

**Update on the Implementation of the National  
Academies' Program Recommendations: NIOSH  
Hearing Loss Research Program**

**Presented to:**

**NIOSH Board of Scientific Counselors**

**June, 2014**

## **Introduction:**

This document contains the October 2011 report submitted to the NIOSH Board of Scientific Counselors regarding the activities related to 7 of the 15 recommendations made by the National Academies (NA) regarding the NIOSH Hearing Loss Research Program. These 7 recommendations were selected for response based on their representing the highest perceived needs and providing the most comprehensive coverage of NIOSH hearing loss prevention research. Although the 7 recommendations discussed within this report were selected for GPRA tracking purposes, it should be noted that following the NA review, the NIOSH Hearing Loss Research (HLR) Cross-Sector program developed a planned response to each of the 15 NA recommendations and submitted this response to the NIOSH BSC. In 2009, the BSC reviewed all 15 responses and concluded:

“Overall, the BSC finds the NIOSH HLR Implementation Plan complete and responsive to each of the 15 recommendations of NA. In particular, the BSC would like to compliment the NIOSH HLRP for the development of a detailed Strategic Plan”.

In October, 2011 a subsequent report was provided as part of a follow-on BSC review of the HLR Program’s progress regarding the seven goals being tracked for GPRA. In January, 2012 the BSC provided a comprehensive score report (please see Appendix 1) for each of these seven recommendations in the areas of Achievement, Sustainability and Impact for those recommendations classified as “Fulfilled”, and areas of Relevance, Sustainability, Progress and Potential Impact for those recommendations classified as “In Progress”. This document updates the activities and progress on these goals from January 2012 to December 2013. Given the breadth of NIOSH HLR activities, it is recognized that any summary report may not capture the full scope and commitment to hearing loss prevention carried out over the last two years. However, by utilizing an effective “living” strategic plan, and with the continued support of an outstanding staff and management team, we are confident that the NIOSH HLR program continues to make excellent progress towards its goal of preventing occupational hearing loss. To that end, in the two years following the prior BSC review, the NIOSH HLR team has produced 45 peer-reviewed journal articles, 5 book chapters, and 2 books. The market penetration of commercialized NIOSH noise controls has grown to the point that over 40% of the continuous mining machine operators in underground coal mines are protected by NIOSH technology. Additionally, in keeping with CDC Director Frieden’s encouragement to make our science available and meaningful to the public, we have taken steps to employ electronic and social media outreach avenues whenever possible. For example, in 2012 and 2013, the NIOSH HLR-related web pages were viewed 520,000 times. This accounted for 1.8% of all views on the NIOSH website, or 28% more views than expected given the number of hearing loss pages contributing to the total. For several years, the top noise-based page has been the Noise and Hearing Loss Prevention topic page. Its traffic has increased by 80% since 2011. A November, 2013, Twitter Chat on noise-induced hearing loss jointly supported by NIOSH and the National Institute of Health (NIH) was considered an overwhelming success reaching more than 1,178,000 Twitter accounts and resulting in more than 12,170,000 impressions (total number of times a certain keyword/search term was delivered to Twitter accounts), as reported by TweetReach. Additional details regarding progress, impacts, and future plans are appended to the bottom of the text for each of the HLR program trackable goals listed below.

**Recommendation #1:** *Foster effective leadership*

**Status as of October 2011:**

**Background**

**Status:** Completed

**External Factors:** None

**Implementation of Recommendation**

**Activity A:** Establishment of Program Manager Position for the Hearing Loss Research cross-sector program

**Description:** Since 2006, NIOSH has had a single Program Manager to oversee all HLR efforts across multiple divisions and research sites in Cincinnati, OH, Pittsburgh, PA, Morgantown, WV, and Spokane, WA.

**Progress:** The Program Manager provides Institute-wide senior scientific and administrative leadership. The Program Manager also formulates strategic goals and implements research plans to ensure the hearing loss cross-sector research program is responsive to input from external reviews, stakeholders, emerging research, and the NIOSH Director.

**Impact:** Establishing the position of a Program Manager has improved NIOSH's ability to allocate program resources in accordance with Institute and national priorities. It has improved coordination between the NIOSH divisions performing intramural research and improved integration of extramural research supported by the Office of Extramural Programs. The matrix management structure has also enabled NIOSH HLR programs to be championed in an arena with significant competition for programmatic resources. This has led to the establishment of prioritized sector and cross-sector strategic goals for preventing occupational hearing loss as well as to funding for several important research projects that respond to the NIOSH National Occupational Research Agenda (NORA). The Program Manager has directed updates to the strategic plan that have also documented significant progress toward achieving the strategic goals and identified remaining research gaps.

**Future Plans:** Continued use of Program Manager for the Hearing Loss Research cross-sector program.

**Activity B:** Appointment of Program Coordinator and Assistant Coordinator

**Description:** Since 2006, NIOSH has had a Research Coordinator and Assistant Coordinator to help the Program Manager manage the Hearing Loss Research cross-sector program.

**Progress:** In 2006, the Coordinator established a Hearing Loss Steering Committee. The Steering Committee is comprised of the Program Manager, Research Coordinator, Assistant Coordinator, and one member from each NIOSH division with active or planned hearing loss prevention research projects. The Steering Committee interacts regularly as well as convening at least one face-to-face meeting annually to review NIOSH HLR progress and to develop future research plans. The Steering Committee members also execute responsibility for interacting with stakeholders in academia,

industry, labor and other governmental agencies to ensure current and planned research is relevant to stakeholder needs and the overall NIOSH mission.

**Impact:** The Steering Committee activities have resulted in NIOSH research that responds to the NA recommendations to provide a more cohesive structure to program efforts that are both technically diverse and geographically separated. Increased internal collaboration has proven successful in better utilizing existing internal resources in hearing loss prevention research, surveillance, and development of engineering controls.

**Future Plans:** Continued use of a Program Coordinator, Assistant Coordinator, and Steering Committee.

### **2014 UPDATE ON RECOMMENDATION # 1 - Foster Effective Leadership**

**Addition of or modifications to activities since last review:** The previous report to the BSC described the leadership and management structure of the HLR program, i.e., a Program Manager, Coordinator, Assistant Coordinator, and Steering Committee. During its 2012 review, the BSC expressed concern that, “the degree to which the installation of these extra personnel is financially sustainable and evidence that sustained organizational commitment to maintain the extra personnel was not offered.” Given that the Hearing Loss Research program was the first program to be reviewed during the 2011/2012 review cycle, it may have been that the BSC reviewers were unaware that the the HLR Program leadership structure reflects the implementation of a standardized leadership structure used by all NIOSH Sector and Cross-Sector programs. This structure pulls from NIOSH’s multidisciplinary expertise across its Division, Laboratories, and Offices and geographic locations and aims to integrate work in the Program Portfolio areas. In the case of the HLR Cross-Sector program, the management was tapped from existing experts and does not represent additional new staff or an additional financial burden. In addition, within the NIOSH Program Portfolio management structure, the performance plans of Sector and Cross-Sector leaders have performance elements related to their role in Program Portfolio leadership. NIOSH remains committed to this matrix management structure to support and advance its Research Program Portfolio.

**Maintenance efforts since last review:** The NA review occurred just as the NIOSH Research Program Portfolio was being organized into its current matrix structure of Sectors and Cross-sectors. The 2006 NA recommendation to “Foster effective leadership” undoubtedly reflected the fact that the NA review occurred at a time when the NIOSH HLR program was transitioning into its current organizational structure (i.e., a Program Manager, Coordinator, Assistant Coordinator, and a Steering Committee). The new management structure was successfully implemented and executed as was reflected by an “Achievement” score of 5 during the 2012 BSC review. Given the successful implementation of this leadership and management structure, and in the absence of any directives from NIOSH senior leadership to alter this structure, no changes were implemented in 2012 or 2013.

**Impact(s) made since last review (process or outcome related):** The mission of the NIOSH HLR Program is to provide national and world leadership to reduce the prevalence of occupational hearing loss through a focused program of research and prevention. By effectively focusing and directing

limited resources, the HLR management team has successfully and positively stimulated the advancement of this mission. Specifically, the HLR leadership team developed research goals that were adopted as research priorities in five NIOSH divisions (OMSHR, DART, DSHEFS, EID, and NPPTL) as well as the Office of Extramural Programs. This led to the funding of 19 new intramural HLR projects during the period of this current review. In addition to increasing collaboration with internal partners, the HLR management team has also improved coordination with external partners such as the US Army, MSHA, OSHA, and the National Hearing Conservation Association. Since 2012, the NIOSH HLR team has produced 52 journal articles, professional publications, book chapters, and NIOSH Numbered Documents. The impact of this diverse body of work led to the adoption of new hearing loss prevention policies, practices, and standards by governmental and professional agencies and organizations (e.g., MSHA, OSHA, the Department of Interior, the Department of Defense, the American National Standards Institute, the American Academy of Audiology, the National Hearing Conservation Association, and the National Academy of Engineering – to name just a few). In the nation’s workplace, commercialized controls employing NIOSH technologies are being used every day to protect workers hearing. In today’s fiscal arena, the continued growth and productivity of NIOSH HLR is unambiguous testimony of effective, efficient leadership and management.

***Future plans:*** Continued use of the NIOSH matrix management approach with a Program Manager, Cross-Sector Coordinator, Assistant Coordinator, and Steering Committee.

**Recommendation #4:** *Develop a strategic plan*

**Status as of October 2011:**

**Background**

**Status:** Completed

**External Factors:** None

**Implementation of Recommendation**

**Activity A:** Develop a strategic plan for the Hearing Loss Research Cross-Sector

**Description:** In addition to responding to the overall NIOSH mission, the HLR Strategic Plan developed a focused research program which addresses many of the suggestions offered by the NA review panel. The strategic plan is organized around five Strategic Goals:

1. Improve surveillance.
2. Reduce noise emission levels from equipment.
3. Develop hearing protector technology.
4. Develop evidence-based best practices for hearing loss prevention programs.
5. Identify hearing loss risk factors through epidemiologic research.

The detailed plans for each of the five strategic goals contain descriptions of the overall goal, the intermediate goals necessary to attain the overall goal, and the annual goals that must be met in the process. A Strategic Goal Leader has been identified for each of the five strategic goals and charged to lead development and tracking of their portion of the plan.

**Progress:** In response to the 2006 NA review, the HLR Cross-Sector completed two documents: (1) response to the NA review and recommendations (implementation plan), and (2) the initial HLR strategic plan. These documents were submitted to the NIOSH Board of Scientific Counselors for their review. Appendix 1 summarizes the 15 NA recommendations and the Hearing Loss Research Cross-Sector Program (HLR) response. The ensuing BSC report concluded that

- “The BSC finds the NIOSH HLRP Implementation Plan complete and responsive to each of the 15 recommendations of NA.”
- “In particular, the BSC would like to compliment the NIOSH HLRP for the development of a detailed Strategic Plan.”

Progress under the strategic plan is reviewed at least annually by the HLR Steering Committee and the plan itself is updated when necessary to document completed tasks and goals. In April, 2011, the committee completed a revised strategic plan. The updated plan provides a more detailed description of planned activities from 2012 to 2016. The updated plan is also a component of NIOSH’s second decade of the NORA in which hearing loss prevention is a key cross-sector program area in the

overall program portfolio. Thus, the programs are more sharply tailored to meet the newer NIOSH sector and cross-sector prioritized goals.

**Impact:** The strategic plan provides a specific roadmap for research plans through 2016. Specific research projects are identified to accomplish the overall and intermediate goals. Some of the goals will be met by existing projects, but a number of significant gaps are listed where new projects will be needed. The plan identifies existing and new resources needed to undertake the new projects. The new projects are identified as intramural (if NIOSH resources are expected to be sufficient) or extramural (if intramural resources are not available or it is otherwise more appropriate to have the project performed externally to NIOSH). The plan has already been used to select the current portfolio of projects that have been funded across the program. Additionally, the Strategic Plan provides specific guidance to all NIOSH Sectors and Cross-Sectors for use in developing their respective Program Portfolio research area priorities that are relevant to occupational hearing loss. Finally, the Strategic Plan provides guidance to the extramural research community with respect to identifying NIOSH research priorities related to preventing occupational hearing loss. This has helped clarify the program's coordination with the NIOSH Office of Extramural Programs.

**Future Plans:** Conduct annual program review to update the plan as necessary. Conduct major strategic review every 5 years. The major program review will solicit participation from external stakeholders (industry, academia, other governmental agencies), as well as internal (NIOSH) stakeholders in other sectors and cross-sectors to obtain input and coordinate research plans.

#### **2014 UPDATE ON RECOMMENDATION # 4 - Develop a Strategic Plan**

***Addition of or modifications to activities since last review:*** As was noted above, the HLR strategic plan was revised and updated in 2011 and includes performance measures consistent with the overall strategic planning framework that NIOSH programs use to achieve end outcomes (in this case, reduction of occupational hearing loss) through achievement of intermediate outcomes, which are stakeholder actions prompted by NIOSH research that impact the burden of occupational disease and injury. Major updates are planned to be undertaken on a 5-year basis, with the next update to occur in 2016 with input from external and internal stakeholders. Nevertheless, the HLR Strategic Plan is not a static document. Exceptional efforts to accomplish annual updates and general maintenance are described below.

***Maintenance efforts since last review:*** The HLR Strategic Plan successfully operates as a "living document". The HLR strategic plan is reviewed annually as part of the annual NIOSH program portfolio call for new project proposals. This provides an opportunity to adjust, add, or delete goals in order to meet the mission and research needs of NIOSH and its stakeholders. As projects are completed, associated goals may be retired, and as new program needs are identified, corresponding goals may be added. Additionally, the prioritization of goals may be adjusted to reflect Institute or stakeholder priority research needs. For example, as progress was made on the development of methods for quantifying impulse sounds and measuring the health effects of these sounds, the HLP leadership increased the prioritization of an intermediate goal to reflect a priority need to develop NIOSH recommended exposure limits for impulse sounds. Similarly, in response to Institute guidance

to strengthen programmatic ties between intramural and extramural efforts, an additional priority research goal was added. This goal was designed to reflect a research need that could initially be best met through an extramural research effort.

***Impact(s) made since last review (process or outcome related):*** The Hearing Loss Research Strategic Plan remains a practical, functional document that is employed by intramural and extramural researchers to guide the development of research proposals. Simply put, without exception, every research proposal funded since the initial development of this strategic plan has reflected a mission-related research need identified in this plan. Another measure of the impact of this plan is that it continues to serve as the roadmap for five NIOSH divisions and provides the framework for coordinating a wide range of activities covering many aspects of hearing loss. All the other exceptional impacts discussed in this document are the result of this plan and its implementation across the organization.

***Future plans:*** Continued annual review of HLP goals. A 5-year review and strategic plan update is planned for 2016.

**Recommendation #5:** *Use surveillance data as well as stakeholder input to identify priorities*

**Status as of October 2011:**

**Background**

**Status:** In Progress

**External Factors:** Obtaining surveillance data presents several challenges, including addressing privacy concerns for audiometric data and liability concerns with exposure data.

**Implementation of Recommendation**

**Activity A:** Establishment of a national repository for Occupational Hearing Loss (OHL) surveillance data.

**Description:** This includes recruiting audiometric service providers willing to share their data with NIOSH, collecting exposure data through workplace sampling and obtaining samples from regulatory sources, creating an electronic database for audiometric and exposure data, and developing and implementing guidelines for systematic yearly data collection and cleanup.

**Progress:** Twelve audiometric service providers have agreed to share their data with NIOSH, and seven have already provided data. Nearly 7 million audiograms have been collected, representing 2.6 million workers at over 36,000 workplaces, based on data from the first five providers. The data have been cleaned and are housed in an SAS database.

**Impact:** Establishing the repository is the first step in performing vital OHL surveillance. No such repository existed previously. Before this repository was established, the numbers of workers with hearing loss and their levels of hearing impairment had to be estimated from subjective responses collected during population surveys. Much more accurate surveillance is now possible based on the results of audiograms performed by health care professionals. Two influential publications, about self-report exposure and hearing difficulty, have been produced within this activity setting the stage for future reports containing audiometric and exposure data.

**Future Plans:** Continue to recruit audiometric service providers, and collect and cleanup audiometric data.

**Activity B:** Analysis of audiometric data, dissemination of results to stakeholders, and solicitation of stakeholder feedback.

**Description:** Analyses include 1) measuring the incidence and prevalence of OHL; 2) identifying industrial sectors and sub-sectors with the highest prevalence of OHL; 3) measuring the average annual change in hearing ability among workers within industrial sectors and sub-sectors; and 4) identifying workplace factors that may be related to OHL (e.g., industry characteristics, geographic region, etc.).

**Progress:** Analyses have recently commenced and the first preliminary report is expected to be completed and disseminated to participating audiometric service providers before January 2012. Their feedback on the report will be solicited. Presentation at the National Hearing Conservation Association (NHCA) annual conference and the first publication are expected in 2012.

**Impact:** OHL is an understudied condition affecting thousands of workers each year, and surveillance of the incidence, prevalence, and trends among industries is critical for worker safety and health. Results from these analyses and the feedback from stakeholders will help the HLR cross-sector program to guide important workplace interventions to reduce OHL and to develop research priorities. Feedback from stakeholders will also help improve future analyses and solidify partnerships with the hearing loss research community.

**Future Plans:** Results will be disseminated to providers who have shared their data with NIOSH, presented at the NHCA conference, and published in peer-reviewed and trade journals.

**Activity C:** Collection of stakeholder input for use in setting program priorities.

**Description:** Systematic interactions with stakeholder groups will be conducted to identify hearing loss prevention issues and potential solutions.

**Progress:** NIOSH has worked with the hearing conservation community and industry groups to establish mechanisms for obtaining industry input. NHCA was identified as a key group for establishing ties with industry and vendor representatives. In 2008, NIOSH became a signatory to the NHCA-OSHA-NIOSH Alliance that is using meetings and roundtables to “help forge innovative solutions in the workplace or to provide input on safety and health issues”. The mining program has implemented a regular series of meetings and workshops with MSHA, manufacturing companies, and industry groups.

In addition, NIOSH interacts regularly with the major stakeholders in the mining industry. There are at least quarterly meetings with the key equipment manufacturers for two-way interactions on current projects and future needs. NIOSH provides two to three workshops each year for mining operators. NIOSH team members also participate in UMWA and MSHA seminars with mining personnel from across the nation to discuss current research and receive feedback on noise issues and concerns. At the SME national conference and other smaller events there are both formal workshops and informal meetings for interactions with a wide range of stakeholders.

**Impact:** Surveillance data and stakeholder input has become an integral component of the HLR program. Every new project proposal is required to contain surveillance evidence that it will address a high priority hazard.

**Future Plans:** Complete statistical analyses, trend analyses, and periodic updates; disseminate surveillance data and reports; and conduct additional stakeholder meetings and other engagement activities to solicit program input.

### **2014 UPDATE ON RECOMMENDATION # 5 (Activity A) - Establishment of a national repository for OHL surveillance data**

**Addition of or modifications to activities since last review:** Having incorporated the establishment of a national repository as part of the team’s objectives, a NIOSH NORA project proposal was submitted to continue funding for the OHL Surveillance Project, and the proposal was funded for fiscal

years 2014-2017. Funds will be used for the purchase of private sector worker audiometric data and industry coding, in addition to the collection and occupation coding of United States Air Force (USAF) audiometric, noise exposure and chemical exposure data.

Four additional private sector audiometric service providers were recruited to partner with NIOSH and share their audiometric data, and millions of additional private sector worker audiograms were collected and added to the project data repository through exceptional efforts by the team. Only with constant attention to this effort and close work with potential contributors has this been possible. This brings the current total to 8,884,491 audiograms of varying quality for 2,293,722 workers from 38,440 companies.

***Maintenance efforts since last review:*** Data collection and cleanup, and industry coding continued.

***Impact(s) made since last review (process or outcome related):*** It is too soon to assess the true impact of these efforts, which are ongoing. Only the first project research results have yet been published, with several other manuscripts in review or in press. Also, the project web page has been live for less than a year. However, a significant impact is expected. For example, as a result of the availability of these data, the National Hearing Conservation Association initiated a collaborative effort with industry, academia, and NIOSH to revise methods used to age-correct audiometric monitoring data when determining the presence/absence of a significant shift in hearing. The results will be used to provide OSHA with updated tables for their Hearing Conservation Standard. With a projected completion date of 2015, this will represent the first updated age-correction table since 1972. Because the application of these data will authoritatively establish an updated standard of practice, they will be employed in every audiometric monitoring program in the U.S. Also, data from our first analyses are in the process of being added to the project topic page on the NIOSH website, which will allow any researcher to access over a million worker audiograms and conduct his/her own analyses.

***Future plans:*** The approval of a 2014 large NORA (follow-on) surveillance effort will enable the continued large-scale collection of private sector worker audiometric data, including the recruitment of additional audiometric service providers, and new collection of USAF audiometric, noise and chemical exposure data. Data will be added to the project topic page on the NIOSH website.

**2014 UPDATE ON RECOMMENDATION # 5 (Activity B) - Analysis of audiometric data, dissemination of results to stakeholders, and solicitation of stakeholder feedback**

***Addition of or modifications to activities since last review:*** Several data analyses have been completed, and research results were strategically disseminated to stakeholders using a variety of avenues with a focus on translating research to practice. Consistent with dissemination plans, results were disseminated in peer-reviewed journals to reach the research community, in trade journals/newsletters to reach occupational hearing conservationists and other stakeholders, via presentations at the NHCA annual meetings. Dissemination was also accomplished in NIOSH ENews, via a new topic page on the NIOSH website (which was also linked with other NIOSH topic pages), and tweets on Twitter. A project fact sheet was also developed to increase Project visibility among stakeholders. Furthermore, in 2012 and 2013, published documents included five journal articles and an additional NIOSH numbered document. An additional manuscript is currently undergoing peer-review.

Feedback has been requested from each of our Occupational Hearing Loss (OHL) Project partners on every Project analysis prior to releasing results to the public. All journal publications were also peer-reviewed by one or more leaders in the hearing conservation field prior to journal submission. Feedback was also solicited on the content and format of the new NIOSH topic page on OHL Surveillance, and the Project fact sheet.

***Maintenance efforts since last review:*** Additional statistical analyses were performed and manuscripts were completed. Additional analyses are in process, in addition to an update to the Project topic page on the NIOSH website. Draft manuscripts were provided to Project partners for comment and input was also solicited for the Project Web page and fact sheet.

***Impact(s) made since last review (process or outcome related):*** It is too soon to assess the true impact of these efforts, which are ongoing. Only the first Project research results have yet been published, with several other manuscripts in review or in press. Also, the Project Web page has been live for less than a year. However, a significant impact is expected. For example, the online (pre-print) version of the first Project paper titled “Prevalence of Hearing Loss in the United States by Industry” was featured as #7 of the top 20 read articles of 2012 on MDLinx.com, a physician and nurse practitioner website. Data from this analysis are in the process of being added to the Project website, which will allow any researcher to access over a million worker audiograms and conduct his/her own analyses.

***Future plans:*** Continued statistical analyses, including those of military audiograms and noise/chemical exposures; dissemination of research results to stakeholders; and continued solicitation of partner/stakeholder input; data will be added to the project topic page on the NIOSH website, furthering the field of occupational hearing conservation.

### **2014 UPDATE ON RECOMMENDATION # 5 (Activity C) - Collection of stakeholder input for use in setting program priorities**

***Addition of or modifications to activities since last review:*** A NORA proposal was submitted to continue funding for the OHL Surveillance Project, and the proposal was funded for fiscal years 2014-2017. In addition to data collection and industry and occupation coding, funds will facilitate in-person communications with project partners and other stakeholders at NHCA annual meetings. A large proportion of our stakeholders regularly attend these meetings. In both formal and informal meetings, we have solicited feedback on research that would be useful for practitioners about issues encountered when performing audiometric testing in the field. By making Project / Cross-Sector representatives available at these meetings, we have also received helpful unsolicited comments and feedback.

The NORA funding also allows us to continue in-person meetings with military stakeholders; namely USAF hearing conservation program staff members. While developing a partnership with the USAF, we have discussed their aims and research interests at length, which will guide our planned statistical analyses of USAF audiometric, noise exposure, and chemical exposure data once it has been received and the occupations have been coded.

Comments and feedback have been formally requested from each of our project partners on every OHL Surveillance Project analysis prior to releasing results to the public. All journal publications were also peer-reviewed by one or more leaders in the hearing conservation field prior to journal submission. Feedback was also solicited on the content and format of the new NIOSH topic page on OHL Surveillance. The comments received have not only improved document content, but have included important ideas for additional research that would be useful to the field.

The project has maintained regular communications via e-mail and telephone with project partners in order to maintain relationships and build trust. Informal conversations have often yielded important information leading to planned analyses.

***Maintenance efforts since last review:*** Draft manuscripts were provided to Project partners for comment and input was also solicited for the project fact sheet and topic page on the NIOSH website.

***Impact(s) made since last review (process or outcome related):*** It is too soon to assess the true impact of these efforts, which are ongoing. Only the first project research results have been published, with several other manuscripts in review or in press. Also, the project webpage has been live for less than a year. However, a significant impact is expected. For example, we have received very positive feedback from our project partners on the quality of our documents and the progress of the project, in addition to statements about how they will use published results to target at-risk workers during testing and follow-up. Our partners have expressed excitement and willingness to contribute to this important effort. We have maintained every partner since recruitment began in 2010. We have also received positive feedback from other stakeholders at NHCA meetings.

***Future plans:*** Continued attendance at meetings important to stakeholders, meetings with project partners. We will continue regular in-person, phone and e-mail communications with project partners and other stakeholders, and continue formal solicitation of project partner input on project documents and OHL surveillance topic page enhancements. An additional 2015 project proposal has been developed to specifically address development of research and analysis tools for soliciting/evaluating feedback from stakeholders.

**Recommendation #7:** *Systematize collaboration with regulatory partners*

**Status as of October 2011:**

**Background**

**Status:** Completed

**External Factors:** None

**Implementation of Recommendation**

**Activity A:** NIOSH interactions with MSHA

**Description:** NIOSH has established a system of regular and frequent collaborations with MSHA to obtain input on noise hazards in mining that can be used to identify and prioritize research initiatives. Also, NIOSH and MSHA are key organizational members of the Mining Noise Partnership that provides a forum for programmatic input. Collaborations also enable NIOSH and MSHA to jointly implement NIOSH-developed hearing loss solutions.

**Progress:**

- Quarterly meetings with MSHA Directorate of Technical Support to address collaborative activities.
- Periodic joint workshops, e.g., 2006 workshop on hearing loss prevention, regular workshops for MSHA inspectorate and mining operation safety and health representatives at MSHA district offices across the nation.
- 2011 NIOSH prioritized research initiatives to develop drill noise controls for coal mine roof bolting machines, metal/nonmetal rock drills, and powered tools used in metal/nonmetal mines.
- NIOSH Office of Mine Safety and Health Research (OMSHR) policy for submitting all noise and hearing loss-related publications to MSHA for technical review.

**Impact:**

- MSHA reliance upon NIOSH for scientific evidence and research products.
- MSHA adoption of NIOSH-developed products: a) the NIOSH Hearing Loss Simulator is listed on MSHA's "Health Standards for Occupational Noise Exposure Resources Page" on their website; b) the NIOSH QuickFit earplug test device is in use at every field office in MSHA's Southeast District; and c) MSHA adoption of NIOSH recommendations for an improved hearing loss prevention program for mine inspectors.

**Future Plans:** Continue systematic collaborations with MSHA.

**Activity B:** NIOSH interactions with OSHA

**Description:** HLR Cross Sector interactions with OSHA are numerous and on-going. The scope of these interactions ranges from requests to NIOSH for technical support on specific questions, to

discussions of research needs and research results for use in establishing OSHA regulatory and compliance policies.

**Progress:**

- 2008 formal alliance with OSHA and the NHCA quarterly meetings to facilitate joint efforts to prevent OHL.
- Invited to OSHA town hall meetings across U.S to provide technical assistance on proposed rule-making for the construction sector and the use of engineering controls to reduce occupational noise levels.
- Address occupational hearing loss issues at planned interagency meetings between the NIOSH Director and the Assistant Secretary for Labor.

**Impact:**

- 2009: Hearing Loss Prevention Program for OSHA field inspectors; adopted NIOSH recommendations to incorporate hearing protection device (HPD) fit-tests, and audiometric test protocol. Used as template for “best practices” for industry and other government agencies.
- 2010: OSHA and NHCA alliance toolbox talks adopt NIOSH health communication model; annual training feasible for workers in maritime and construction sectors.
- 2010: completed white paper for OSHA proposed rulemaking regarding engineering controls.
- 2011: completed white paper for OSHA regarding best practices for determining the work-relatedness of hearing loss.  
2011: major update to OSHA noise and hearing loss web pages highlights NIOSH best practice recommendations.

**Future Plans:** Continue to have an active role in the NHCA/OSHA/NIOSH Alliance.

**Activity C:** NIOSH interactions with the U.S. Environmental Protection Agency (EPA)

**Description:** The U.S. EPA is responsible for HPD labeling. NIOSH is collaborating with the EPA to update the HPD labeling regulation.

**Progress:**

- 2006: EPA/NIOSH interagency agreement to completely revise HPD labeling.
- 2006-2010: conduct research documenting limitations of existing rule and develop technical solutions leading to methods that a) predict HPD performance in the workplace, b) predict HPD attenuation for impulsive sounds, and c) predict performance of nonlinear HPDs and HPDs that use active noise reduction technology.
- 2011: final recommendations to EPA on new labeling rule; regulation undergoing final administrative review prior to promulgation.

**Impact:** Significant elements of this NIOSH-led research have been embodied in three American National Standards Institute (ANSI) standards:

- ANSI S12.6-2008 Methods for Measuring Real Ear Attenuation at Threshold
- ANSI S12.68-2007 Methods to Estimate Effective Exposure when Hearing Protection Devices are Worn
- ANSI S12.42-2010 Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures

Also, as a result of NIOSH research, every hearing protector sold in the United States will have a label that will predict the expected attenuation in the workplace.

**Future Plans:** Continue leadership role in advancing hearing protector performance technology by maintaining prioritized research in the area of hearing protector technology and by maintaining liaisons with governmental agencies such as the EPA and the Departments of Labor, and Defense, and by continuing to exercise leadership roles on national and international standards bodies such as ANSI and the International Organization for Standardization (ISO).

#### **2014 UPDATE ON RECOMMENDATION #7 (Activity A) - NIOSH Interactions with MSHA**

***Addition of or modifications to activities since last review:*** NIOSH continues to hold quarterly meetings with the MSHA Directorate for Technical Support. These meetings have evolved to have a very specific focus on NIOSH-developed noise controls and have helped to expedite their incorporation into the MSHA Public Information Bulletin for Technologically Achievable, Administratively Achievable, and Promising Noise Controls. The aggressive work by NIOSH has led to a very productive program of interaction and has resulted in these meetings providing direction to some of MSHA's activities. In addition, the discussions have focused on how to make MSHA personnel aware of the new controls and their ability to reduce noise emissions. MSHA has pledged support for the development of a Hearing Loss Prevention course being developed by NIOSH for stakeholders. This course is planned for rollout in the latter half of 2014, and will provide useful knowledge on the issues and basic principles related to regulations, hearing loss, acoustics fundamentals, noise controls, and available noise controls.

***Maintenance efforts since last review:*** It should be noted that the HLR Program has continued to hold quarterly meetings with MSHA with full participation of both parties. Through a continued high level of effort, NIOSH has remained the driving force for these meetings. There continues to be an exchange of scientific documents between the groups to make each aware of the other's activities and to provide an understanding of new projects and technologies being developed by NIOSH.

***Impact(s) made since last review (process or outcome related):*** Through these exchanges, MSHA has become aware of new commercialized noise control technologies and is working to incorporate these technologies in the MSHA Public Information Bulletin for Technologically Achievable, Administratively Achievable, and Promising Noise Controls. This is truly a cooperative effort between the two parties. NIOSH continues to work with industry stakeholders to support their commercialization efforts while working with MSHA to make these controls part of recommended practices. The implementation of these control recommendations has had a major impact on the noise

exposure of miners. Due to this effort, thousands of miners' hearing is protected by commercialized NIOSH research. In today's fiscal arena, this partnership holds great value for both participants, for the related industries in mining companies, for equipment manufacturers, and for third party suppliers.

**Future plans:** The continued use of these quarterly meetings with MSHA and frequent information exchanges to make the latest noise control technologies available for miners hearing loss prevention.

#### **2014 UPDATE ON RECOMMENDATION #7 (Activity B) - NIOSH Interactions with OSHA**

**Addition of or modifications to activities since last review:** Per requests from OSHA, NIOSH provided scientific/technical support on the following:

- NIOSH provided a formal letter to OSHA describing the updated science on the use of insert earphones for audiometric testing.
- In response to an OSHA review of the potential application of hearing protector fit-test technology, NIOSH provided data on the validity and performance of hearing protector fit-test systems that NIOSH evaluated in a multi-laboratory study conducted in 2012 and 2013. A formal letter was drafted and submitted to OSHA.
- At OSHA's request, NIOSH provided training material suitable for a 1-hour web-based training module designed to provide the general public with a comparison between the OSHA Hearing Conservation Standard and emerging best practices for preventing work-related hearing loss.
- At the request of OSHA, NIOSH has worked diligently to provide technical support and assistance in developing comprehensive training materials for the OSHA Training Institute to be used in revamping the curricula for training OSHA personnel about hearing conservation.
- At the request of OSHA, NIOSH provided a scientific review of the emerging technical capabilities for quantifying performance of non-passive hearing protector devices such as those which utilize sound restoration or active noise reduction technologies.

**Maintenance efforts since last review:** The NHCA/OSHA/NIOSH alliance continues to function effectively through quarterly meetings. NIOSH HLP scientists have continued to provide significant contributions to the NIOSH-OSHA Quarterly Information Conference Calls between the NIOSH Director's staff and Senior OSHA officials.

#### **Impact(s) made since last review (process or outcome related):**

- In 2013, materials used by the OSHA Training Institute for webinars to instruct OSHA staff on hearing conservation were substantially based on NIOSH recommendations regarding "best practices".
- While it is too soon to quantify the impact of NIOSH recommendations to OSHA regarding the use of insert earphones, NIOSH continues to provide technical assistance regarding the potential development of an OSHA Letter of Interpretation that would have the effect of authorizing the use of insert earphones in all OSHA –compliant hearing conservation programs in the U.S.
- In 2013, OSHA released OSHA Technical Manual (OTM), Section III: Chapter 5 – Noise. This new chapter provides technical information and guidance to help Compliance Safety and Health Officers (CSHOs) evaluate noise hazards in the workplace. Information is offered in

NIOSH research publications on damage risk criteria, noise controls, ototoxicants in the workplace, and other resources, such as Health Hazard Evaluation Reports, NIOSH's Industrial Noise Control Manual, the NIOSH Hearing Loss Simulator, and the Safe-In-Sound Excellence in Hearing Loss Prevention Award.

**Future Plans:** Continue to have an active role in NHCA/OSHA/NIOSH alliance and in Quarterly NIOSH-OSHA conference calls.

### **2014 UPDATE ON RECOMMENDATION # 7 (Activity C) - NIOSH Interactions with EPA**

#### ***Addition of or modifications to activities since last review:***

- In 2012, completed development of a calculator for the Noise Reduction Rating and provided it to the EPA in support of the promulgation of the revised rule for labeling HPDs.
- In 2013, development of a pamphlet designed to help the general public understand hearing protector performance ratings. This pamphlet has been developed in both English and Spanish and is ready to be transferred to the EPA should NIOSH be notified that the EPA has elected to proceed with rulemaking regarding new hearing protector labeling.

**Maintenance efforts since last review:** All pertinent analyses have been completed and NIOSH recommendations have been forwarded to the U.S. EPA.

**Impact(s) made since last review (process or outcome related):** As the NIOSH recommendations have been forwarded to the EPA Administrator, the final decision as to whether or when a new labeling rule will be promulgated now rests with the U.S. EPA and the relevant congressional legislative staff.

**Future Plans:** This effort is now completed.

**Recommendation #8:** *Place greater emphasis on evaluation of the effectiveness of hearing loss prevention measures on the basis of outcomes that are as closely related as possible to reducing noise exposure and the incidence of occupational hearing loss*

**Status as of October 2011:**

**Background**

**Status:** Completed.

**External Factors:** None

**Implementation of Recommendation**

**Activity A:** Engineering control technology

**Description:** Develop and implement engineering noise controls for major occupational noise sources.

**Progress:**

- A process model of lab and field studies has been implemented to evaluate exposure reduction potential. Field tests assess durability, usability, and other factors affecting implementation.
- Lab and field studies have been completed for roof bolting machine drill bit isolators and continuous mining machine coated chains, both of which reduce noise exposure.
- Lab studies have been completed on jackhammers used in construction and vibrating screens for coal preparation plants.

**Impact:**

- Drill bit isolators are commercially available from manufacturing partners.
- Mining noise control evaluations by NIOSH are used by MSHA to rate noise controls, including continuous mining machine coated chains and roof bolting machine drill bit isolators, as “technologically achievable” and recommend their use in all affected US mines.
- Data from lab testing has been incorporated into a powered hand tool database to promote implementation.

**Future Plans:** Evaluate noise reduction provided by noise controls applied to haul trucks, load-haul-dumps, rock drills, and construction equipment. Use results of these evaluations to increase implementation and overall impact of these controls.

**Activity B:** Develop HPD fit-test technology

**Description:** Develop a hearing protector fit-test system that can be incorporated into any existing or new hearing conservation program, can be used with any ear plug, can provide a personal attenuation rating in < 10 minutes, and has a high degree of accuracy.

**Progress:**

- Field and laboratory studies demonstrated proof of concept for revolutionary new NIOSH hearing protector fit test system: HPD Well-Fit; PC-based, inexpensive, very fast, works with any earplug; provides personal attenuation rating (PAR) that accurately predicts workers' exposures.
- CDC invention report for HPD Well-Fit; great commercial and professional interest
- Material transfer data agreements in place with US Army, U.S. Navy, and U.S. Department of Interior; Commercial license agreements in negotiation.
- Round robin laboratory study underway with industry; field studies underway with US Army and U.S. Department of Interior.
- Advanced development underway to integrate into audiometer.

**Impact:**

- Speed and accuracy enable first-ever ability to train-to-mastery because the NIOSH HPD Well-Fit system can provide rapid (~3-minutes) capability to re-test attenuation performance using built-in training. One outcome of this will be the ability to eliminate de-rating hearing protector attenuation
- OSHA, in partnership with NIOSH and NHCA, issued joint recommendation for fit-testing
- OSHA implemented new regulation requiring fit-testing for its inspectors
- HPD Well-Fit adopted for use by Department of Interior

**Future Plans:** Implement commercial licenses for QuickFit and HPD Well-Fit. Continue HPD Well-Fit development to integrate it into an audiometer.

**2014 UPDATE ON RECOMMENDATION # 8 (Activity A) –Engineering Control Technology**

***Addition of or modifications to activities since last review:*** NIOSH continues to expend exceptional effort to grow the breadth and depth of noise control technologies being used to prevent hearing loss. Over the period since the last review, NIOSH has added significant measurement capabilities and achieved major strides in the ability to model noise generation and radiation. These capabilities are now industry leading in their technical sophistication.

A major new capability for NIOSH has been the incorporation of Source Path Contribution (SPC) technology. This technology uses volume velocity sources and multiple methods of transfer function analysis to determine the characteristic noise sources for a machine and to precisely define the acoustic and structural paths for sound energy from these sources to the worker. The complex procedures use large numbers of microphone and accelerometers to gather the necessary information and complex computational routines to define the sources and paths. Using this technique one is able to better define the noise problems with a complex machine and to evaluate possible control solutions in the software environment. With innovative approaches and close cooperation with stakeholders, SPC has been applied to haul trucks and load-haul-dumps where it identified the engine cooling fan as a primary noise source. This was the first time such technology had been applied in

underground mining. The identification of the engine cooling fan was an unexpected result and led to innovative noise controls that have gained support from the equipment manufacturer.

Yet another expansion of noise control technology has been the design, development, and installation of an engine cooling system test stand. This stand was developed to evaluate noise controls on the load haul dump (LHD) and haul truck engineering systems noted in the studies above. The stand accurately represents the airflow through the entire engine cooling package. The geometry of the entire package is replicated including flow obstructions from the engine and ancillary equipment. The only other similar test stand known to exist is at the Caterpillar research center. This unique stand provides the ability to do noise control development on engine cooling systems and greatly increases the team's experimental investigative capabilities. This development program was an exceptional undertaking during the course of the research program. Its successful completion is a testament to the dedication and resourcefulness of the NIOSH team.

Another major additional capability for NIOSH noise control has been the development of a full suite of tools for modeling vibration and noise radiation from complex machines. Expertise has been developed in the finite element software program ANSYS to permit the prediction of vibration in complex structures to high frequencies. In a recent project, using innovative sub-structuring techniques, NIOSH was able to accurately predict vibration to 2000 Hz in a machine cutting drum measuring 1.5 m in diameter. This was a major accomplishment. Many of the experts in the field indicated that NIOSH was pushing the technology beyond what was possible. The extraordinary efforts and innovation caused the team to overcome significant obstacles in order to make this a success. In addition, Boundary Element Modeling tools have been incorporated by NIOSH to allow accurate predictions of sound radiation. This tool permits the prediction of the noise at a worker's ear in complex working environments. It greatly enhances the ability to understand the source of noise exposures and the effectiveness of potential controls.

Along with the development of these tools, NIOSH has hired two advanced degree engineers in these fields to ensure that this effort is successful. These individuals provide significant expertise and experience and greatly enhance NIOSH's technical skill sets.

In response to the BSC's 2012 concern about the role of worker behavior and organizational culture as drivers of hearing loss prevention, the HLR program includes worker behavior as an integral part of its approach. For example, research on engineering controls first conducts observational studies of actual worker behavior and task performance. End products are targeted to stakeholders, including workers, whose actions play a key role in implementing controls. Recent NIOSH studies on organizational behavior and hearing loss have been nominated for or received awards such as CDC Charles C. Shephard Science Award, the Bullard Sherwood Research to Practice Award, and NIOSH Science Awards.

***Maintenance efforts since last review:*** NIOSH continues to aggressively pursue exceptional noise control development programs using both the existing and new tools noted above. Noise control and other technical training programs are used regularly to keep NIOSH personnel current with latest technology and to grow new skills where possible.

The process model continues to provide the core of noise control development programs. This model has been featured in a number of publications and been the source of many inquiries about the success of NIOSH noise control programs. The commitment to developing innovative and practical noise controls that are thoroughly evaluated and ready for commercialization continues. To meet this goal, new and innovative technology is always being sought and incorporated based on the ability to help NIOSH meet these objectives.

**Impact(s) made since last review (process or outcome related):** The number of successfully commercialized noise controls has continued to grow and the usage in industry has also expanded. The team has had an exceptional impact with thousands of workers' hearing being protected with NIOSH-developed technology. The drill bill isolator provides 3-6 dB of noise reduction for roof bolting machine (RBM) operators. This control has been commercialized by Corry Rubber and Kennametal. These are currently available for sale, with large batches already produced.

It is also significant to note that the first commercialized control noted in the previous review, the dual sprocket chain, for continuous mining machines (CMMs) has made outstanding market penetration. It is currently being used in over 40% of the CMMs used in underground mines in the US and is being used in at least four foreign countries as well. The usage growth shows no sign of diminishing.

In addition, the work with LHD and haul truck noise in metal/nonmetal mines has had a major impact. For the first time, controls have been developed that can be easily retrofitted to existing equipment and used as part of a low noise package for new equipment, thus increasing the impact. The participation of both fan and machine manufacturers provides the opportunity for a major impact in the metal/nonmetal mining sector. This is an exceptional achievement, setting the stage for much wider implementation of controls.

**Future plans:** A major trend for NIOSH noise control technology will be the greater use of modeling in conjunction with experimental techniques. The goal is not to replace experimentation, but to develop better controls more quickly through the use of both modeling and experimentation. The ultimate goal is to predict noise overexposures before a machine is put into place and provide noise control guidance to the manufacturer in the design stage to prevent the problem of noise exposure from ever occurring. This prevention through design approach is an important trend for the future.

### **2014 UPDATE ON RECOMMENDATION # 8 (Activity B) - Develop Hearing Protector Fit-Test Technology**

**Addition of or modifications to activities since last review:** NIOSH continues to pursue a robust program focused on advancing hearing protector fit-test technologies, particularly with respect to transitioning this technology from arcane laboratory procedures to commercially-available technology.

- 2012: Developed a modification of a circumaural headphone for use with the HPD Well-Fit system. This new headset now enables the HPD Well-Fit system to test any commercially available ear plug.
- 2012: The NIOSH HPD Well-Fit system became commercially available via the NIOSH Research to Practice (r2p) Office execution of a commercial license agreement with Michael & Associates (Fit-Check Solo™).

- 2013: Expanded commercial availability of NIOSH HPD Well-Fit technology via Custom Protect Ear development of marketing materials and campaign to promote Fit-Check Solo™ for use with the dB Blockers earplug and other hearing protectors.
- 2013: Round robin laboratory study was completed by NIOSH, Honeywell, Michael & Associates, and US Army Aeromedical Research Laboratories to compare three fit-test systems with the laboratory-based hearing protector test according to the ANSI standard.
- 2012-2013: Field studies underway with University of Connecticut, US Army, and U.S. Department of Interior to evaluate effectiveness of NIOSH fit-test technologies under diverse operational conditions.
- 2013: New NORA project initiated to use HPD Well-Fit to conduct first-ever analyses of earplug attenuation stability over the course of a work shift.

***Maintenance efforts since last review:***

- 2012-2014: Advanced development underway to integrate the HPD Well-Fit development into an audiometer.

***Impact(s) made since last review (process or outcome related):***

- The exceptional impact of this effort is exemplified by the HPD Well-Fit program receiving the NIOSH 2013 Bullard-Sherwood Award for singularly outstanding achievement in Research-to-Practice.
- The Council for Accreditation in Occupational Hearing Conservation (CAOHC) has included a chapter in their two newly revised manuals for training that covers HPD Fit-testing methods. Fit-Testing instruction will become a required portion for certification by CAOHC. This is very important as CAOHC provides certification for the 24,000 occupational hearing conservationists and Hearing Conservation Course Supervisors in the U.S. and Canada. CAOHC represents the following organizations:
  - American Academy of Audiology
  - American Speech-Language-Hearing Association
  - Military Audiology Association
  - American Academy of Otolaryngology
  - American Association of Occupational Health Nurses
  - American College of Occupational and Environmental Medicine
  - American Society of Safety Engineers
  - Institute of Noise Control Engineering
  - American Industrial Hygiene Association

It is fair to state that NIOSH fit-test technology has been transitioned to and endorsed by the entire professional hearing loss prevention community in North America.

- NIOSH development of a new headset for earplug fit-testing enables all commercially available earplugs to be fit-tested.

***Future Plans:***

- Continued implementation of activities regarding the commercial licensing for QuickFit and HPD Well-Fit.
- Continue HPD Well-Fit development to integrate it into an audiometer. This will enable HPD Fit-testing to be performed in any facility where routine monitoring audiometry is performed, and to conduct fit-testing on earmuffs as well as earplugs.
- Complete the development of ANSI/ASA S12.71 standard for validating the performance of hearing protector fit-testing systems. Identify the ambient noise conditions for which different circumaural audiometric headphones may be used for fit-testing and audiometric testing.

**RECOMMENDATION #11:** Develop noise control engineering approaches for non-mining sectors

**Status as of October 2011:**

**Background**

**Status:** In Progress

**External Factors:** None

**Implementation of Recommendation**

**Activity A:** Engineering control technology

**Description:** Develop improved in-house capacity to conduct noise control technology research.

**Progress:**

- Enhanced in-house engineering control research capacity: hired new engineer; post-master's degree training for two existing researchers.
- Methodology developed for sound power measurement of tools and equipment; stakeholders notified of this via publication in Federal Register.
- Tests successfully completed for laboratory-based sound power measurements of equipment; results presented at scientific meetings and published.
- Tests successfully completed for field sound power measurements of equipment. Data analysis/publication of results in progress.
- NIOSH Safe-in-Sound award created with national partners. Successful case studies of engineering controls completed.

**Impact:**

- Safe-in-Sound Award established a national platform for highlighting feasibility of and successful application of engineering controls.
- Model approach for sampling sound power of tools/equipment to identify and prioritize candidates for engineering controls.

**Future Plans:** Develop case studies for use in helping industry identify "low hanging" fruit for application of engineering controls. Transfer technology to university programs to assist in the development of graduate training programs. Continue Safe-in-Sound award.

**Activity B:** Develop an informational database of sound levels of powered hand tools.

**Description:** Administrative controls are the 2<sup>nd</sup> element of control technology (the first being engineering controls). This activity focuses on administrative controls and specifically on methods for implementing "buy quiet" technology as an efficient means for reducing occupational noise exposures.

**Progress:**

- Established partnership with NASA to capitalize on "lessons learned" from early buy-quiet initiatives.
- Identified candidate power tool list and acquired tools.
- Developed new protocol for sound power measurements that was predictive of how the tools performed in the workplace.
- Completed development of comprehensive set of sound power measurements of powered hand tools, and established web-based database.

**Impact:** A database is the primary input to a “buy-quiet” program and the primary input to sustaining a successful “buy quiet” process.

- Largest database of its kind in the world.
- Highly regarded and used extensively by: National Academy of Engineering, NASA, New York City Department of Environmental Protection, National Parks Service, U.S. Department of Defense, General Services Administration, Noise Pollution Clearinghouse, Laborer’s Union.

**Future Plans:** The 3rd edition of the revised database will go live by the end of calendar year 2011. Continue to periodically add power tools to the database. Initiate study of sound power changes in powered hand tools as they age.

## **2014 UPDATE ON RECOMMENDATION # 11 (Activity A) – Engineering Control Technology**

### ***Addition of or modifications to activities since last review:***

- Enhanced in-house engineering control research capacity: one engineer completed a Master’s degree in acoustical engineering, and a second engineer was selected for and has begun long-term, full-time training to complete a Ph.D. in acoustical engineering. A 3<sup>rd</sup> scientist completed his Ph.D. with a specialty in the biophysics of speech intelligibility processing in noise.
- In 2013, NIOSH successfully implemented what is anticipated to be a continuing graduate internship for acoustical engineering. In 2013, we hosted a doctoral candidate from Rensselaer Polytechnic Institute for a 9-month research internship. This facilitated our ability to upgrade our impulse noise control acoustic test facility.

***Maintenance efforts since last review:*** The HLR Program Strategic Plan continues to include goals relevant to the three sectors where the majority of hearing loss occurs: Manufacturing, Construction, and Mining. The strategic plan includes performance measures consistent with the overall strategic planning framework that NIOSH programs use to achieve end outcomes (in this case, reduction of occupational hearing loss) through achievement of intermediate outcomes, which are stakeholder actions prompted by NIOSH research that impact the burden of occupational disease and injury.

Specific maintenance efforts include:

- A major effort was undertaken to develop a new methodology for sound power measurement of tools and equipment; stakeholders were notified of this via publication in the Federal Register. NIOSH engineers are currently assisting in the revision of existing test standards for sound power measurement of powered hand tools, much of which was developed by NIOSH engineers.
- A comprehensive test program successfully completed multiple, complex laboratory-based sound power measurements of powered hand tools. The NIOSH powered hand tool database has been appropriately updated and the results have been presented at scientific meetings and published. The results will also be presented at a National Academy of Engineering workshop as a template for use by industry and academia.
- NIOSH Safe-in-Sound Award was created with national partners, in 2007.
- Successful case studies of engineering controls were completed.
- NIOSH Engineering Noise Control website currently in development to provide dissemination of NIOSH-developed and general state-of-the-art information regarding efforts to control noise in the workplace, the community, and the general environment.
- 2012-2016: Successfully competed for NIOSH Intramural Public Health Practice Program funding to continue NIOSH sponsorship of the Safe-in-Sound Award in partnership with the NHCA. As noted below, this is of national significance with respect to promoting the use of noise control technologies in sectors other than mining.

***Impact(s) made since last review (process or outcome related):***

- Since 2007, NIOSH has assumed a strong leadership role in an influential partnership with the NHCA to create the Safe-in-Sound Award™ for Excellence and Innovation in Hearing Loss Prevention ([www.safeinsound.us](http://www.safeinsound.us)). The objectives of this award program are to recognize effective and innovative initiatives, and to share leading edge information to a broader community. Since the first award was presented in 2009, awards have been presented annually. The award process has resulted in the acquisition of high quality field data related to successful noise control outcomes. In several cases, noise control has led to the elimination of the need for a hearing conservation program or in the reduction of number of workers enrolled in the program. In addition, award recipients demonstrated a strong return on investment from noise control initiatives such as “Buy-Quiet” and “Quiet-by-Design”.
- The NIOSH HLP has retained its leadership in the national and international occupational safety and health arena through its substantial participation in Cochrane Reviews. In 2012, NIOSH co-authored Cochrane Systematic Reviews on the effectiveness of interventions to prevent occupational hearing loss. These reports are considered to be among the most prestigious and influential international publications in the fields of health, safety, and medicine.
- Standards committee revision activities promote NIOSH test methodologies use on a broad scale, providing data relevant to estimating worker’s noise exposure. NIOSH has developed standards for estimating the attenuation of hearing protection devices when used in impulsive noise. As well, methods to rate the performance of active noise reduction hearing protection devices were developed and validated through the research conducted at the NIOSH Taft Laboratories. These methods provided objective, standardized methods for assessing hearing

protector performance where no such previous methods existed regarding active noise cancellation or impulse noise reduction hearing protection devices.

***Future Plans:***

- Maintain our exemplary capacity to provide advanced graduate internships in acoustical engineering, and retain our influence in training the next generation of acoustical engineers.
- Maintain in-house research capacity to conduct cutting-edge acoustical engineering research
- Maintain NIOSH leadership as a principal sponsor of the Safe-in-Sound award.

**2014 UPDATE ON RECOMMENDATION # 11 (Activity B) – Develop an informational database of sound levels of powered hand tools**

***Addition of or modifications to activities since last review:*** No additions or modifications in 2012 or 2013; i.e., we have been continuing prior work to get the NIOSH noise database of powered hand tools and the Buy Quiet web tool and global tool database prepared for dissemination.

***Maintenance efforts since last review:*** Exceptional progress has been made towards the continued development of an informational database of sound levels of powered hand tools and general equipment and machinery along with guidance and motivational material for using the database, including training videos for the construction and manufacturing sectors.

- Expanded development of a comprehensive set of sound power measurements of powered hand tools, and established a web-based database. For example, the NIOSH powered hand tool database is in the 3<sup>rd</sup> edition. It was originally developed by Rohit Verma, The second edition was developed by SRA/Constella and the third edition is the product of the Tier One team. This database is now icon based which makes it easier to search for tools. It went live this past year.
- Developed user-friendly, web-based “Buy-Quiet” program to guide users in the manufacturing and construction industries on how to establish and maintain a “Buy-Quiet” program within their organizations. The site both encourages and provides a path to the purchase of quieter equipment while tracking and maintaining the cost effectiveness of those purchases.
- Developed the Global Database of Noise Levels, modeled after NIOSH’s Powered Hand Tool Database, to include a wide range of noise producing machinery and equipment. The Global Database is integral to providing “Buy-Quiet” programs necessary noise level information.

***Impact(s) made since last review (process or outcome related):*** Above activities resulted in an exceptional impact as evidenced by the Powered Hand Tool database being highly regarded and used extensively by the National Academy of Engineering, NASA, New York City Department of Environmental Protection, National Parks Service, U.S. Department of Defense, General Services Administration, Noise Pollution Clearinghouse, and Laborer’s Union. A broader impact, use, and referencing of the Global Database of Noise Levels than the existing Powered Hand Tool database is anticipated when the Global Database is released to the public later in 2014. The Global Database may potentially replace all other existing noise level databases due to its inclusiveness and

functionality that is unavailable elsewhere. Further, simultaneous release of the “Buy-Quiet” program will champion, motivate, and educate use of the Global Database as part of the procurement process.

***Future Plans:*** The “Buy-Quiet” program and the Global Database of Noise Levels will be released to the public by the end of calendar year 2014. The Global Database will be inclusive of all other existing noise level databases and easily added to and edited by the manufacturers of noise producing products, making that information available to their customers, particularly those customers considering noise level in the procurement process through a “Buy-Quiet” program.

**Recommendation 13:** Accredit laboratories used to conduct studies for the HLRP

**Status as of October 2011:**

**Background**

**Status:** Completed

**External Factors:** None

**Implementation of Recommendation**

**Activity A:** Achieve or maintain accreditation of sound power level laboratories by the National Voluntary Laboratory Accreditation Program (NVLAP).

**Description:** The NIOSH/University of Cincinnati Acoustics Test Lab (NUC ATL) is an anechoic chamber that has been used to measure the sound power level of powered hand tools. In 2010, the NUC ATL was NVLAP accredited for measuring sound power level according to ISO 3744 and ANSI S12.15. NIOSH OMSHR's Acoustic Test Chamber (ATC) is a large reverberation chamber that is used to measure the sound power level generated by mining equipment. In 2005, the ATC was NVLAP accredited for the measurement of sound power level according to ISO 3741/ANSI S12.51.

**Progress:** Completed

**Impact:** NVLAP accreditation provides credibility to the test results obtained in these laboratories and the resulting publications.

**Future Plans:** NVLAP accreditation of these sound power level testing facilities will be maintained. NVLAP accreditation requires the laboratories' management system documentation to be submitted each year and an on-site assessment every other year. For the NUC ATL, sound power level testing of pneumatic tools according to ISO 15744 will be added to the scope of accreditation.

**Activity B:** Achieve or maintain NVLAP accreditation of hearing protector test laboratories.

**Description:** The NIOSH Taft Hearing Protector Lab in Cincinnati has been used for several national and international studies of hearing protector attenuation following ANSI S12.6-2008. In 2010, the Hearing Protector Lab was NVLAP accredited for measuring hearing protector real-ear attenuation according to ANSI S12.6-2008. The NIOSH OMSHR Hearing Protector Test Chamber is located within the Auditory Research Lab in Pittsburgh. In 2005, the Hearing Protector Test Chamber received NVLAP accreditation for measuring the real-ear attenuation of hearing protectors according to standard ANSI 12.6-2008.

**Progress:** Completed

**Impact:** NVLAP accreditation provides credibility to the test results obtained in these laboratories and the resulting publications.

**Future Plans:** NVLAP accreditation of these sound power level testing facilities will be maintained. NVLAP accreditation requires the laboratories' management system documentation to be submitted each year and an on-site assessment every other year.

**Activity C:** Achieve NVLAP accreditation for NIOSH Cincinnati Impulse Noise Laboratory.

**Description:** The Impulse Noise Laboratory was recently constructed to study the performance of hearing protector devices in impulse noise following the procedures of ANSI S12.42-2010.

**Progress:** Not complete.

**Impact:** NVLAP accreditation provides credibility to the test results obtained in these laboratories and the resulting publications.

**Future Plans:** During the next NVLAP assessment cycle, the Impulse Noise Laboratory will be submitted to the NVLAP accreditation process for the measurement of the insertion loss of hearing protector devices in impulsive noise according to ANSI S12.42-2010.

**Activity D:** Qualify NIOSH OMSHR Hemi-Anechoic chamber (HAC) according to ISO 3745 and ISO 3744.

**Description:** The NIOSH OMSHR HAC is primarily used for noise source identification through techniques such as beam forming, near-field acoustic holography, and source path contribution analysis. Using the procedures specified by ISO 3745, the HAC was qualified as a free field over a reflecting plane. In addition, a reference sound source was used to document the performance of the HAC following the procedures in ISO 3744.

**Progress:** Completed.

**Impact:** Documenting that the performance of the HAC meets the criteria of ISO 3744 and ISO 3745 shows that the HAC is suitable for measurements requiring a free field over a reflecting plane.

**Future Plans:** When it is appropriate, the test procedures of ISO 3744 and 3745 will be used to reevaluate the acoustic environment within the HAC.

**2014 UPDATE ON RECOMMENDATION # 13 (Activity A) - Achieve or maintain sound power level laboratories accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP)**

***Addition of or modifications to activities since last review:*** None; i.e., current activities have been maintained, but there has been no need to modify or add to them. It is important to note the NIOSH is one of only 21 organizations in the nation with NVLAP accredited facilities.

***Maintenance efforts since last review:*** In 2005, the NIOSH OMSHR Acoustic Test (reverberation) Chamber was NVLAP accredited for the measurement of sound power level according to ISO 3741/ANSI S12.15. In 2010, the NIOSH/University of Cincinnati Acoustics Test Lab was NVLAP accredited for measuring sound power level according to ISO 3744 and ANSI S12.15. Both labs have maintained accreditation continuously since initial accreditation was granted and the appropriate personnel and resources are currently in place to sustain accreditation.

To maintain accreditation, it is necessary to keep a record of every test performed in the lab, maintain records of all test protocols and update the details of each whenever a protocol is changed, as well as maintain calibration records for all instrumentation and room performance. Inspections are made once per year with all the above documents reviewed and discussions with regard to testing, protocols,

calibrations, and any anomalies that have occurred since the last inspection. This is a significant effort that NIOSH has committed to continue.

***Impact(s) made since last review (process or outcome related):*** NVLAP accreditation provides credibility to the test results obtained in these laboratories and the resulting publications.

***Future Plans:*** NVLAP accreditation of these sound power level testing facilities will be maintained. NVLAP accreditation requires the laboratories' management system documentation to be submitted each year and an on-site assessment every other year. For the NIOSH-Cincinnati laboratory, sound power level testing of pneumatic tools according to ISO 15744 will be added to the scope of accreditation.

**2014 UPDATE ON RECOMMENDATION #13 (Activity B) - Achieve or maintain NVLAP accreditation of hearing protector test laboratories**

***Addition of or modifications to activities since last review:*** None.

***Maintenance efforts since last review:*** In 2005, the NIOSH OMSHR Hearing Protector Test Chamber received NVLAP accreditation for measuring the real-ear attenuation of hearing protectors according to ANSI/ASA S12.6. In 2010, the NIOSH Taft Hearing Protector Lab in Cincinnati was NVLAP accredited for measuring hearing protector real-ear attenuation according to ANSI/ASA S12.6-2008. Both labs have maintained accreditation continuously since initial accreditation was granted and the appropriate personnel and resources are currently in place to sustain accreditation. As noted above there is a significant effort to the maintenance of accreditation and NIOSH has committed to the effort and expenditures required. NIOSH is proud to be one of only 21 NVLAP accredited organizations in the country.

***Impact(s) made since last review (process or outcome related):*** NVLAP accreditation provides credibility to the test results obtained in these laboratories and the resulting publications.

***Future Plans:*** NVLAP accreditation of these hearing protector testing facilities will be maintained. Based on collaboration with scientists at the NASA Glenn Research Center, upgrades to the laboratories' hardware, software, and test protocols will be implemented.

**2014 UPDATE ON RECOMMENDATION #13 (Activity C) - Achieve NVLAP accreditation for NIOSH-Cincinnati Impulse Noise Laboratory**

***Addition of or modifications to activities since last review:*** The Impulse Noise Laboratory was constructed to study the performance of hearing protector devices in impulse noise following the procedures of ANSI/ASA S12.42-2010. The impulse noise laboratory has successfully demonstrated the capacity to perform impulse noise measurements that comply with the specifications of ANSI/ASA S12.42-2010. As has been noted below, the NIOSH methodology has been widely adopted by other acoustic laboratories. However, because the U.S. EPA has not promulgated a new regulatory requirement to label hearing protector performance in impulse noise, there has been no need to develop a process for NVLAP certification for impulse noise measurement facilities. Thus, there

currently is no NVLAP certification available for impulse noise measurement facilities. Should the U.S. EPA elect to promulgate new hearing protector labeling legislation, NIOSH remains poised to assist the American National Standards Institute in the development of an associated NVLAP certification for impulse noise measurement laboratories, and to subsequently seek NVLAP certification for the NIOSH Impulse Noise Measurement Laboratory.

***Maintenance efforts since last review:*** The NIOSH Cincinnati Impulse Noise laboratory has been updated with acoustical treatments to reduce reverberation in the testing space. Since 2011, five tests have been conducted at other laboratories and facilities to test the same set of protectors with different impulse noise sources. An engineering survey report comparing the performance of two acoustic test fixtures was published in January 2014. The NIOSH impulse noise data analysis software has been compared and validated with a commercially available impulse data analysis software application.

***Impact(s) made since last review (process or outcome related):*** Several external inquiries have been made regarding the test systems and methodologies being developed for the NIOSH impulse noise laboratory. In response, NIOSH has provided the impulse noise laboratory design and methodology protocol. As a result, US Air Force, US Army acoustic laboratories as well as acoustic laboratories in industry and academia have implemented the NIOSH impulse noise measurement methodology.

***Future Plans:*** NIOSH will continue to use this laboratory for investigation of impulse noise measurements and methods to evaluation HPDs with impulse noise. In the future, if the EPA promulgates regulations that require testing in accordance with ANSI/ASA S12.42-2010 standard, then NIOSH may consider applying for this type of accreditation. Currently no other laboratories in the public or private sector have pursued S12.42 accreditation.

#### **2014 UPDATE ON RECOMMENDATION # 13 (Activity D) – Qualify NIOSH OMSHR Hemi-Anechoic chamber (HAC) according to ISO 3745 and ISO 3744**

***Addition of or modifications to activities since last review:*** NIOSH continues to maintain this test facility to meet the latest versions of these two ISO standards. Tests are run regularly in the laboratory confirming to these standards. NIOSH keeps abreast of any changes or updates to these standards to be sure that the laboratories remain in compliance.

***Maintenance efforts since last review:*** To maintain compliance, NIOSH maintains calibration records of all instrumentation to assure proper performance with sufficient accuracy. No changes are made to the rooms that would adversely affect compliance. In addition, NIOSH keeps abreast of any changes or updates to these standards to be sure that the laboratories remain in compliance.

***Impact(s) made since last review (process or outcome related):*** The new noise controls noted in this report's 2014 Update for Recommendation #8 could not have been developed without these facilities and the accuracy provided by compliance with these ISO standards. These noise controls being commercialized are a direct result of these facilities and their compliance with the ISO standards.

***Future plans:*** NIOSH will continue to use these facilities and maintain compliance to these ISO standards as part of its noise control programs.

**Appendix 1**

**Review of Progress Implementation Report for  
NIOSH Hearing Loss Prevention Program**

**Submitted by Board of Scientific Counselors  
January 10, 2012**

**BSC Working Group Members**

**Jim Ramsay  
Benjamin Amick  
Clarion Johnson**

## Hearing Loss Prevention Progress Score Sheet

**Directions:** For each recommendation listed below, please circle a score for each scoring element and provide a brief justification for the assignment of that score. The work group may provide scores in .5 increments where they deem appropriate. If the group chooses to do that, please put a .5 next to the corresponding number and circle that number.

### Fulfilled Recommendations

#### *Recommendation #1: Foster Effective Leadership.*

**Achievement Score:** 1      2      3      4      5 – **SCORE: 5**

**Brief Justification:** The response to this recommendation was well documented. Specifically, hiring a program manager, program coordinator and assistant coordinator were strategically wise moves which should each assist in development, planning and administrative requirements. Development of the steering committee was appropriate and appears to have been effective.

**Sustainability Score:**      1      2      3      4      5 – **SCORE: 4**

**Brief Justification:** Actions taken to date were simple and straightforward. However, the degree to which the installation of these extra personnel is financially sustainable and evidence that sustained organizational commitment to maintain the extra personnel was not offered. Also, it was unclear as to the degree to which the added leadership has demonstrated coordination within NIOSH and other external research partners. Addition of “leadership effectiveness” metrics to the strategic plan would assist in the determination of whether, and to what degree, “effective leadership” was created.

**Impact Score:**      1      2      3      4      5 – **SCORE: 3**

**Brief Justification:** Clear progress was made in establishing more leadership capacity in accordance with the recommendation; however, and it may be too early to tell, but the degree to which this response has been effective is not clear.

***Recommendation # 4: Develop a strategic plan.***

**Achievement Score:** 1      2      3      4      5 – **SCORE: 5**

**Brief Justification:** A strategic plan was developed around five strategic goals, which were clearly stated. The plan was completed.

**Sustainability Score:**      1      2      3      4      5 – **SCORE: 4**

**Brief Justification:** All strategic goals are reasonable and integrated in the hearing loss protection program. In addition, each objective of the strategic plan is compatible with mission set of NORA. However, it is somewhat unclear what measures of success were put into place and whether those metrics were a part of the strategic plan.

**Impact Score:**      1      2      3      4      5 – **SCORE: 3**

**Brief Justification:** The presence of a strategic plan, specific goals and administrative logic behind the plan assures full implementation and an improved likelihood of success but results have not been demonstrated.

***Recommendation #7: Systematize collaboration with regulatory partners.***

**Achievement Score:** 1      2      3      4      5 – **SCORE: 5**

**Brief Justification:** Relationships were formed with MSHA, OSHA and the EPA. The newly established relationship with MSHA was a novel and unique solution to efficiently systematize collaboration with regulatory partners. Firmly establishing several cross-sector partnerships with OSHA including quarterly meetings, town hall meetings, and planned inter-agency meetings supports a high level of achievement. In addition an interagency labeling agreement was formed with the EPA as well as four years of jointly sponsored research resulting in the modification of three ANSI standards.

**Sustainability Score:**      1      2      3      4      5 – **SCORE: 5**

**Brief Justification:** Having established workshops and quarterly meetings firmly support a long term and reproducible partnership with MSHA. Having established numerous cross-sector interactions with OSHA supports a long term partnership with them. The joint research with EPA demonstrates a cost-effective interagency initiative to reduce hearing loss.

**Impact Score:**      1      2      3      4      5 – **SCORE: 5**

**Brief Justification:** Changes to ANSI standards, laying a firm foundation for interagency collaboration and research, the production of workshops and white papers each represents significant contributions to the program and likely to have a positive impact on worker safety and health. In addition, these contributions are likely to be generalizable as best practices within NIOSH, within other Federal agencies as well as duplicated abroad in multinational work settings.

***Recommendation #8: Place greater emphasis on evaluation of the effectiveness of hearing loss prevention measures on the basis of outcomes that are as closely related as possible to reducing noise exposure and the incidence of occupational hearing loss.***

**Achievement Score:** 1      2      3      4      5 – **SCORE: 4**

**Brief Justification:** Although hearing protective devices were developed along with engineering controls for selected sources of occupational hearing loss (i.e., drill bit isolators in mining), perhaps additional engineering controls may have been developed in the same time frame.

**Sustainability Score:** 1      2      3      4      5 – **SCORE: 5**

**Brief Justification:** A database (from lab tests) on powered hand tools has been created. This can act as a reference for industry manufacturers and consumers and therefore impact noise reduction efforts over time. Strong collaborations and focus on product development life cycle are likely to maintain progress over time.

**Impact Score:**      1      2      3      4      5 – **SCORE: 3**

**Brief Justification:** Impact is limited due to the limited application of efforts – primarily drilling in the mining industry, and perhaps overly focused on engineering controls. Engineering controls, while essential and significant, worker behavior and organizational culture are also significant drivers of hearing loss prevention and need to be further investigated.

***Recommendation 13: Accredit laboratories used to conduct studies for the HLRP.***

**Achievement Score:** 1      2      3      4      5 – **SCORE: 4**

**Brief Justification:** The NIOSH/University of Cincinnati Acoustics Test Lab (ATL), the NIOSH OMSHR’s Acoustic Test Chamber (ATC), the NIOSH Taft hearing protector lab were each accredited and remain so, but the NIOSH Cincinnati Impulse Noise Laboratory was not accredited.

**Sustainability Score:** 1      2      3      4      5 – **SCORE: 3**

**Brief Justification:** It is unclear whether NIOSH has set aside funds and personnel to maintain accreditation in all three labs over time although the ATC was accredited in 2005 and remains so; the ATL and the Taft lab weren’t accredited until 2010.

**Impact Score:**      1      2      3      4      5 – **SCORE: 5**

**Brief Justification:** Impact is expected to be high given the level of credibility that accompanies the science and testing which emanate from accredited labs.

## Recommendations In Progress

*Recommendation #5: Use surveillance data as well as stakeholder input to identify priorities.*

**Relevance:** 1 2 3 4 5 – **SCORE: 5**

**Brief Justification:** This activity is highly relevant to the ongoing and continuous improvement in occupational hearing loss sources and stakeholders. To date a national repository of 7 million audiograms have been collected, representing 2.6 million workers at over 36,000 workplaces has been made, an alliance between NIOSH, OSHA and the NHCA has been formed, and a systematic effort to analyze, disseminate results and solicit feedback from stakeholders is underway. Building this publically accessible database is a critically important national resource for industry, researchers and labor.

**Sustainability:** 1 2 3 4 5 – **SCORE: 3**

**Brief Justification:** Efforts to date are straightforward and appear to be sustainable, and cost effective. However, alliances are difficult to maintain over time and the analysis and dissemination and solicitation efforts are relatively not well established, so their sustainability is unclear. This objective (surveillance and stakeholder feedback) needs to be a part of the strategic plan with a metric that indicates relative and ongoing success. In addition, a marketing plan is required to optimize dissemination and solicitation of stakeholder feedback.

**Progress:** 1 2 3 4 5 – **SCORE: 4**

**Brief Justification:** Progress to date has been impressive, mindful and on target.

**Potential Impact:** 1 2 3 4 5 – **SCORE: 5**

**Brief Justification:** The potential impact of all activities within this recommendation is profound and would be precedent setting. It's imperative to the field of prevention to ensure the success of this effort to provide a model of surveillance for other occupational health and safety issues.

***Recommendation #11: Develop noise control engineering approaches for non-mining sectors.***

**Relevance:** 1 2 3 4 5 – **SCORE: 5**

**Brief Justification:** Non mining sector sources of occupational hearing loss require more attention. This recommendation attempts to evaluate how best to address this challenge.

**Sustainability:** 1 2 3 4 5 – **SCORE: 5**

**Brief Justification:** Development of the two activities to date (the database of noise levels for powered hand tools and the effort to enhance in-house noise control technology research) are warranted, and appear economically achievable. To ensure sustainability, it's important that greater clarity be included in the strategic plan as to how these efforts might best integrate in other, cross sector initiatives within NORA.

**Progress:** 1 2 3 4 5 – **SCORE: 4**

**Brief Justification:** Both activities demonstrate substantial progress and achievement. It is important to add that leadership needs to be held accountable for progress and that metrics for success are laid out clearly in the strategic plan.

**Potential Impact:** 1 2 3 4 5 – **SCORE: 4**

**Brief Justification:** The “buy-quiet” program and the database are unique and compelling interventions that are expected to have continuous impact. It appears too early to discern the impact of the in-house research efforts.