprehensive and detailed geophysical investigations were carried out on site, it has been found that these investigations are not specific to hydrogeological studies, locations of boreholes and piezometers were not determined based on the results of the geophysical studies, extreme values of ground water and their potential hazards were not analyzed and chemical monitoring studies were not carried out on site.

There were either no or insufficient information on Büyükeceli aquifer that would contribute to conceptual model, hydrometeorological data relating to seasonal and annual rain and evapotranspiration, meteorological analyses and ground water recharge estimations, potential contamination paths, all stagnant waters or drainage systems on ground.

Within this framework, it has been assessed that the conceptual model does not represent the real situation and the information gathered during the site investigations were not enough, in quality and quantity, for hydrogeological conceptualization, and APC were notified about additional site investigations needed, together with expected scope of work.

It has been determined that the detailed and definitive definition of hydrogeological, physical, physicochemical and biological characteristics that would contribute to transportation, dispersion and retention of radioactive materials were not made, the list of existing drinking, usage, and agricultural water sources was not completed, and food consumption and other related routines of the population was not documented.

It has been found that the three main parameters (transmissivities, specific yield and storage coefficients) of the transportation model developed for calculation of dispersion and retention of radionuclides released to ground water were not site specific, that models do not include the hydrogeological characteristics of the site, having used reference values from literature.

APC was notified that the surface and ground water monitoring programs need to be developed in accordance with IAEA guideline NS-G-3.2 to ensure the suitability and representation of site, and monitoring should be commenced two years prior to the construction starts.

Within the scope of site investigations, it has been determined that the database were established based on the geological, geophysical and geotechnical studies including the onsite and laboratory testing, but the studies were not encompassing all areas. APC has been notified about the missing studies, which are defined as geological and geotechnical studies for definition of the stratigraphic and geological structure of the site, hydrogeological studies and additional studies of the site effects.

In addition to missing studies, it has been determined that the test results and basic relations that support the site values were not provided, and not enough information were provided on probability of permanent displacements due to earthquakes (fault capability, liquefaction, subsidence or collapse due to underground cavities) and on static and dynamic characteristics (P-wave and S-wave velocities, etc.) of foundation materials. APC has been notified about the needs for evaluation of hazards of seismic liquefaction for critical and non-critical structures and related risks, for ensuring consistency of information provided for surface faulting and seismic hazard evaluations, and for ensuring the consistency of the results of the seismic hazard analyses with the given V_{s30} values.

Despite that the studies regarding the determination of geotechnical site parameters and results provided were adequate, it has been determined that the evaluation process and discussions that lead to determination of these parametric values were not adequately reflected in the report. It has been found that the effects of uncertainties in parameters on the variability of analytical results were not parametrically studied, and consequently, an appropriate model of the site were not provided and discussed.

As part of the seismic hazard assessment, acceleration time series, V_{s30} value at reference free field on site was given as 1100 m/s. APC has been notified that if the site is not compatible with the selected reference value, the adaptation would be needed so that the acceleration time series corresponds to site response analyses in correct conditions.

It has been determined that the site earthquake catalogues, developed as a result of establishing a seismological database including the historical and measured earthquakes, were not used in probabilistic seismic hazard assessment, and that seismotectonic models developed by three different teams (KOERI/ENVY, Rizzo and WP) were used different catalogues for both historical and instrumental periods. Furthermore, it has been determined that these catalogues do not contain all necessary information.

Three different models for seismic hazard analyses based on different catalogues were given and considered in final hazard assessment by weight factors. The APC has been notified that the catalogues are need to be consolidated for using the output of the models together and all models need to be studies using the same database.

It has been determined that the second model developed by ENVY-KOERI is not up to date, does not represent the current faults, and results in low values. Additionally, it has been determined that the parameters used in seismotectonic models and logic trees are not defined and information provided is not enough for evaluation of these parameters. Similarly, it has been determined that not all seismogenic structures were used for development of seismotectonic models, characteristics and parameters of these seismogenic structures were not identified and uncertainties in parameters were not provided.

It has been found that the parameters such as maximum potential magnitude (M_{max}) or magnitude-frequency relations and uncertainties in these parameters were not defined and justified, and sensitivity of hazard to selection of M_{max} distribution was not investigated.

It has been determined that some of the ground motion prediction equations used in models were not compatible with the regional characteristics while they are with the site conditions.

It has been found that the seismotectonic model was not assessed on the basis of seismic sources determined within the scope of probabilistic seismic hazard analyses, uncertainty levels used for variation of ground motion were not provided and results were not presented in sufficient detail.

For the deterministic seismic hazard analyses, the same seismic sources were used, ground motion prediction equations were selected separately for seismic sources, and assumed that the M_{max} occur at closest point to the site for each seismogenic structure and the M_{max} in a zone of diffuse seismicity that includes the site of the NPP occurs at some identified specific horizontal distance from the site.

Despite the results of the probabilistic and deterministic seismic hazards analyses were provided, they were not interpreted or compared, while the S1 and S2 ground motion hazard levels were described with appropriate spectral representations and with time histories to establish bases for seismic design of the NPP units. However, it has been determined that the time histories do not base on the experimental ground motions and do not have the characteristics of real earthquakes. Additionally, it has been determined that different abbreviations such as SL-1, OBE, SL-2, SSE were used for S1 and S2

It has been found that the information provided on surface faulting was inadequate, and there are faults that were not studied. APC was notified that the capable faults need to be identified and shown on maps.

Within the scope of soil liquefaction, 3 m saturated soil layer thickness was presented as a screening criterion without any justification. It has been found that the comments on soil liquefaction are not objective and base on undocumented assessments. In this respect, APC was requested to perform a detailed seismic soil liquefaction triggering analysis, to discuss the results and assess the seismic soil liquefaction-induced hazard and corollary risks for critical and non-critical structures

Even though the information regarding natural slopes were provided, it has been determined that the potentially hazardous slopes were not defined in terms of distance, angle, height, geology, water content and other geotechnical conditions of the slope material. This deprives all discussions and assessments from a foundation. APC has been notified that an assessment of soil and rock stability and discontinuity should be performed and documented.

Within the scope of this chapter, ACNS commented that the results of geological and geotechnical site investigations were presented in general, and there need to be further explanation on how the results of the detailed site investigations could be used in foundation design of NPP units and which standards need to be used for the same purpose.

ACNS stated that the seismic hazard analyses were based on different seismotectonic models, and the studies of General Directorate of Mineral Research and Exploration were not used. Additionally, ACNS suggested that use of different programs in analyses provides some further consideration of differences. This suggestion was considered as beyond the scope of the Site Parameters Report.

Lastly, ACNS pointed out to the need for clear description of liquefaction and soil stability potentials for the safety of the installation, stressing the importance of these studies.

This issue was also worked in collaboration with IAEA, and IAEA experts recommended that;

- An integrated picture of the regional geology and the seismotectonic setting of the site and the region should be established and substantiated by the data collection and field work,
- The data used for probabilistic seismic hazard analyses need to be referenced, the assumptions need to be justified based on the collected data and seismotectonic setting of the region,

- The relationships used in propagating the seismic motion from the source to the site need to be evaluated for its applicability for the specific site in view of the description of the geology and seismic setting established in the earlier sections,
- A systematic presentation need to be provided for the maximum magnitude (M_{max}) of seismic sources and the uncertainty of M_{max}, and for the basis for selecting candidate ground motion prediction equations,
- Data observed at the site, site vicinity and regions should be used in the seismic hazard assessment,
- Standard deviation that represent uncertainty of the ground motion prediction equations and how they are used in probabilistic seismic hazards analyses should clearly be stated,
- The conclusions made on the potential for liquefaction should be elaborated and explanatory statements should be justified, and
- Technical justification should be provided demonstrating that the slope instability would not pose a threat to the plant safety.

In addition to the IAEA contributions, the site activities requested by Authority, particularly hydrogeological studies were monitored closely through the inspections, and follow-up of inspection findings. Information on these inspections were provided in detail in Section 2 of this report.

Furthermore, based on the importance of the issues, advisory services of four of the five external experts (Table 2) were procured regarding the issues presented in this chapter of SPR.

Findings were communicated with the APC electronically, and discussed with their experts in 16 working group meetings, providing further explanations.

4.6.3 Evaluation of SPRv2

With SPRv2 [7], extensive additional information was provided, reflecting the results of the hydrogeological site investigations to the SPR. However, it has been found that some important issues were not addressed with these information and assessments. After the submission and evaluation of SPRv2, these findings were communicated with the APC through working group meetings, and this section of the report had various updates without official revision. All the modifications made in this chapter until the submission of SPRv3 and SPR v4 were also evaluated, and the evaluations provided below is the results of all these evaluations.

In this respect, the findings on regional, near regional and site vicinity databases were resolved [40] with these updates, and they were closed.

The site investigations performed on hydrogeology in accordance with the Akkuyu License Conditions for Site License were kept under regulatory control and regularly inspected. The findings of the inspections were resolved, and information provided in SPR was found adequate. All findings regarding hydrogeological studies were closed.

The database developed through site investigations and its presentation were found satisfactory. Also, it has been determined that the potential for permanent ground displacement and seismic soil

liquefaction-induced hazard for critical and non-critical structures were assessed and these assessments were found adequate.

The missing data within the scope of geotechnical parameters were provided. Based on the assessments, the generalized V_{s30} value for Akkuyu site was given as 1038 m/s with standard deviation of 266 m/s. This value is considered by APC as the reference V_{s30} value in free field conditions representing the area for reactor units 1 through 4.

On the other hand, since most of the geotechnical parameters are not suitable for reduction to mean values to characterize the entire site and need to be derived and used specific to location and/or structure, they were not transformed into parameters that will characterize the site, despite some information is provided in SPR on studies, data and results regarding this transformation.

The evaluation of this issue shall be considered during the review stage of the Preliminary Safety Analysis Report.

Within the scope of the finding on inadequate investigation of karstic structures, the studies and results provided by APC has been found adequate. APC defined the karsts on site as undeveloped karst with rare occurrence and small cavities, stating that investigations will continue to identify any heterogeneities on the scale of a building size that may cause tilting and/or unacceptable differential settlements. Findings regarding the karst were closed.

The seismologic database was updated, defined and consolidated, and used for all seismotectonic models after declustering and homogenization. The issues regarding seismic database were resolved.

The findings on seismic sources and parameters used in seismotectonic models within the scope of seismic hazard analyses of Akkuyu site, were provided, justified and compared. The issues regarding the models were resolved.

It has been found that the appropriate approaches were adopted in selection of ground motion prediction equations and they are properly justified. The elected equations were given in references and it has been stated that there was no truncation in ground motion variability. Issues were resolved.

Within the scope of probabilistic seismic hazard analyses, Uniform Hazard Spectra were revised for annual exceedance probabilities of 10^{-3}, 10^{-4}, 10^{-5} and for fractile levels of 0.05, 0.16, 0.50, 0.84 and 0.95. Hazard deaggregation was also revised and the selected scenario was justified.

The absent information was provided for the deterministic seismic hazard analyses, and sensitivity studies were provided regarding the V_{s30}, M_{max} and M_{min}. The results of deterministic and probabilistic seismic hazard analyses were given together with the comparison of the results.

Design acceleration values for S1 and S2, horizontal and vertical components compatible with the design response spectrum were provided and found in compliance with national regulations. The issues regarding the seismic hazard analyses were closed.

The information, interpretation of aerial photographs, analyses and studies provided within the context of surface faulting and fault displacement hazard potential were found adequate. Report stated that the geological, geophysical, seismological and paleo-seismological studies clearly

demonstrates that the Akkuyu site does not have surface faulting potential. The issues regarding the surface faulting were resolved.

Within the scope of soil liquefaction, a ground plan with liquefaction potential were provided, including the determination of relevant parameters, analyzed to develop Liquefaction Potential Index map. The issues regarding the soil liquefaction were resolved.

The stability of natural slopes enclosing the Akkuyu site has been studied with respect to safety of the installation, models has been developed, safety factors were calculated under static and pseudo static conditions, and assessment of slope stability were provided together with the engineering geology factors. The slope stability issues were resolved.

4.6.4 Conclusion

SPRv4 has been controlled for inclusion of all intermediate revisions. It has been determined that the design bases parameters were reflected to Chapter 13 consistently.

As a result of the hydrogeological modelling of the site, including the regional seismotectonic characteristics, the peak ground acceleration has been determined as S2=0.3875g for 5 % damping and 10000 years return period. It has also determined that the soil liquefaction, karst and the slope stability are other potential hazards of the site.

Some issues were identified as issues to be followed up by the Authority at following stages, since their characteristics did not allow completion, and these are:

a) Determination of location specific geotechnical characteristic, taking into account the layout of buildings, and consideration of them in design,

b) Determination of floor response spectra based on the vertical and horizontal components of response spectra derived for different damping values, and consideration of them in design,

c) Measures to be taken for stability of new slopes that emerge during construction, and

d) Consideration of karstic systems in design of foundation of the structures.

4.7. Ecological Effects

APC is expected to provide information on the effects of flora and fauna on the installation, particularly focusing on effects that may have an impact on nuclear safety.

4.7.1 Information Provided in SPRv1

Stating in SPRv1 [6] that the main adverse impacts are the effect of sea and flora and fauna on the installation and no effects are foreseen from terrestrial flora and fauna, information were not provided for the terrestrial flora and fauna for the site and vicinity. In this respect, a detailed study on aquatic organisms were provided identifying the species among known ones in hundreds that may have impact on water intake structures. In addition to microscopic organisms, it was stated that 112 species of fish were identified based on ichthyofauna data of fishing in 1999-2000 in Akkuyu Bay and Babadıl harbor, where 13 of them have commercial value.

Hydro-chemical and hydro-biological parameters of the sea in Akkuyu Bay were carefully studied for determining the conditions contributing to the biofouling and the adequate design measures for safe and efficient operation of the installation. An experiment has been conducted to determine the

species that may cause biofouling, resulted in identifying nine such species. Also, number of organisms on experimental plates for fouling were given as table. It has been stated based on the conclusions of these studies that the conditions are favorable for building an NPP on the site.

Within the scope of these ecological conditions, it was stated that measures were taken for protection of service water systems for cooling of turbine condensers and equipment directly in contact with sea water, normal operating systems and safety systems, and coastal structures from the environmental effects. To avoid ingress of wastes, algae, fish and other marine animals in service water, cooling seawater from the Akkuyu bay runs through intake structures with trash coarse screens and fish protection structures installed in the body of a protective dam.

To prevent the biofouling of the equipment exposed to seawater, the cooling sea water need to be treated with sodium hypochlorite, which is provided by design in adequate concentration. While the sea water flows through the pipelines and equipment, sodium hypochlorite loses its properties prior to discharge to the sea, to the extent that it does not influence the chemical composition of sea water.

4.7.2 Review and Assessment of SPRv1

In review and assessment of this chapter, IAEA guideline NS-G-1.5 (App. I) regarding design consideration of the external events other than the earthquake for nuclear power plants was used in addition to the general regulatory documents.

Based on the review and assessment performed on SPRv1 [41], it has been found that the information provided for aquatic flora and fauna is adequate, however further studies and information would be needed for terrestrial flora and fauna and their potential impact on the installation.

The findings were electronically provided to APC and communicated with their experts in working group meetings. In working group meetings, examples of impact of terrestrial flora and fauna were presented to APC to substantiate the request.

There were no suggestions from IAEA mission or ACNS review on this subject and no inspection findings.

4.7.3 Review and Assessment of SRPv2

In SPRv2 [7], it has been found that the adequate information on terrestrial flora and fauna was provided and discussions on their impact on the installation were given. According to SPR, 114 species of vertebrates and 30 species of invertebrates inhabit the site and its surroundings.

It is stated in the report that there is no terrestrial flora and fauna in site and its vicinity to have an effect on the installation, and hence, no additional measure would be needed. According to the report, design provides conventional solutions such as isolation of cables with synthetic material resistant to biological effects, having grids in ventilation systems with periodic inspection and cleaning, and maintaining on site sanitation for preventing the multiplication of rodents.

It is also stated that ecological conditions at the site, determined both by natural conditions and the existing human-induced impacts, are generally favorable for NPP location. Fauna inhabiting the site area predominantly uses the habitats outside of the construction site, which is the main zone of the NPP location. The main reason of this is given as absence of the appropriate habitat characteristics in

the construction site to meet the environmental needs of the majority of species of invertebrate and vertebrate animals. This would also exclude the occurrence of significant accumulations of insects which may cause clogging of the ventilation systems.

4.7.4 Conclusion

With SPRv2, it has been determined that adverse impacts of ecological factors are adequately considered and discussed, complying with the regulatory documents [41]. Additionally, SPRv4 is controlled and found that it contains all necessary information. There are no design related site parameters regarding this chapter that need to be reflected to Chapter 13.

On the other hand, the measures stated in the report for biofouling in water intake mechanisms and coastal structures were only preliminary information that would be detailed in later stages of the design. This issue will be pursued by the Authority.

4.8. Human Induced External Events

APC is expected to provide information on external event scenarios based on the previously given nearby industrial facilities and activities, and analyses of their potential effects on plant safety.

4.8.1 Information Provided in SPRv1

In this chapter of the SPRv1 [6], in accordance with the regulation [9], all facilities and activities within 10 km radius which may create potential threat for the site, have been given. Any facility or activity beyond 10 km that may have an impact on plant safety were also considered. Human induced external events that may have the radiological consequences or that have probability of occurrence 10^{-7} 1/year or more were considered as design basis external events. Pre-selected human induced events that may need further attention were also described in the report.

Potential explosion sources have been listed in the report as explosions on highways, in quarries, on sea vessels, in gas stations and aircraft crash, and Regulatory Guideline 1.91 of US National Regulatory Commission (App. I) were used for estimation of the impact of such explosions. It has been calculated with this approach that any explosion on nearest highway would not establish a threat on site. Similarly, an explosion in nearest quarry, on a vessel on the sea beyond 10 km while there is no transportation route closer than 10 km, and on closest gas station would not possibly effect the site.

Regarding the aircraft crash, it has been stated that the calculations are carried out for 400 t aircraft with 200 m/s speed and 150 t of fuel by assuming that no more than 10 % of the fuel is dispersed. Maximum pressure was calculated as 26 kPa for these conditions. Variation of the excess pressure at the front of the air shock wave with distance from the explosion center is given in a diagram. It is concluded that the aircraft crash at a distance of more than 250 m does not pose hazard to the plant.

Within the scope of sea accidents, transportation of flammable or toxic gas or liquids were considered. Impact areas of flammable and toxic gases were studied for different categories and types. Considering the accident statistics, it has been shown that the total probability of occurrence of flammable gas cloud, and explosion of toxic and radioactive clouds arisen from a sea accident near the Akkuyu site remains below the limits. It is further stated that 10-fold increase in sea routes traffic would not carry the possibility over the limits.

Spilled fuel fire based on an accident scenario in Akkuyu bay was considered as design basis external event in accordance with the regulation [9]. It has been stated that the safety related coastal structures should be able to withstand at least 20 kPa air pressure, based on the calculations of this scenario with a safety margin. Additionally, it has been stated that further measures such as having firefighting equipment at every pier, equipment for collecting and isolating the spilled fuel and emergency response plans for mitigating the consequences need to be developed.

Impact of a leakage from an explosion occurred at a tanker carrying toxic cargo was investigated in accordance with a Russian Federation guideline (App. I), and considering that the closest highway D400 is separated from the site with hills higher than 100 m, it has been concluded that the possibility of dangerous impact is low and does not require additional measures.

Within the scope of aircraft crash, it has been stated that the air corridors W84/UW84 and A28/UA28 constitutes to half of the probability of aircraft crash. It was suggested to reduce the number of flights in these corridors or move the corridors further away from the site. Additionally, it has been stated that a declaration of non-flight zone of 5 km radius and 14 km height from the site would be reasonable.

On the other hand, it was stated that the crash of an aircraft of 20 t weight and 215 m/s speed, corresponding to a F16 warplane or a CL60 passenger plane, would be considered as design basis event and of 400 t and 200 m/s speed would be considered as beyond design basis event, and safety analyses regarding such crashes would be provided with the preliminary safety analysis report of Akkuyu NPP.

Within the scope of the forest fires, it was stated that the forest fires are common in the area due to pine forests without undergrowth or bushes which are also surrounding the Akkuyu site, and that the probability of impact of forest fires on the plant was calculated as 10^{-3} events/year based on the statistical data provided.

It was claimed in the report that the smoke and the combustion gases will spread upwards through the hills because of the site topography and the open space on seaside, and will have no significant impact on plant area. Additional measures taken for protection from the forest fires were also listed.

Regarding the other fire sources, the closest fire potential was determined as the gas stations in Büyükeceli and Yanışlı, 3.3 km and 5.3 km from the site, respectively. It was stated that considering the impact radius for the flammable liquids and gases are no more than 0.7 km and 1.3 km, respectively, these sources would not pose any threats to the plant.

Regarding the collision with intake mechanisms, it was stated that each mechanism is 180 m long, and in case of a collision, considering potential size of vessels, only 90 % of the flow area could be blocked. As the water needed for cooling of the safety systems and systems other than the turbine condensers is only 6 % of the total, 90 % decrease in flow area was not considered as a threat on safety. Additionally, it was stated that collisions of touristic boats, yachts and fishing boats to intake mechanisms would not have an impact on safety. The probability of collision of a vessel at a size that may inflict a damage on intake mechanisms was given as below 10^{-8} events/year based on statistical data, and it was stated that even in case of 10 folds increase in traffic would not carry this probability over 10^{-7} event/year.

Regarding other dangers, oil spill is considered as surface water pollution, estimating dispersion to about 6 km radius in case of a stranding accident. It was stated that the water intake mechanisms are built at 5 m depth for ensuring the operation in minimum water level conditions, and no ingress of pollution is foreseen to cooling water systems.

No release of corrosive fluids was envisaged due to absence of industrial facility within 10 km of site that may leak such fluids to ground and surface waters. It is stated that only possible sources of wastewater are the local settlements. Absence of industrial facilities within 10 km of the site also eliminates the possibility of releases of explosive, flammable, toxic gases, vapors and aerosols that may have impact on safety. Only potential air pollution was identified as the domestic heating in local settlements.

It is stated that measurements of electromagnetic radiation from external sources including existing power lines, radio and television antennas and mobile communication systems made in the vicinity of site demonstrated that electromagnetic radiation is below the limit values described by ICNIRP (International Commission on Non-Ionizing Radiation Protection) and WHO (World Health Organization).

4.8.2 Review and Assessment of SPRv1

In review and assessment of human induced external events, in addition to the general documents, IAEA guidelines NS-G-1.5 on external events other than earthquakes and NS-G-3.1 on human induced external events, two regulations and two guidelines from the Russian Federation and a guideline from United States were used. The list of these documents was provided in Appendix I.

According to the review and assessment, it was found that the event categories were not reflected properly to the report. It was determined that the absence of systematic approach, previously identified for updated site report was repeated itself [42].

It is also found that the explosions of gas stations were excluded only for having hills in between without any calculation, and it was not stated whether any closer gas station for the plant is planned or not.

The assumptions made for impact assessments were not properly substantiated despite that some of them were due to the absence of local statistical data. Suitability of such assumptions need to be discussed or referenced. Some of the references provided for assumptions were not legible and could not be verified. Additionally, there was no information that worst atmospheric conditions were considered in impact analyses. For example, no calculation was provided for dispersion of flammable or toxic gases towards the site in such atmospheric conditions.

Similarly, only heat and pressure impact was considered in fire analyses while it was expected to include transportation of the toxic gases released as a result of fire in worst atmospheric conditions.

It was found that the information provided in Chapter three of SPR regarding air corridors were not fully considered in this chapter, and impact assumptions made were conflicting with the ones given in Updated Site Report. For example, the critical impact radius was given as 50 km for an oil spill on sea surface in Updated Site Report, while it was given as less than 6 km in this report.

The evaluations of the IAEA experts were supported the findings of experts of the Authority, noting the absence of systematic approach, and need for referencing the information sources and

justification of assumptions. IAEA experts emphasized that the term “according to experts” cannot be accepted as proof of or justification for safety.

The findings were communicated to the APC in electronic form in various occasions and discussed with their experts in working group meetings.

4.8.3 Review and Assessment of SPRv2

Review and assessment of additional information provided in SPRv2 revealed that despite an oil spill occurred in Akkuyu bay was identified as design basis external event, this parameter and its probability was not reflected in conclusion part. Additionally, it has been found that the explosion pressure value determined as 20 kPa for coastal structures does not satisfy the requirements coming from the Russian regulatory documents and APC has been requested to address these issues.

4.8.4 Conclusion

The review and assessment of this chapter mainly completed with the SPRv2, while a few issues were addressed in SPRv4. SPRv4 was controlled and found adequate [42]. It has been determined that the site related design parameters of this Chapter were reflected consistently in Chapter 13.

However, the Authority will pursue that following issues were properly addressed at later stages;

a) Consideration of aircraft crash criteria given in the Turkish guidelines, in design,

b) Taking the necessary measures to change the air corridors above the site in timely manner, and

c) Consideration of characteristics of missiles originated from tornados and their impact on the plant in preliminary safety analysis report.

4.9. Radiological Impact of the Plant

APC is expected to provide information on radiological impact of the plant to the environment during the normal operation and maximum credible accident together with their analyses with atmospheric dispersion models.

Despite that the radiological consequence analysis of maximum credible accident requested for determination of the emergency response zones, within the restructuring national emergency response mechanisms under the Presidency of Disaster and Emergency Management (AFAD) in 2009, National Radiation Emergency Plan (URAP) was prepared and submitted to the approval of the AFAD. URAP defines the emergency response zones in accordance with IAEA requirements, determining the zone radii independent from the installation. For this reason, the maximum credible accident is only used for verification of the zones to remain within the distances determined in URAP.

4.9.1 Information Provided in SPRv1

Maximum credible accident scenario has been defined in the report as the double-ended break on main circulation pipe of d=850 mm with station blackout. The source term was determined and provided for this scenario. According to the radionuclides released, the accident falls into the fourth category of the International Nuclear Event Scale. It was stated that the weather conditions was considered as wind speed with respect to stability in the analysis, and complex topographical conditions were considered by a correction factor $R_n(x)$ to wind speed. Analysis was performed by

SULTAN code. Dose calculation parameters and results of calculations of the RBE-weighted doses in human organs, effective and equivalent doses with respect to distances from NPP were given. The calculated dose distributions were used for determining the sizes of emergency planning zones and distances, and they were given as 0.32 km for Precautionary Action Zone, 1.3 km for Urgent Protective Action Planning Zone, 50 km for Extended Planning Distance and 10 km for Ingestion and Commodities Planning Distance.

Atmospheric dispersion analysis of the releases of radioactive materials to the environment in normal operation conditions were made for the reactor operation at nominal power, for reactor cool down during shutdown for planned preventive maintenance and for reactor head opening during such maintenance. Radionuclides release from the reactor containment to the atmosphere at power operation, cool down and reactor head opening conditions are calculated with LEAK3 computer code and the results are presented as fission product activity in the primary coolant corresponding to design limit and safe operation limit.

For these cases, the specific activities of fission products corresponding to the design limit of activity in the primary coolant determined for the minimum significant level of 10 μSv/year, were used as source term for gaseous release and liquid discharge for assessment of radioactive release.

The total dose quote for public members in normal operation of all units of the NPP is established as 100 μSv/year, 50 μSv/year for each of the gaseous releases and liquid discharges.

Assessment of the effective dose for annual release of radionuclides in normal operation of the reactor was presented based on the calculations made by using equations of statistics theory of atmospheric diffusion with Pasquill's stability classification system. For short-term release of radionuclides during reactor cool down and reactor head opening for maintenance, DOZA-M computer code was used. Children of age one to two years were considered as the critical group of the population. The joint frequency distribution of atmospheric stability category and wind speed was defined for 16 sectors of the Akkuyu site. For every possible combination of the atmospheric stability category and wind speed doses were calculated at different distances from the radiation source by DOZA-M software and the contribution to annual dose of population for every possible weather category combined with specific wind speed was defined. Annual food consumption and inhalation rate were taken from IAEA SRS-19.

External exposure from the plume and from the ground, internal exposure from inhalation and ingestion were calculated up to 80 km. The cumulative effective dose to a member of the critical group of population due to gaseous releases from one unit of Akkuyu NPP at 1300 m distance is 9.81 μSv/year, which is less than the minimum significant level of 10 μSv/year.

Doses for cool down and reactor head opening cases were 42.9 μSv/year at 1300 m distance. It is stated that this value is less than the dose quote of 100 μSv/year for an incident event at one unit. It is stated that if an incident occurs at one unit in a year with the assumption that other three units remains under normal operation conditions, the cumulative effective dose due to radioactive releases from all four units of Akkuyu NPP adds up 72,3 μSv/year, which is less than the total dose quote of 100 μSv/year.

4.9.2 Review and Assessment of SPRv1

The guidelines used for review and assessment of this chapter in addition to general documents were given in Appendix I.

With the review and assessment [43], it has been determined that the utilization of SULTAN code for the analyses of maximum credible accident is not acceptable for its modelling inadequacies, topographical conditions were only considered for wind speed, but not for turbulence and deposition. Similarly, wet deposition and land-sea breeze were not considered. This analysis does not satisfy the expected atmospheric dispersion analysis requested by the License Conditions of Akkuyu Site License.

Regarding the emergency response measures, it has been determined that there were non-compliances with the regulations, and the emergency planning zones were not compatible with the National Radiation Emergency Plan. It was determined that the radiological consequences for given for only two age groups while more critical age groups were mentioned in the report, and the selection of these two groups was not justified. Additionally, information on selection of radiological criteria and justification of the selection, and results of some calculations were not provided in the report.

It was found that the DOZA-M used for modelling the normal operation conditions, does not consider the wet deposition, and IAEA based generic data were used for food and water usage, instead of local data.

It was determined that the results of the analyses were not given for appropriate and rational distances, the doses from onsite radioactive waste management facility were not considered as requested in License Conditions of Akkuyu Site License, and there were deficiencies in information and justifications provided.

In analyses of doses of fishermen, ingestion of terrestrial food, inhalation and external exposure from the plume and the ground were not considered, and no preliminary assessment was provided for possible events.

It has been determined that the information provided on the impact of radionuclides released to the sea during the normal operation conditions needs further explanations, and seafood consumption data used were not local.

No explanation was provided for dose constraints on liquid discharges, and no information was provided regarding the liquid discharges to the sea during normal operation.

There were no comments from IAEA mission or ACNS on this chapter, or no inspection issues.

All findings were communicated with the APC experts during the working group meetings, and provided to APC through electronic means.

4.9.3 Review and Assessment of SPRv2

The information provided with SPRv2 [7] were reviewed and assessed, and findings were discussed with the APC. It was agreed that the scenario of the maximum credible accident and the releases can be reconsidered together with preliminary safety analysis report due to uncertainties in design at this stage.

While the use of RECASS NT code instead of SULTAN enabled consideration of various effects requested, it was found that global meteorological data were used for wet deposition, breeze, rain and

topographical effects. The calculations based on global meteorological data was verified with calculations based on real site data, however, statistical incompatibilities were observed between the global and site data.

It was found that the issues regarding the use of SODAR data and related calculation procedures, and consideration of land-sea breeze were resolved, and findings were closed.

Most of the findings requesting additional explanations and justifications were also resolved and closed.

It was determined that the model methodology of considering wet deposition in DOZA-M has been changed to Elevated Simple Terrain Method for normal operation conditions. Additional explanation was requested regarding the suitability of DOZA-M since some calculation at the site border resulted in doses higher than the dose constraint defined as 10 µSv/y.

It was determined that the consumption data used for the dose calculations either considered the local data or demonstrated to be more conservative. Issue was considered as resolved. Additional information or explanations provided by APC resolved the issues or provided a rationale for closure of the findings.

The issue of preliminary dose assessment for anticipated operational occurrences were discussed in working group meetings and it was agreed that this issue may remain in general scope in the SPR since it has no effects on the site parameters, and has to be considered in detail within the scope of review and assessment of preliminary safety analysis report.

The findings of SPRv2 has been discussed during the process aiming to finalize the review and assessment with unofficial revisions of the chapter.

4.9.4 Review and Assessment of SPRv4

Some additional information subject to evaluation of the Authority was provided with SPRv4 only on this Chapter, and this information was reviewed [43]. It was found that all requested amendments to the SPRv4 were implemented and necessary information provided to comply with the regulations. It was found that this chapter has adequate information.

4.9.5 Conclusion

The review and assessment of this chapter could only be completed with the submission of SPRv4, resolving and closing the findings. There is no site related design parameter from this Chapter that need to be reflected to Chapter 13.

However, it has been concluded that;

a) Because of the incompleteness of design and absence of information to verify some issues, the review and assessment of the scenario of the maximum credible accident and the releases can be considered within the scope of the preliminary safety analysis report,

b) Radiological impact of the anticipated operational occurrences can be reviewed and assessed with the preliminary safety analysis report, since there is no direct impact of such incidents on site parameters, and

c) APC shall be expected to provide more representative and detailed simulation of the atmospheric dispersion on ANS site together with the preliminary safety analysis report.

These issues will be pursued by the Authority.

4.10. Emergency Planning

In this chapter of the SPR, APC is expected to determine the emergency planning zones, and provide information regarding the necessary infrastructure for and applicability of the emergency response plans.

4.10.1 Information Provided in SPRv1

With the SPRv1 [6], after a general introduction and a list of reference regulatory documents, the dimensions of emergency planning zones determined in Chapter 9 were given, and comparing these dimensions with the predefined dimensions given in URAP [44], it was stated that the zones remain within the dimensions given in URAP.

URAP provides definitions and dimensions for two emergency planning zones and two emergency distances. The Precautionary Action Zone is determined in URAP as about 5 km radius, with due consideration to the district and residential area borders, and local geography. The radius of Urgent Protective Action Zone is determined as around 20 km, the Extended Planning Distance is determined as 100 km and Ingestion and Commodities Planning Distance is determined as 300 km.

Population distribution with respect to different age groups were given for the Precautionary Action and Urgent Protective Action Zones, and residential areas and facilities like hospitals, schools, etc., were given in tables and figures. There are three villages and ANS's residential area within the Precautionary Action Zone, and partial territory of three townships, Gülnar, Silifke ve Aydıncık with 18 residential areas within the Urgent Protective Action Zone. Partial territory of Mersin, Antalya and Karaman cities, and Cyprus are within the Extended Planning Distance, for which the population and distribution information was provided. Within the Ingestion and Commodities Planning Distance, there are 13 cities in Turkey, whole Cyprus and partial territory of Syria. In this respect, there is no population center in terms of definition given in the regulation within the Precautionary Action and Urgent Protective Action Zones, and four population centers, Anamur, Erdemli, Mut and Silifke, within 100 km radius.

It has been stated within the scope of demography that the existing infrastructure was investigated for applicability of three main protective actions, namely sheltering, evacuating and using iodine pills, and no facility was found suitable for sheltering and hence the evacuation would be the applicable solution. It has also been stated that the highways is the only method of evacuation.

It has been claimed in the report that the main obstacle in taking emergency measures and bringing in the intervention teams and equipment would be the insufficiencies in highway infrastructure, and main natural disaster that may have an impact of implementation of emergency measures is the earthquake.

The subsections from 7 to 11 of this Chapter has been resubmitted as interim revision due to translation problems to the extent of unreadable text, and these are reviewed and assessed as part of SPRv1. Impacts of emergency situations and intervention targets were given in these section,

explaining the emergency measures. Information was provided regarding the off-site emergency plans, measures for protecting the plant personnel and operation centers to be used for emergency measures of ANS. Additionally, the measures for monitoring the radiation levels in accident conditions, and for prevention and mitigation of the accidents were introduced, and information was provided on emergency alarm system.

As a consequence, APC stated that the site is suitable for implementation of the emergency measures, the transportation infrastructure need to be enhanced, human, material and equipment resources can be provided to site via highways and sea routes in case of emergency, and emergency plans shall be updated within the scope of URAP.

4.10.2 Review and Assessment of SPRv1

In review and assessment of this chapter, the Regulation on Disaster and Emergency Intervention Services, and a set of IAEA guidelines given in Appendix I were used in addition to general regulatory documents.

According to the review and assessment [45], main findings are inconsistencies in information given in tables, insufficient information and translational problems. It was determined that the hotels in the region was completely ignored in emergency measures, classification of emergency situations does not comply with the regulations. Some important information was given without any reference or justification.

There was no comments on this chapter from IAEA mission or ACNS review or no findings from inspections. In this respect, the findings were communicated with APC experts in working group meetings and provided to them through electronic means.

4.10.3 Review and Assessment of SPRv2

With the review and assessment of SPRv2 [7], it has been found that issues regarding absent information and inconsistencies in referencing and data were resolved to the satisfaction. However, it has been determined that the emergency zones were established based on the Russian regulations and IAEA documents instead of URAP, which is considered as non-compliance, and information regarding the schools and health centers within 20 km were not provided. These findings together with a few more of lesser importance were communicated to APC for providing solutions.

APC has provided the all the conclusions regarding the development of emergency plans and implementation of the intervention in case of emergency, and measures to be taken. Among them, APC emphasized the importance of further development of transportation infrastructure in precautionary Action and Urgent Protective Action Zones to facilitate the emergency management, pledged the use of URAP in development of emergency plans, and stated that the Akkuyu site has no rejection characteristics regarding emergency situations.

During the review and assessment, interim revisions were used in this chapter and all issues were resolved.

4.10.4 Conclusion

The SPRv4 was controlled and found that it contains all interim revisions. It was concluded that the information provided in the report regarding emergency issues were in line with the regulatory

documents. The site related design parameters of this chapter were reflected to the chapter 13 consistently.

4.11. Electrical Systems

APC is expected to provide information on connection to national grid, transmission lines, main characteristics of national grid and power supply to the plant itself.

4.11.1 Information Provided in SPRv1

With SPRv1 [6], information on capacity, source distribution and network load of the national grid, and total transmission lines and international connections were provided together with the growth estimations. The control points of the grid, control software and normal operating conditions of the grid were also provided in the report. It was stated that the system frequency is controlled within ± 0.2 Hz band around 50 Hz under normal operating conditions and operating frequency shall not be exceeded for longer than 10 minutes. The requirements of the Electricity Market Grid Regulation were also given.

It has been stated that the ANS will be connected with six lines to 380 kV and with two lines to 154 kV transmission lines of the grid, presenting the connection points in a map. The expected commissioning dates of these transmission lines were also provided in the report.

Information has been provided for the equipment for transmitting the electricity to the grid and their technical properties. It has been stated that the plant provide electricity to grid over two switchyards, each serving two units of the plant. Measures taken for simultaneous outage both switchyards were also given.

The national grid with 64 GW installed capacity and considering its existing and projected transmission lines of 380 kV and 154 kV, transformer capacities, existing load distribution system and integration with European grid ENTSO-E, was given as a reliable off-site power supply.

Additionally, it has been stated that the six lines connecting the plant to 380 kV transmission lines at west and north of the grid and two short lines of 380 kV connecting the plant to 154 kV transmission lines through 380/154 autotransformers provides adequate redundancy for a reliable power source. It was also stated that the operation of any unit in island mode in case of loss of all connections from both switchyards to outside will be allowed to ensure providing emergency power to all units.

It was stated that transmission of power to the grid would be maintained in full, even if any two equipment (generator, transmission line, transformer or autotransformer) were lost simultaneously, because of the use of N-2 criteria.

To verify the safe operability of the plant as connected to the national grid, it was stated that reliability analysis of the national grid will be performed and the result will be provided at the design stage.

4.11.2 Review and Assessment of SPRv1

In review and assessment of this chapter, IAEA safety guide NS-G-1.8 (App. I) on emergency power systems was used in addition to general regulatory documents.

With the review and assessment [46], it has been found that requirements on the frequency and voltage control of national grids extents only up to 770 MW load or loss of generation, and two

switchyards of ANS were electrically connected while they are physically separated. It has been determined that no analysis provided for fluctuations in frequency and voltage when one or more of 1200 MW units were lost under these conditions.

According to IAEA criteria, at least two transmission lines shall be provided to connect the plant to the grid provided that they meet national grid at different points on different networks to ensure independency and to avoid common cause failures in two or more transmission lines. It was determined that there is no information or analysis to demonstrate the compliance with this criteria and information provided was not based on any analysis. It should be demonstrated that the transmission lines are independent enough to avoid common cause failures and that the plant can be operated safely while connected to the national grid. To demonstrate that load flow and stability analysis of the national grid shall be performed and the results need to be submitted at the design stage.

Schematics of only one 380 kV transmission line was provided in the report to show the connection to the grid, stating that this is a draft and will be modified based on the need arises from the load flow and stability analysis performed later. Therefore, the configuration of the connection to the grid and results of load flow, stability and reliability analyses will be reviewed at design stage.

There was no comment on this chapter from IAEA mission or no findings from inspections.

However, ACNS pointed out that the off-site power need of the plant was not defined clearly, it could not be understood why the necessary voltage was provided by going up to 380 kV and then decreasing down, there is no regulation regarding the switchyard, and no information provided regarding emergency power need and operation. Additionally, ACNS stated that there is no information regarding the electricity trade with neighboring countries and stressed some issues regarding the use of switchyards. These last issues mentioned by ACNS was considered as out of scope of the SPR and were not considered during the review and assessment.

In this respect, the findings were communicated with APC experts in working group meetings and provided to them through electronic means.

4.11.3 Review and Assessment of SPRv2

It has been identified that all modifications requested was implemented [46] in SPRv2 [7].

4.11.4 Conclusion

Basically, the review and assessment of this chapter has been completed with SPRv2, and all issues were resolved and closed. SPRv4 was also controlled for existence of any further modifications.

Followings were determined as issues that need to be provided with the preliminary safety analysis report [46];

a) Results of the load flow, stability and reliability analyses, and configuration of connection to the grid, and

b) Provision of results and evaluations of above mentioned analyses demonstrating the transmission lines providing power to the plant are independent enough to avoid common cause failure and safe operability of the plant while in connection with the grid.

These issues will be pursued by the Authority.

4.12. Additional Information

In this chapter, APC is expected to provide information on the measures taken within the scope of lessons learned from the Fukushima Daiichi Accident.

With SPRv1, APC provided a brief description of the accident and information about the organizations that were participated in accident management, and their roles. The Action Plan of IAEA was introduced together with the studies performed by the World Association of Nuclear Operators and European Nuclear Safety Regulators Group.

Finally, the measures taken by IAEA member states and the Russian Federation were described.

Since this chapter was considered as informative only, it was not reviewed by the Authority. However, the site related issues among the lessons learned from the Fukushima accident were paid more attention during the review and assessment, and measures were taken to ensure that the site related design parameters were determined in the light of these lessons. Particularly, the tsunami study and safety margins are strongly effected from this consideration.

4.13. List of Site Parameters and Exact Values

This chapter of the SPR contains a summary of parameters that need to be considered in design of the plant and their values. It is a compilation of results of detailed site investigations introduced in earlier chapters. In this respect, this chapter was not reviewed separately but controlled to ensure that the information determined elsewhere of the SPR were consistently reflected here.

Section 5 Conclusion

The site stage consists of two sub stages according to the national regulations. After the Site License is granted as a result of first stage, in Akkuyu case after the endorsement of the Updated Site Report, the applicant is expected to continue with the detailed site investigations to determine the exact values of site related design parameters, and to submit the results of the detailed site investigations and exact values of the site related design parameters to the approval of the Authority. These parameters shall be used in site specific design of the nuclear power plant after the approval.

Since the site stage is completed with the approval of site parameters, ensuring the compliance with the decree and all other relevant regulations was targeted. Another target was to ensure that the site related design parameters were derived with appropriate methods, assumptions, data and software, appropriately analyzed and determined. The review and assessment was performed in this framework.

The issues tackled before in Updated Site Report, such as bad translation, poor justification and referencing, was encountered again in Site Parameter Report submitted in December 2014. SPR was found far from the demonstration of adequacy of the investigations and proper presentation of the results and justification. The main findings of the review of Advisory Committee on Nuclear Safety and the IAEA experts were the same inadequacies.

The findings of the review and assessment of the site group, considering the suggestions of the ACNS and IAEA team, were the main tool to discuss the issues regarding the results of detailed site investigations and site related design parameters. These findings were extensively discussed in detail in working group meetings, held frequently from time to time. Additionally, within the scope of absent

information in version one of SPR, implementing the hydrogeological studies and some analyses, requested earlier by the License Conditions for Akkuyu Site License, requested again and these activities were monitored with a comprehensive inspection program.

The first version of SPR submitted in December 2014 was updated to version two in December 2015. However, it was found that the studies were not reflected in second version also, and discussion of the findings, including the findings of second version, continued in working group meetings. While there were chapters completed with second version, discussions on some issues like meteorology, seismic hazard analyses and tsunami studies were continued. During the review and assessment of the second version, some parts of the SPR were updated without increasing the version number, and updated texts were also reviewed and assessed by the Authority experts.

The third version, submitted prior to completion of discussions on the second version, was not reviewed on consideration of causing undue delays in review and assessment, and discussions were continued based on the findings of version two. After mutual agreement reached on all issues, version four of SPR was submitted in January 2017, reflecting all amendments. The review and assessment of this version was kept on the level of control of inclusion of all amendments agreed on.

The SPR was brought up to the full compliance with the provisions of the national and international regulations and suggestions of the guidelines (App. I) based on the review and assessment and with the amendments. It was concluded that the detailed site investigations and their results, and the site related deign parameters reflected to the Chapter 13 of the report are adequate.

On the other hand, the experts of the Authority agreed that resolution of some of the issues could not be achieved at this stage based on the justification provided by APC or because of the characteristics of the issues. These issues were noted to be pursued by the Authority in due time after the approval. These issues were separately listed under the conclusion part of each subheading of Chapter four of this report.

Within this context, Department of Nuclear Safety, concluding that the SPR meets all provisions of the national regulations, IAEA documents and Russian Federation documents, that the detailed site investigations and analyses are acceptable in terms of methods, data, assumptions and results, and that the site related design parameters given in Chapter 13 of SPR are adequate, prepared this report to establish a basis to the approval of the Site Parameters Report and site related design parameters in accordance with the Decree [1].

References

1. Decree on Licensing of Nuclear Installations, Official Gazette dated 19.12.1983 and no: 18256
2. License Conditions for Akkuyu Site License, 13.10.2011
3. Basic Report for Akkuyu NPP Site, AKU.C.010.&.&&&&&.&&&&.002.HC.0004, Revision 1, Moscow, May 2013
4. License Conditions for Akkuyu Site License, Rev. 1, 13.12.2013
5. Report on Sufficiency Control of ANS Site Parameters Report, ANS.S.GRSG.033, B. Sayın, M.B. Öztemiz, R. Terzi, K. Öney, A. Kara, 05.12.2014
6. Akkuyu NPP Site Parameters Report, AKU-BDD0132 Rev B01, 23.12.2014
7. Akkuyu NPP Site Parameters Report, AKU-BDD0132 Rev B02, 30.12.2015
8. Akkuyu NPP Site Parameters Report, AKU-BDD0132 Rev B04, 31.01.2017
9. Regulation on Nuclear Power Plant Sites, Official Gazette dated 21.03.2009 and no: 27176
10. Guidelines on Format and Content of Site Report for Nuclear Power Plants, 10.12.2009
11. NP-064-05 Consideration of External Natural and Man-caused Impacts on Projects of Nuclear Power Application, June 2011, (251-07.07.2011)
12. NP-032-01 Nuclear Power Plant Siting - Main Criteria and Safety Requirements, 2001
13. NS-R-3 Site Evaluation for Nuclear Installations, IAEA Safety Requirements, 2003
14. Guidelines on Specific Design Principles, 29.06.2012
15. Inspection Report 2012-ANS-01, NGD, 12.07.2012
16. Inspection Report 2012-ANS-02, NGD, 08.10.2012
17. Mission Report on Technical Visit to Akkuyu Site on 05-06 Oct. 2012, October 2012
18. Inspection Report 2012-ANS-03, NGD, 08.11.2012
19. Mission Report on Technical Visit to Akkuyu Site on 16 May 2013, May 2013
20. Mission Report on Technical Visit to Akkuyu Site on 27-28 June 2013, June 2013
21. Mission Report on Technical Visit to Akkuyu Site on 17-18 Apr. 2014, April 2014
22. Inspection Report 2014-ANS-01, NGD, 27.06.2014
23. Mission Report on Technical Visit to Akkuyu Site on 1 Oct. 2014, October 2014
24. Mission Report on Technical Visit to Akkuyu Site on 19 Mar. 2015, March 2015
25. Inspection Report 2015-ANS-01, NGD, 24.04.2015
26. Inspection Report 2015-ANS-02, NGD, 14.05.2015
27. Mission Report on Technical Visit to Akkuyu Site on 28-29 Apr. 2015, May 2015
28. Mission Report on Technical Visit to Akkuyu Site on 13-14 May 2015, May 2015
29. Inspection Report 2015-ANS-03, NGD, 04.06.2015
30. Inspection Report 2015-ANS-04, NGD, 28.07.2015
31. Opinion Paper of ACNS on “Akkuyu NPP Site Parameters Report” (SPR) prepared by Akkuyu Nuclear JSC dated December 2014, March 2015
32. Site and External Events Design (SEED) Review Mission, Review of the Akkuyu NPP Site Parameter Report, 18-20 Feb. 2015, International Seismic Safety Centre, UAEA
33. Review and Assessment Report ANS.S.GSG.034, A. Kara, February 2017
34. ANS.S.GSG.034-Ek 1: ANS.S.GSG.034.05, S. Köse, February 2017
35. ANS.S.GSG.034-Ek 2: ANS.S.GSG.034.06, G. Gökeri, Y. Gülay, B. Uçak, M.N. Aksoy, February 2017
36. ANS.S.GSG.034-Ek 3: ANS.S.GSG.034.07, B. Sayın, February 2017
37. ANS.S.GSG.034-Ek 4: ANS.S.GSG.034.08, M.N. Aksoy, L.Ö. Ünver, February 2017
38. ANS.S.GSG.034-Ek 5: ANS.S.GSG.034.09, B. İşcan, February 2017
39. Rizzo, “Draft Initial Seismic Inputs Report Akkuyu Nuclear Power Plant Site Deliverable 3.5” Paul c. Rizzo Associates, Inc. 500 Penn Center Boulevard, Suite 100 Pittsburgh, Pennsylvania USA 15235 Project No. 11-4545 November 23, 2011
40. ANS.S.GSG.034-Ek 6: ANS.S.GSG.034.10, B. Güner, February 2017

41. ANS.S.GSG.034-Ek 7: ANS.S.GSG.034.11, S. Ünlü, Ocak 2017
42. ANS.S.GSG.034-Ek 8: ANS.S.GSG.034.12, B. Güner, January 2017
43. ANS.S.GSG.034-Ek 9: ANS.S.GSG.034.13, E.T.Demir, G. Gökeri, Ö. Ünver, Y.Gülay, February 2017
44. National Radiation Emergency Plan, Draft Approved by Atomic Energy Commission, 2015
45. ANS.S.GSG.034-Ek 10: ANS.S.GSG.034.14, G. Gökeri, February 2017
46. ANS.S.GSG.034-Ek 11: ANS.S.GSG.034.15, M. Doğan, January 2017

Appendix I. The Regulations Used for Review and Assessment of Site Parameters Report

General

- Decree on Licensing of Nuclear Installations, 1983
- License Conditions for Akkuyu Site License, Rev. 1, 2013
- Regulation on Nuclear Power Plant Sites, 2009
- Guidelines on Format and Content of Site Report for Nuclear Power Plants, 2009
- NS-R-3 Site Evaluation for Nuclear Installations, IAEA Safety Requirements, 2003
- NP-064-05 Consideration of External Natural and Man-caused Impacts on Projects of Nuclear Power Application, Russian Federation, 2011,
- NP-032-01 Nuclear Power Plant Siting - Main Criteria and Safety Requirements, Russian Federation, 2001
- Guidelines on Specific Design Principles, 2012

Chapter 3 Nearby Industrial Installations and Activities

- NS-G-3.1, External Human Induced Events in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series, 2001

Chapter 4 Meteorology

- SSG-18, Meteorological And Hydrological Hazards In Site Evaluation For Nuclear Installations, IAEA Safety Standard Series, 2011
- NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standard Series, 2002.
- SanPin 2.6.1.24-03, Sanitary rules for designing and operation of NPP, Russian Federation
- Sppnae-87, General Requirements to the Scope of Investigation and Survey for a Place For NPP Site Selection, Russian Federation, 2000
- RB-022-01, Recommendations on Evaluation of Tornado Characteristics for Nuclear Facilities, Russian Federation, 2001.
- SNiP 23-01-99, Construction Regulations, Russian Federation
- SP 20.13330.2011, Loads and effects, Updated revision of SNiP 2.01.07-85*. - M., Russian Federation, 2011

Chapter 5 Hydrology

- SSG-18, Meteorological And Hydrological Hazards In Site Evaluation For Nuclear Installations, IAEA Safety Standard Series, 2011
- NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standard Series, 2002.

Chapter 6 Geology, Geophysics and Seismology

- SSG-18, Meteorological And Hydrological Hazards In Site Evaluation For Nuclear Installations, IAEA Safety Standard Series, 2011
- NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standard Series, 2002.
- SSG-9, Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standard Series, 2010
- NS-G-3.6, Geotechnical Aspects of Site Evaluation and Foundations for NPPs, IAEA Safety Standard Series, 2004

Chapter 7 Ecological Effects

- NS-G-1.5, External Events Excluding Earthquakes in the Design of Nuclear Power Plants, IAEA Safety Standard Series, 2003

Chapter 8 Human Induced External Events

- NS-G-3.1, External Human Induced Events in Site Evaluation for Nuclear Power Plants, IAEA, 2002
- NS-G-1.5, External Events Excluding Earthquakes in the Design of Nuclear Power Plants, IAEA Safety Standard Series, 2003
- Regulatory Guide 1.91, Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants, Rev.2, US NRC, April 2013
- RD 52.04.253-90, Methodology of Predicting the Extent of Contamination with Highly Toxic Substances at Accidents (Destruction) on Chemically Hazardous Facilities and Transport, Russian Federation, 1990
- RD 31.03.01-90, Technical and Economic Characteristics of the Navy Ships, Russian Federation, 1991

Chapter 9 Radiological Impact of the Plant

- GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standard Series, 2015
- GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standard Series, 2007
- Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor, IAEA EPR-NPP, 2013
- NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series, 2002
- Generic Models for use in Assessing the Impact of Discharges of Radioactive Substances to the Environment, IAEA Safety Report Series No. 19, 2001
- SanPin 2.6.1.24-03. Sanitary Rules of Designing and Operation of NPP, (SP AS-03), Russian Federation, 2003

- Main Sanitary Regulations to Ensure Radiation Safety (OSPORB – 99/2010) Sanitary Norms and Regulations SP 2.6.1.2612-10, Russian Federation, 2010 (Revision 2013)
- Radiation Safety Standards (NRB-99/2009): Sanitary Regulations and Standards SanPiN 2.6.1.2523-09-09, Russian Federation, 2009

Chapter 10 Emergency Planning

- Disaster and Emergency Intervention Services Regulation, 2013
- GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standard Series, 2015
- GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standard Series, 2007
- GSG-2, Criteria for use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standard Series, 2011
- Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor, IAEA EPR-NPP, 2013

Chapter 11 Electrical System

- NS-G-1.8, Design of Emergency Power Systems for Nuclear Power Plants, IAEA Safety Standard Series, 2004