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DEPARTMENT OF COMMERCE
RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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AWARD INFORMATION	
1. Federal Agency: Department of Commerce / NOAA	2. Federal Award Number: NA19NES4320002
3. Project Title: Cooperative Institute for Satellite Earth System Studies	
4. Award Period of Performance Start Date: 07/01/2019	5. Award Period of Performance End Date: 06/30/2024
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	
6. Last Name and Suffix: Williams , null	7. First and Middle Name: Ellen , D
8. Title: Director, Earth Systems Science Interdisciplinary Center	
9. Email: edw@umd.edu	10. Phone Number: 301-405-3291
AUTHORIZING OFFICIAL	
11. Last Name and Suffix: Anderson , null	12. First and Middle Name: Monique , null
13. Title:	
14. Email: oraa@umd.edu	15. Phone Number: 301-405-6269
REPORTING INFORMATION	
Signature of Submitting Official: Monique Anderson	
16. Submission Date and Time Stamp: 04/29/2021	17. Reporting Period End Date: 03/31/2021
18. Reporting Frequency: (●) Annual ( ) Semi-Annual ( ) Quarterly	19. Report Type: (●) Not Final ( ) Final
RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF MARYLAND, COLLEGE PARK	
21. Recipient Address: 3112 LEE BLDG 7809 REGENTS DR, COLLEGE PARK, MD 20742-0001 USA	
22. Recipient UEI: NPU8ULVAAS23	23. Recipient EIN: 526002033

ACCOMPLISHMENTS

24. What were the major goals and objectives of this project?

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The Cooperative Institute for Satellite Earth System Studies (CISESS) is a national consortium of academic and nonprofit institutions, with leadership from the University of Maryland College Park (UMD) and North Carolina State University (NCSU). The CISESS Consortium's primary objectives are to 1) support NOAA's National Environmental Satellite Data and Information Service (NESDIS) and its mission to provide "secure and timely access to global environmental data and information from satellites and other sources to both promote and protect the Nation's environment, security, economy, and quality of life"; 2) promote and augment the research capabilities of NOAA and support its mission "to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources"; and 3) deliver innovative research products, education, training, and outreach aligned with these missions.

The grand scientific challenge of CISESS is to enhance the understanding of how the natural atmosphere–ocean–land–biosphere components of Earth interact with human activities as an interactive system. CISESS engages in collaborative and transformative research activities with NOAA scientists to enhance NOAA's ability to generate and use satellite and in situ observations and Earth System models to meet that challenge, advance NOAA's science mission, and identify emerging science needs that will effectively contribute to meeting NOAA's mission in the future. In conjunction with its research operations, CISESS educates and trains students and scientists in areas of priority to NOAA and carries out relevant outreach and engagement activities with the scientific community, decision makers, and the public.

CISESS research activities are organized around three broad science themes: Satellite Services, Earth System Observations and Services, and Earth System Research. Through a research program aligned with these three major themes, CISESS contributes to NOAA mission-directed research leading to greater observation, understanding, and prediction of the global Earth System. CISESS will provide the capabilities and expertise to improve systems for data access, quality, management, processing, analysis, assimilation, modeling, dissemination, and visualization.

The range of CISESS expertise supporting NOAA is broad and varied—from basic and applied research on the natural Earth System, through study of the coupling of the Earth System to societal responses, social science, and policy research, to stakeholder engagement and communication with the general public. The CISESS Consortium brings together a broad complement of institution that, collectively, are well equipped to address the wide variety of scientific, research, and outreach functions to support NOAA.

25. What was accomplished under these goals?

Under this project, the following performance metrics were accomplished during this period of performance.

Number of new or improved products developed that became or may become operational:189
Number of peer reviewed papers: 200
Number of NOAA Technical Reports: 15
Number of invited presentations:19

Number of graduate students supported by a CISESS task: 9
Number of graduate students formally advised: 26
Number of undergraduate students mentored during the year: 24
Number of students mentored by Consortium members: 28

ACCOMPLISHMENTS *(cont'd)*

26. What opportunities for training and professional development has the project provided?

During this period, this project provided professional development activities through work on research tasks with NOAA scientists for the following:

Number of scientists 186
Number of graduate students 16
Number of undergraduate and high school students 5

CISESS personnel have supported training activities to onboard new staff as data managers within the NCEI archive system.

CISESS UMD provided Peer-Intervention training for all personnel.

CISESS personnel are routinely alerted to career development activities provided through the CI campus or professional organizations and encouraged to participate as appropriate to their research goals.

CISESS NC provides the opportunity for 13 graduate and undergraduate students to explore their interest in science and/or apply their ongoing education to current projects through its student internship program. CISESS NC staff also mentored 3 NASA DEVELOP teams and 2 NOAA Hollings Scholars

27. How were the results disseminated to communities of interest?

Coral Reef Watch (CRW) staff broadly communicates critical product information (including summaries & analyses of satellite- and model-based products) to users worldwide via CRW's public website, email networks, social media accounts, regular partner and monitoring network reports, numerous presentations, and outreach materials. CRW staff also provide all data products, datasets, and supporting metadata to NESDIS/NCEI and CoRIS for archiving, and all publications (in a 508-compliant format) to CoRIS and the NOAA Central Library's IR.

A prime-sub relationship with ReefSense based out of Australia was used to disseminate information internationally

Key accomplishments this year included the co-production of a series of six climate change webinars in partnership with the State Climate Office of North Carolina, initiating of a new series of monthly science seminars, editorial support for multiple papers and reports, and graphic design and visual communication support for NCEI's annual State of the Climate Report, Spectrum Broadband, and the Extended Continental Shelf Report.

CISESS NC serves as the NOAA Big Data Program (BDP) data broker and 23 new or enhanced datasets were made available through NOAA Big Data Program (BDP) cloud service provider partners. (broadening access to NOAA data through cloud-based mechanisms)

CISESS Consortium partner University of Nebraska Medical Center and the National Integrated Drought Information System (NIDIS) conducted a regional workshop on drought and health for the Carolinas. The project team is evaluating the impact of historical drought events on mortality and morbidity in Nebraska.

Research is disseminated via public and private code repositories, social media, technical reports, internal memos, science team teleconferences, conference oral presentations and posters, and peer-reviewed journal articles. Products are on NCEI websites, NOAA CLASS System, STAR website, NOAA NWS AWIPS, data.gov, ftp sites, NASA SPoRT, Copernicus Climate Change Services (C3S) Climate Data Store, and other international collaborative data sites.

ACCOMPLISHMENTS *(cont'd)*

28. What do you plan to do during the next reporting period to accomplish the goals and objectives?

28. What do you plan to do during the next reporting period to accomplish the goals and objectives?
CISESS will continue to conduct collaborative research, education, and outreach programs aligned with NOAA strategic goals to achieve the following objectives:

• Advance and refine the use of satellite information to operationally derive accurate measures of the Earth System components and develop long-term quality assurance of satellite observations that can be included in future reanalysis projects;

• Research and design best practices for management and stewardship of big data sets;

• Provide cutting-edge, end-to-end research and development services to assist the NOAA science enterprise in transforming raw data received from satellites and other sources into valuable information about the environment;

• Deliver innovative research products, education, training, and outreach to enhance the understanding and utility of that information for respective constituencies, and engage with diverse stakeholders of such information;

• Design information products and systems to monitor changes in the Earth System: atmosphere, oceans, land, cryosphere, ecosystems, socioeconomics, and other components of the anthroposphere;

• Develop experimental virtual reality tools for use in forecasting environments; and

• Strengthen overall NOAA-related research capabilities and capacity at CISESS institutions in a way that complements and contributes to NOAA's ability to reach its mission goals.

PRODUCTS

29. Publications, conference papers, and presentations

A total of 200 peer-reviewed publications and 15 NOAA technical reports were produced by CISESS during this reporting period. A list is attached to this document.

A total of 487 talks and posters were presented at national conferences. Of these, 19 were invited presentations.

PRODUCTS *(cont'd)*

30. Technologies or techniques

Algorithm refinements and data base updates led to a significant improvement in both retrieval quality and spatial coverage of satellite products.

A new Soil Moisture EDR product was evaluated using ground observations and then inter-compared with soil moisture products from other satellite missions, such as SMOS, SMAP and ASCAT. An impact assessment of the individual contributions was also done.

An AI model was developed that can be used to cross-compare JPSS CrIS and ATMS observations.

Land surface albedo and aerosol load products were obtained through a new process that directly used BRDF parameters daily from the accumulation of clear-sky geostationary satellite data.

A graph structured database analog for the Global Historical Climatology Network-Daily (GHCNd) is under development with an initial database design created. (GHCNd contains over 3 billion weather observations and is growing. This work will support the transition of the GHCNd processing platform to a more efficient cloud-based operation)

31. Inventions, patent applications, and/or licenses

Nothing to Report

PRODUCTS *(cont'd)*

32. Other products

Standardization of U.S. Climate Reference Network (USCRN) Soil Moisture Observations: A daily soil moisture-based drought index was developed from the standardized soil moisture dataset and made publicly available through CISESS NC. Comparisons between USCRN and the European Space Agency's (ESA) Climate Change Initiative (CCI) remotely sensed soil moisture dataset were evaluated for both volumetric (raw) and standardized measures.

Value-Added Precipitation product suite from CDRs: The three satellite precipitation products (SPPs) were renamed to avoid confusion with in situ Normals products, and an evaluation of the SPSs was completed for the years up to 2018, including a more complete evaluation for CONUS with comparisons to USCRN data.

A list of products is attached.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

Name: Ellen Williams
Role: PD/PI
Number of months (calendar) on project: 3
Contribution to the project: Dr. Williams is the tasked with overall responsibility of the Cooperative Institute, including managing the relationship between Consortium members, and between the overall Consortium and NOAA. She serves as the primary point-of-contact of the CI with NOAA. . She provides overall CI scientific and operational leadership, r working with NOAA and Consortium team members. . She reports to the CISESS Executive Council.
Residence: State of Maryland

Name: E. Hugo Berbery Role: PD/PI
Number of months (calendar) on project: 12
Contribution to the project: As Deputy Director of CISESS, Dr. Berbery also acts as Director for the campus in MD: tasked with supporting management of the overall Consortium, as well as management of the MD campus of CISESS, with scientific and financial responsibility over all research, education, and outreach/engagement activities taking place in this campus. In the role of CISESS Deputy Director and Director of the Maryland Campus, he supports the Director in managing the Consortium. He oversees scientific research, education, and outreach/engagement activities taking place in the Maryland campus as well as financial operations. At CISESS, Dr. Berbery has worked on advancing the Institute's scientific profile, improving its visibility, and developing best management practices.
Residence: State of Maryland

Name: Otis B. Brown Role: Co-PD/PI
Number of months (calendar) on project: 12
Contribution to the project: Dr. Brown is responsible for the campus of CISESS in NC, tasked with overall management, scientific and financial responsibility over all research, education, and outreach/engagement activities taking place in this campus.
Residence: State of North Carolina

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS *(cont'd)*

34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Professor Williams joined CISESS as PD/PI on July 1, 2020 following departure of former PD/PI Fernando Mirrales-Wilhelm for a position at another University.

35. What other organizations have been involved as partners?

The CISESS Consortium consists of UMD and NCSU as lead institutions and the University of North Carolina System (17 campuses, including NCSU); the University of Maryland, Baltimore County (UMBC); the University of Alabama (UA); the University of Alabama in Huntsville (UAH); the City University of New York (CUNY); George Mason University (GMU); Oregon State University (OSU); Howard University (HU); the University of Michigan (UM); the University of South Carolina (USC); the University of Georgia (UGA); the University of California, Irvine (UCI); South Dakota State University (SDSU); Florida International University (FIU); and the University of Nebraska Medical Center (UNMC) as academic institutions. Nonacademic institutions of the CISESS Consortium are the Pacific Northwest National Laboratory (PNNL), the University Corporation for Atmospheric Research (UCAR), The Nature Conservancy (TNC), and the Research Triangle Institute (RTI).

FY20 Consortium Contributions:

Consortium Partner	Location	Tasks
CESSRST, City College of New York	New York, NY	10
George Mason University	Fairfax, VA	6
RSC, University of Alabama	Tuscaloosa, AL	3
University of Maryland Baltimore County	Baltimore, MD	2
Howard University	Washington, DC	1
Oregon State University	Corvalis, OR	1
GSCE, South Dakota State University	Brookings, SD	1
University of New Hampshire	Durham, NH	1

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS *(cont'd)*

36. Have other collaborators or contacts been involved?

FY20 Contributions (Non-Consortium):

Partner Location Tasks
University of Colorado at Boulder Boulder, CO 1
Kansas University Lawrence, KS 1
Texas Technical University Lubbock, TX 1
ReefSense Townsville, Australia 1
Jet Propulsion Laboratory Pasadena, CA 1

IMPACT

37. What was the impact on the development of the principal discipline(s) of the project?

CISESS has engaged in collaborative and transformative research activities with NOAA scientists to enhance NOAA's ability to generate and use satellite and in situ observations and Earth System models to meet that challenge, advance NOAA's science mission, and identify emerging science needs that will effectively contribute to meeting NOAA's mission in the future. In conjunction with its research operations, CISESS has educated and trained students and scientists in areas of priority to NOAA and carry out relevant outreach and engagement activities with the scientific community, decision makers, and the public.

Specific impacts can be detailed as follows:

Algorithm development and calibration/validation efforts
• Scientific support for NOAA's JPSS satellite series. For each of the instruments (ATMS, CrIS, VIIRS, and OMPS), scientific staff apply critical capabilities for maximum beneficial collected data usage and support key performance parameters.
• Geostationary surface albedo (GSA) algorithm being used as US contribution to international effort to produce joint climate record; new technique to estimate net solar radiation from geostationary (GEO) satellites.
• NOAA GOES-16/17 post-launch mission scientific assistance/support, including the calibration/validation, research/development, and dissemination of GOES-R data.
• Pre- and post-launch Radio Occultation (RO) data retrieval, processing, analysis, validation, and bias-monitoring in support of the Global Navigation Satellite System (GNSS) RO activity.

New applications/products development
• Providing continuous records of the ocean heat content, salt content, steric sea level estimates to the scientific community. This maintain public awareness about climate change and supports related decision-making.
• Developed the first ever coastal ocean acidification data product
• Initial data stewardship maturity matrix (DSMM) for long-term stewardship of NOAA data products.
• New approaches to uncertainty quantification for observational datasets. Novel statistical approach for fusing multiple platform/instrument observations.
• Version 4 of NOAA's Global Historical Climatology Network monthly temperature dataset, which aligns GHCN-M monthly temperature values with GHCN-D daily data and expands global coverage.
• Expansion of the operational Snowfall Rate (SFR) product for applications in weather forecasting.
• CRW staff support of the NOAA CRW mission. CRW continues utilizing remote sensing, modeled and in situ data to observe, predict, and report to its users on the coral reef environment worldwide. Staff leads and executes the development, operation, testing, validation, improvement, and operationalization of all products within NOAA CRW's world-renowned decision support system for coral reef management.

IMPACT *(cont'd)*

38. What was the impact on other disciplines?

Our four projects on the GOES-R satellite Geostationary Lightning Mapper (GLM) facilitates the understanding of lightning physics and detection in a broader area in atmospheric science, remote sensing, electrical engineering, and education. It also impacts astronomy in that it has captured meteor paths in the atmosphere.

39. What was the impact on the development of human resources?

CISESS has supported NOAA's commitment to developing a future diverse workforce, and to this end it is led by a Minority Serving Institution (UMD is a MSI) and has significant participation of other MSIs. CISESS supports K–12, undergraduate, graduate, and postdoctoral education through mentoring early career staff, advising, teaching students, supporting student research activities, enabling student internships and fellowships, and advancing research collaborations.

Specific impacts on the development of Human Resources include:
• Created information/discussion exchange venues bringing together industry decision makers, academic researchers, and federal data experts (e.g., Executive Forum for Business and Climate and Dataset Discovery Days).
• Targeted outreach efforts with local schools and other STEM organizations (e.g., science museum, science festivals, STEM high schools, etc.).
• Maintain annual CISESS summer intern initiative, a mentoring program for undergraduate students to work on NOAA-related research.

• Continuing Seminar series both at UMD and NCSU.

CISESS NCEI staff have taken advantage of many different professional development training opportunities over the course of the past year, and Zachary Mason continued working on a new degree in Computer Science and Software Development that will be finished in summer 2021. In addition, staff have supported training activities to onboard new staff as data managers within the NCEI archive system.
One project organized a week-long satellite class for NOAA staff. (25 participants). All participants indicated they are now more confident and more likely to use satellite data in their research projects.system.

IMPACT *(cont'd)*

40. What was the impact on teaching and educational experiences?

40. What was the impact on teaching and educational experiences?
CISESS scientists involve students in earth science and enable students and teachers to explore and understand the large volumes of climate data that NOAA collects about the Earth. Working collaboratively with other academic and public partners, stakeholders, and the private sector, CISESS supports and engages in various educational and outreach-related activities to advance the following areas:
i. Increase awareness of climate science and changes in the climate system
ii. Grow the understanding of how climate data is collected, observed, analyzed, and used in research purposes
iii. Increase awareness of climate datasets and products, and how educational teachers/professors can make use of climate data products for teaching climate science
iv. Demonstrate capacity building on the various impacts of climate change across public, private, and academic arenas
v. Increase private sector understanding and use of climate data and information for their strategic and operational use
CISESS provide internship opportunities to undergraduate and graduate student during the summer time. We also take on undergraduate meteorology majors during the school for their senior research projects. Some of our grants support graduate students whose research is on NOAA mission-related areas. We also have projects that fund student interns for NOAA personnel. For example, CISESS staff who work at NCEI on the coral reef database CoRIS have made it a priority to continue outreach to students and educators by posting educational content on the CoRIS site and by working closely with internal and external organizations to promote coral reef-based educational content on websites and social media. In addition to these efforts, CISESS staff mentored two students this past year. These students provided data analysis and visualization support to CISESS staff as part of a NOAA Heritage Program Project.

41. What was the impact on physical, institutional, and information resources that form infrastructure?

Nothing to Report

Attach a separate document if more space is needed for #6-10, or #24-50.

IMPACT *(cont'd)*

42. What was the impact on technology transfer?

Monitoring and improving GCOM AMSR2 rainfall rate retrieval performance helps developers identify regions and regimes where the algorithm underperforms and guides future improvements, while the EDR itself serves nowcasting, forecasting and climate communities to track, understand and evaluate precipitation systems across wide range of spatial and temporal scales.
The dual-pass data assimilation algorithm does not need the so-called "bias-correction" process. It actually adjusts the model climatology to the observation climatology, rather than using model simulations to change observations. The latter is believed to lose observation information (Nearing et al, 2013). The efficiency and effectiveness of the dual-pass data assimilation algorithm will be inter-compared with and is expected to be higher than those of the conventional algorithm (i.e.. the EnKF).

43. What was the impact on society beyond science and technology?

CISESS supports the NESDIS mission of providing secure and timely access to global environmental data and information from satellites and other sources in order to promote and protect the Nation's security, environment, economy, and quality of life, as well as NOAA's broader mission to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources.

The need for global Earth System frameworks that included human system drivers and feedbacks has been recognized since the 1980s, notably documented in the pioneering report by the Earth System Sciences Committee of the NASA Advisory Council, chaired by Francis P. Bretherton (National Research Council 1988). This conceptual framework captures the interactive dynamics of the key components of the coupled Earth System with two-way feedbacks. This framework combines data collection from satellites and other sources, analysis techniques, and modeling to couple Earth System natural components, such as atmosphere, land (including vegetation and land use), and water (including oceans, ice, atmospheric, surface and subsurface water), with human components such as population demographics, freshwater, energy, agriculture, food production, industry, development, and transportation. The focus is on activities with spatial scales ranging from regional to global and time scales spanning from minutes to decades, covering a variety of forecasting needs across societal (human system) applications and sectors. The investigators and institutions assembled in the CISESS Consortium have the expertise and resources necessary to develop and evaluate complex algorithms, products, and models that exploit both satellite and in situ measurements in order to provide information on the atmosphere, land, ocean, biosphere, and anthroposphere.

Applications of our improved drought forecasts contribute to energy, environment, and public health sectors to reduce their vulnerability to droughts. Our tools will deliver a near real time method of detecting inundation without requiring clear skies or active transponders at a small enough resolution to help advise first responders.

The quality NOAA operational VIIRS Day-Night Band instrument product calibrated in this project assures its application in social-economic and disaster monitoring studies. For example, the Day-Night Band products were used to assess power outages in Texas after the March 13 – 15, 2021 snowstorm.

CISESS UMD and NC scientists participated in several COVID-19 research activities during the year and one CISESS NC researcher worked with local county health officials to develop a COVID-19 Self Checker tool to connect vulnerable area residents with needed care and testing resources

IMPACT *(cont'd)*

44. What percentage of the award's budget was spent in foreign country(ies)?

1 , In FY20, we worked with ReefSense, an Australia-based subcontractor who provide services to Coral Reef Watch and its CISESS staff. They received $432,721 - this is about 1.2% of the total budget in FY20. (The web page would not allow us to enter a decimal number in the box, so we reported the closest integer.)

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

Nothing to Report

Attach a separate document if more space is needed for #6-10, or #24-50.

CHANGES/PROBLEMS *(cont'd)*

46. Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to Report

47. Changes that had a significant impact on expenditures

Nothing to Report

Attach a separate document if more space is needed for #6-10, or #24-50.

CHANGES/PROBLEMS *(cont'd)*

48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Nothing to Report

49. Change of primary performance site location from that originally proposed

During COVID, all work was initially transitioned to remote effort. At UMD, a slowly staged process of safely allowing staff to work on site with appropriate social distancing was implemented. All meetings, including seminars, were handled via VTC. This sets the stage for a careful return to more on-site performance over the next year. For CISESS scientists working at NOAA sites, all NOAA protocols were followed, and will be followed in the future.

Attach a separate document if more space is needed for #6-10, or #24-50.

PROJECT OUTCOMES

50. What were the outcomes of the award?

Outcomes of CISESS are the following:

Through this year's tasks, CISESS:

•harnessed expertise in satellite and in situ observing systems required to produce reliable and authoritative data, and provide project management and data stewardship skills necessary for making these data usable and available;

•contributed to NOAA mission-directed research that will utilize these observing systems and lead to an understanding of the Earth System at regional to global scales and from minutes to decades;

•provided educational and outreach opportunities in NOAA-related research on applications of satellite data and information, supporting students' participation in areas that will contribute to the development of a diverse workforce in NOAA;

•engaged with stakeholders, offer the communication expertise required to understand user needs, and deliver actionable information about the Earth System;

•identified emerging science needs requiring satellite and other Earth observations that will contribute to effectively and efficiently meeting NOAA's mission.

DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)

Gender:

- ◯ Male
- ◯ Female
- ◯ Do not wish to provide

Ethnicity:

- ◯ Hispanic or Latina/o Not
- ◯ Hispanic or Latina/o Do not
- ◯ wish to provide

Race:

- ◯ American Indian or Alaska Native Asian
- ◯ Black or African American
- ◯ Native Hawaiian or other Pacific Islander
- ◯ White
- ◯ Do not wish to provide

Disability Status:

- ◯ Yes
  - [ ] Deaf or serious difficulty hearing
  - [ ] Blind or serious difficulty seeing even when wearing glasses
  - [ ] Serious difficulty walking or climbing stairs
  - [ ] Other serious disability related to a physical, mental, or emotional condition
- ◯ No
- ◯ Do not wish to provide

Attach a separate document if more space is needed for #6-10, or #24-50.