**Summary of Recent U.S. Nuclear Regulatory Commission Training
Related to Risk-Informed Decision-Making for Managers and Staff**

This enclosure responds to Commission direction in staff requirements memorandum (SRM) M170511 to "summarize the current mandatory training requirements related to risk-informed decision-making for managers and staff." As noted in the Commission paper, training requirements for staff are currently included in several voluntary certificate programs and mandatory position-specific qualification programs, referenced in the left-hand column of the table as follows:

1)   The PRA Certificate Program, which is available to all staff but not required.
2)   The Risk-Informed Thinking Certificate, which is available to all staff but not required.
3)   Office of Nuclear Reactor Regulation (NRR) Office Instruction ADM-504, "Qualification Program," Revision 3, Enclosure 2, "General Qualification Requirements and Forms," dated September 6, 2013, which is required for all new NRR staff.
4)   Office of Nuclear Regulatory Research (RES), Division of Systems Analysis, Accident Analysis Branch, "MELCOR Accident Consequence Code System Analyst Training and Qualification Plan," Version 2.0, dated September 29, 2015, which is required for qualifying staff in the relevant branch.
5)   NRR Office Instruction ADM-504, Revision 3, Appendix M, "Branch Specific Qualifications for Reliability and Risk Analysts in the Office of Nuclear Reactor Regulation," dated September 6, 2013, which is required for qualifying staff in the relevant branches.
6)   Inspection Manual Chapter (IMC) 1245, "Qualification Program for New and Operating Reactor Programs," Appendix C-9, "Senior Reactor Analyst Training and Qualification Program," dated November 24, 2015, which is required for qualifying Senior Reactor Analysts.
7)   NRR Office Instruction ADM-507, "'Grow Your Own' PRA Analyst Training Qualification Program," dated November 1, 2012, which is required for staff who are selected for the "Grow Your Own" program in NRR.
8)   IMC 1245, Appendix D1, "Maintaining Qualifications," dated November 24, 2015, which provides continuing training requirements for all NRC inspectors qualified after September 2, 2005.
9)   Office of New Reactors (NRO) Office Instruction NRO-PER-105, "Qualification and Training Program," Revision 2, Appendix E, which requires qualifying construction reactor oversight specialists or engineers to take one of the two specified classes.
10)   IMC 1245, Appendix A, "Basic-Level Training and Qualification Journal," dated August 24, 2017, which is required for qualifying power reactor and construction inspectors only.
11)   NRO, Division of Safety Systems and Risk Assessment, Probabilistic Risk Assessment and Severe Accident Branch, Reliability and Risk Analyst Training Plan, dated December 15, 2010, which is required for qualifying staff in the relevant branch.
12)   NRO, "'Grow Your Own' PRA Analyst Qualification and Training Program," dated July 8, 2015, which is required for staff who are selected for the "Grow Your Own" program in NRO.

The table also includes additional training activities that are not typically required for staff, but which demonstrate the breadth of RIDM-related training that exists to draw on as a knowledge base. As noted in the Commission paper, no specific RIDM training is currently required of supervisors and managers, but a training course is being developed.

Training Item[a]	Audience	Description
Introductory Courses *The U.S. Nuclear Regulatory Commission (NRC) designed these courses to introduce staff to risk-informed decision making (RIDM) and probabilistic risk assessment (PRA) techniques.*		
Risk-Informed Regulation for Technical Staff (P-101)[*,1,2]	All Staff	This course introduces students to the concept of risk-informed regulation as it primarily applies to nuclear power plant regulation. The course presents the NRC's policy for integrating risk information with deterministic insights and discusses the many applications of risk information at the NRC. Students are introduced to the basic elements of a PRA, the insights that technical reviewers can gain from PRA, and the ways that risk analysts compensate for uncertainty. This course also addresses the topic of risk communication. Note: This course is not required by NRO-PER-105, but is offered as an alternative, more efficient means to conduct the individual study activity on risk-informed regulation.
PRA Basics for Regulatory Applications (P-105)[*,1,2,3,4,5,6,7,9,10,12]	All Staff	This course addresses the special needs of the regulator who requires knowledge of PRA issues and insights to better evaluate the effects of design, testing, maintenance, and operating strategies on system reliability. The course presents a full range of PRA topics in abbreviated form with the goal of introducing the regulatory staff to basic concepts and terminology in PRA. It presents the overall PRA methodology along with several PRA applications used within the regulatory agency framework for evaluating plant safety issues.
PRA Technology and Regulatory Perspectives (P-111)[*,1,2,3,4,5,6,7,8,9,11,12]	Reliability and Risk Analysts, NRC Inspectors, Senior Reactor Analysts (SRAs), and All Staff	This course addresses the special needs of regional inspectors, resident inspectors, and reliability and risk analysts who require knowledge of reactor PRA issues and insights to better evaluate the effects of design, testing, maintenance, and operating strategies on system reliability. The course concentrates on using reactor PRA results in inspection planning, monitoring licensee performance, and reviewing licensee risk-informed submittals.
Risk Informed-Thinking Workshop[1,2]	All Staff	This workshop provides students with a hands-on experience in applying a RIDM framework to agency work examples. After a brief refresher of risk-informed concepts, senior agency staff will lead working sessions using scenarios of practical agency work. Students will work in groups following the RIDM framework to make and communicate recommendations. This workshop experience may enable students to apply the framework to their work. By the end of this workshop, the participant will be able to do the following: • Discuss how risk information can be used to (1) complement the traditional evaluation approaches and (2) focus the evaluation process for effectiveness and efficiency. • Communicate and apply the RIDM process to agency work.

Training Item[a]	Audience	Description
Risk-Informed Thinking Workshop Introduction	All Staff	This recorded online training session features various agency leaders discussing RIDM topics and perspectives. December 15, 2016: William Dean, Director, Office of Nuclear Reactor Regulation (NRR), discusses the importance of engineering RIDM in the agency to ensure safety determinations are made in a holistic manner. Gary Holahan, Chief Technical Advisor, Office of the Executive Director of Operations, presents a walk-through history of PRA from a personal perspective. April 24, 2017: Michael Weber, Director, Office of Nuclear Regulatory Research (RES), discusses the importance of risk-informed thinking and explains how RES contributes to advance the agency's efforts. August 2, 2017: Mark Dapas, Director, Office of Nuclear Material Safety and Safeguards, discusses the importance of risk-informed thinking and decisionmaking in the agency based on his regional and headquarters experiences.
Achieving Basic Level in PRA Competency Model[2]	All Staff	This learning activity develops the students' skills and knowledge to perform basic PRA assignments successfully. The PRA Competency Model defines a five-level proficiency rating, from Learning Level 1 to Expert Level 5. The PRA Competency Model provides flexibility in achieving a particular level based on training, experience, and interest. Achieving Basic Level 2 in all tasks in the PRA Competency Model shows that the student has a basic proficiency in performing a PRA job.
PRA Certificate Program Rotation Assignment[2]	All Staff	This rotation assignment is the last learning activity in the PRA Certificate Program. The objective of this activity is for the student to gain work experience in a branch that applies PRA methodology within the agency.
Risk-Informed Thinking Individual Study Activity[1]	All Staff	This individual study activity is the last learning activity in the Risk-Informed Thinking Certificate Program. The participant completes a worksheet activity associated with applying a RIDM framework.
Fuel Cycle Process Seminar (F-201)	All Staff	This 5-day course provides an overview of the nuclear fuel cycle from uranium mining to waste disposal. It covers conventional uranium mining and uranium recovery through in situ leach extraction, uranium conversion, uranium enrichment, fuel fabrication, and waste disposal. It also covers special topics such as radiological (including criticality) and chemical hazards associated with fuel cycle operations and the purpose and scope of the associated integrated safety analysis.

Training Item[a]	Audience	Description
Courses for NRC Managers		
Perspectives on Risk-Informed Decision-Making for NRC Managers	NRC Managers	This course for NRC managers focuses on practical applications of PRA and how risk insights can inform decision-making. Topics include RIDM from a regulatory and historical perspective, basic PRA techniques, and external stakeholder uses and perspectives on RIDM and risk assessment tools. This course is currently under development.
NRC Significance Determination Process (SDP) Decision-Making	NRC Senior Managers	This course provides an overview of the Significance Evaluation Review Panel (SERP) process and is intended for use by Senior Executive Service Managers who may be assigned to a role on a SERP. The course consists of three modules. The first is the SERP process module, which all registered users must complete. The other modules serve as a refresher and are optional. The modules include a review of PRA basics and RIDM.
Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision-making	Managers and All Staff	The course conveys a high-level understanding of the content in NUREG-1855, "Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decisionmaking," Revision 1, issued March 2017, such that participants can identify the importance of uncertainties in decision-making, identify key concepts associated with RIDM, identify types of uncertainties, and identify the approach used to treat PRA uncertainties in decision-making.
Core Courses for Reliability and Risk Analysts and SRAs		
Bayesian Inference in Risk Assessment (P-102)[5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course presents selected quantitative concepts from the fields of probabilistic modeling, statistics, and reliability theory that arise frequently in PRA. Through lecture and practical workshop problems, the course presents participants with mathematical techniques from probability and statistics that have applications in current PRA practices. The topics covered include a review of classical probability and statistics, selected distributions important to PRA, uncertainty analysis techniques, and Bayesian analysis.
System Modeling Techniques for PRA (P-200)[5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course develops advanced user-level skills in performing event tree and fault tree analysis, with numerous practice workshops. The course covers the calculation of initiating event frequencies, component failure rates and probabilities, fault tree and event tree sequence results, importance measures, uncertainty, and common-cause failures. The course covers dependent failure analysis details by presenting the estimation of common-cause failure probabilities through basic parameter, beta factor, multiple Greek letter, and alpha factor methods.

Training Item[a]	Audience	Description
Systems Analysis Programs for Hands-on Integrated Reliability Evaluation (SAPHIRE) Basics (P-201)[5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course provides hands-on training in the use of the SAPHIRE software to perform PRA analysis. Participants learn how to input event tree and fault tree models, initiating event frequencies, and basic event failure data including uncertainty parameters to generate risk results using SAPHIRE. The course explains how to generate risk results and reports of fault tree and event tree minimal cut sets, quantification, uncertainty, and importance measures.
Advanced SAPHIRE (P-202)[5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course provides hands-on training in the advanced features of SAPHIRE software to perform PRA analysis. Participants will learn advanced features such as flag sets, advanced basic events (i.e., template, compound, common-cause, and human error events), and various rule editors (i.e., event tree linking, recovery, and partition rules).
Human Reliability Assessment (HRA) Course (P-203)[5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course provides an introduction to HRA with respect to PRA applications. Presentations cover a broad introduction to the HRA methods used in modeling human errors and the various methods of estimating human error probabilities. HRA strengths, limitations, and results are covered.
External Events (P-204)[5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course covers how external events such as fires, floods, earthquakes, high winds, and transportation accidents are analyzed within a PRA. The course covers how external events were addressed in the Individual Plant Examination of External Events as well as how recent probabilistic methods for external events are analyzed in the Standardized Plant Analysis Risk Models.
Accident Progression Analysis (P-300)[4,5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course covers the analysis performed as part of the Level 2 PRA. The course addresses accident phenomenology under post-core damage conditions and presents the development of the Level 2 PRA model for the severe accident regime. This course emphasizes what a Level 2 PRA analysis requires, not how specific modeling software is used.
Accident Consequence Analysis (P-301)[4,5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course covers the analysis performed as part of the Level 3 PRA. The course addresses environmental transport of radionuclides and the estimation of offsite consequences from core damage accidents. This course primarily emphasizes important modeling issues and describes how they are dealt with; it also explains how to use specific modeling software. The course covers hands-on modeling examples using the MELCOR Accident Consequence Code System software code.

Training Item[a]	Audience	Description
Risk Assessment in Event Evaluation (P-302)[4,5,6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	This course covers the use of PRA models and the techniques used to assess the risk significance of initiating events and condition assessments. The course addresses the use of PRA models to estimate conditional risk measures for situations that existed at the time of an incident. The course covers the theoretical framework and the key issues that need to be considered for both initiating event and condition assessments. The course covers modeling issues that arise while modifying initiating event or basic event values, or both, and their impact on common-cause failure and recovery event values. Participants learn how to use the SAPHIRE software to perform the various types of event evaluations related to the NRC's SDP; Management Directive 8.3, "NRC Incident Investigation Program," approved June 25, 2014; and the Accident Sequence Precursor Program.
Advanced Risk Assessment Topics (P-501)[6,7,11,12]	Reliability and Risk Analysts, SRAs, and All Staff	The primary objective of this course is to provide a hands-on approach to the investigation and application of a variety of advanced risk assessment methods, tools, and techniques. The course discusses various selected risk assessment topics and then provides hands-on applications through example exercises. As a result of these hands-on exercises, the student will become more proficient with Bayesian methods and the use of tools such as the SAPHIRE software, Microsoft Excel, and OpenBUGS for numerical analysis.
Bayesian Inference in Risk Assessment Advanced Topics (P-502)[6,7]	Reliability and Risk Analysts, SRAs, and All Staff	This course explores advanced applications of Bayesian statistical inference in risk assessment through lectures and hands-on case studies using OpenBUGS and SAPHIRE software.
Courses and Recent Workshops on Application-Specific Topics in RIDM and PRA		
Probabilistic Flood Hazard Assessment Workshop	NRC Probabilistic Flood Hazard Technical Staff	This workshop brought together staff in RES, NRR, and Office of New Reactors (NRO) along with RES contractors to review progress in the NRC/RES probabilistic flood hazard assessment (PFHA) research program. The RES staff and contractors presented the overall scope of the program and work performed in individual projects. The NRO and NRR staff presented the needs of licensing office staff members who work on flooding hazard and risk assessments. This workshop included the following sections: • Section I, "NRC/RES PFHA Research Program Overview" • Section II, "Climate" • Section III, "Precipitation" • Section IV, "Riverine and Coastal Flooding Processes" • Section V, "Plant Response to Flooding Events"

Training Item[a]	Audience	Description
Seismic PRA/ Seismic Margin Assessment Methods	NRC Technical Reviewers of Seismic PRA or Seismic Margin Assessments	This course familiarized the staff with seismic probabilistic risk assessment (SPRA) and seismic margin assessment (SMA) methods and prepared the staff members to efficiently review licensees' responses to Near-Term Task Force (NTTF) Recommendation 2.1 as they related to the expedited approach and subsequent SPRA/SMA evaluations. In addition to providing an understanding of the general approaches and considerations involved in the conduct of an SPRA and SMA, the course covered some specialized topics and approaches that are specific to NTTF Recommendation 2.1 responses (e.g., provisions of seismic evaluation guidance; screening, prioritization, and implementation details; the NRC's SMA interim staff guidance). The attendees developed an understanding of the critical areas of review that involve major uncertainties; judgments (e.g., when to use existing structural models versus new response analysis); and potential pitfalls (e.g., inadequate screening or misuse of generic data) that can affect the results and insights.
Severe Accident Progression Seminars	All Staff	This seminar series summarizes the state-of-the-art in severe accident progression, containment response to severe accident challenges, and source terms. It includes nine seminars on severe accident progression.
Electric Power Research Institute (EPRI) HRA Calculator Training	Reliability and Risk Analysts, SRAs, and All Staff interested in HRA	This course describes HRA theory, process, and requirements including the types of operator actions; the identification, screening, definition, and quantification of human error probabilities; American Society of Mechanical Engineers PRA high-level standards; and the development, quantification, and documentation of human failure events using the EPRI HRA Calculator Version 5.1. The application scope includes internal events HRA and fire HRA.
Human Reliability Analysis for Materials Safety and Waste Management (P-406)	All Staff Interested in HRA for Nuclear Materials and Radioactive Waste Applications	This course serves as an introduction to HRA for nuclear materials and radioactive waste applications. This course provides an overview of HRA, introduces the concepts and methods useful in examining human error, sensitizes the staff to recognize the need and importance of HRA in its daily work, and reviews the contribution of human error to selected events for nuclear materials and radioactive waste applications. As part of this overview, the course introduces students to key components of HRA (e.g., error taxonomies, performance shaping factors and context, error identification, error modeling, error quantification). This course also introduces various methods for estimating human error probabilities and discusses HRA strengths, limitations, and results.

Training Item[a]	Audience	Description
Inspector Training on Risk-Informed Completion Times	NRC Inspectors and All Staff	This Web-based course provides training related to Risk Management Technical Specification Initiative 4b, "Risk-Informed Completion Times [RICT]," in four 10-minute modules. The first gives an overview, while the second provides information on the RIDM process. The third describes the risk calculations involved in RICTs. The final module provides inspector tips. This material is based on the Nuclear Energy Institute's Topical Report NEI 06-09, "Risk-Informed Technical Specifications Initiative 4b, Risk-Managed Technical Specifications (RMTS) Guidelines," Revision 0, issued November 2006, and its related safety evaluation (Agencywide Documents Access and Management System Accession No. ML12286A322). Upon completion of these modules, the learner will have a fundamental understanding of the safety bases and application of risk-informed completion times, risk-management actions, and their limitations.
NRC Inspection Manual Chapter (IMC) 0609 Appendix F Fire Protection SDP Training (P-108)	NRC Inspectors and SRAs	This course introduces the methodology described in Appendix F to the NRC (IMC) 0609, "Fire Protection Significance Determination Process." Students learn the underlying theory of this SDP and how to use computer-based tools to help execute this SDP.
NRC/RES and EPRI Fire PRA Course, Module 1, PRA**,5,7	PRA Practitioners Responsible for the Systems Modeling Aspects of the Fire PRA	Module 1 covers the technical tasks for development of the plant system response to a fire. Specifically, this module covers Sections 2, 4, 5, 7, 14, and 15 of Volume 2 of NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities—Detailed Methodology," EPRI 1011989, issued September 2005.
NRC/RES and EPRI Fire PRA Course, Module 2, Electrical Analysis**,5,7	PRA Practitioners Responsible for the Systems Modeling Aspects of the Fire PRA	Module 2 covers technical tasks for analysis of fire induced circuit failures in support of fire PRA analysis. Specifically, this module covers NUREG/CR-6850, EPRI 1011989, Volume 2, Sections 3, 9, and 10.
NRC/RES and EPRI Fire PRA Course, Module 3, Fire Analysis**,5,7	PRA Practitioners Responsible for the Systems Modeling Aspects of the Fire PRA	Module 3 covers technical tasks involving plant partitioning, fire frequency analysis, and the development and analysis of fire scenarios from fire ignition to target impact and fire suppression. Specifically, this module covers NUREG/CR-6850, EPRI 1011989, Volume 2, Sections 1, 6, 8, and 11.

Training Item[a]	Audience	Description
NRC/RES and EPRI Fire PRA Course, Module 4, HRA**,5,7	PRA Practitioners Responsible for the Systems Modeling Aspects of the Fire PRA	Module 4 covers the technical tasks for development of the plant system response to a fire. Specifically, this module covers NUREG/CR-6850, EPRI 1011989, Volume 2, Sections 2, 4, 5, 7, 14, and 15.
NRC/RES and EPRI Fire PRA Course, Module 5, Advanced Fire Modeling**,5,7	PRA Practitioners Responsible for the Systems Modeling Aspects of the Fire PRA	Module 5 covers the fundamentals of fire science and the guidance for the use of fire models to evaluate fire-generated conditions that may impact the nuclear plants safety functions or impair an operator's ability to safely shutdown the plant after a fire. This module uses the guidance in NUREG-1934/EPRI 1019195, "Nuclear Power Plant Fire-Modeling Applications Guide."
Technical Review of Industry's Seismic Hazard Interim Evaluation Reports	Technical Review Staff Evaluating Seismic Hazard Interim Evaluation Reports	This specialized course was designed to prepare the technical staff for the review of an interim evaluation action known as the "augmented approach." This approach was used by nuclear power plants that whose reevaluated seismic hazard developed as part of the lessons learned from the accident at Fukushima Dai-ichi exceeds the safe-shutdown earthquake. This interim evaluation included a demonstration of seismic margin and, if needed, plant safety enhancements of a safe-shutdown pathway, while more comprehensive plant risk evaluations were being performed. Among other objectives, the course provided technical examples of calculations for components, such as conservative deterministic failure margin and fragility analysis.
ComMIT Workshop	Staff Interested in Improving Site-Specific Tsunami Hazard Skills	The Community Model Interface for Tsunami (ComMIT) workshop provides hands-on training using the National Oceanic and Atmospheric Administration's operational numerical tsunami forecasting model developed for hazard assessment. Used in conjunction with the online forecast/notification tool Tweb, ComMIT can provide an accurate assessment of impacts at nuclear power plant sites during an event.

* Only one of these courses is required for the PRA Certificate Program and Risk-Informed Thinking Certificate Program.

** Only one of these courses is required for the Grow-Your-Own and ADM-504, Appendix M, Qualification Program.