Please note: the substantive content of the 2026 NRI Roadmap Survey begins at Question 20 (with prior questions dealing with administrative and other information).

As such all submissions that are published include the responses submitted from Question 20 onwards only.

Q20.

Part 2: Research themes

2.1 NRI comprises the assets, facilities and associated expertise to support leading-edge research and innovation in Australia and is accessible to publicly and privately funded users across Australia and internationally. We are seeking your input on possible directions for future national-level investment - i.e., where the requirements are of such scale and importance that national-level collaboration and coordination are essential.

The 2021 Roadmap used a challenge framework to support NRI planning and investment. With this in mind, consider likely future research trends in the next 5 - 10 years, and with respect to one or more of the 8 challenge areas identified in the 2021 Roadmap as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or not at sufficient scale and
- describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities.

Q21.

Resources Technology and Critical Minerals Processing

For Australia to become a critical minerals processing powerhouse, resource discovery remains a priority, particularly in the 70% of the Australian continent that is covered by younger un-mineralised sediments. Resource discovery relies on subsurface sampling. Efforts in this space are supported by innovative home-grown drilling infrastructure developed over the last decade within the Deep Exploration Targeting and MinEx Cooperative Research Centres. As technologies developed in CRCs are commercialised, researcher access to this novel infrastructure becomes more challenging. Therefore, there is an opportunity for Australia's NRI to fund researcher access to these technologies, either in a standalone capacity for locally led projects, or as a home-grown infrastructure contribution into internationally driven scientific drilling collaborations. Australia also has an opportunity to build on its strong and thriving minerals industry to become a world leader in quantum sensing and laser technologies. For example, scientific drilling projects undertaken through membership in international research infrastructure initiatives provide access to the latest drilling technology are an ideal innovation platform for testing quantum-based and fibre optic downhole sensing and drill location control technologies.

Q22.
Food and Beverage

Q23.
Medical Products

Q24.
Defence

Q25.
Recycling and Clean Energy

Q26.
Space

An Earth-based NRI system that continues to support long-term membership in international research infrastructure initiatives presents opportunities to advance Australia's emerging global position in space technologies and space exploration. In recent years, there has been significant global progress in growing links between space explorers and long-standing international research infrastructure collaborations such as the International Ocean Discovery Program (IODP). IODP's efforts in subsurface sampling over more than five decades share many challenges in common with exploration in extreme extraterrestrial environments. Space exploration has adopted microbiology contamination protocols used in scientific drilling to ensure the integrity of samples that could reveal extraterrestrial life. Similarly, biomarkers developed by IODP's biologists and geologists to detect traces of ancient, extremophile life in subsurface sediment and rocks on Earth are directly translatable to the search for extraterrestrial life. Further, the cutting-edge drilling systems on NASA's latest Mars rover were co-designed with engineers responsible for advanced deep-sea drilling systems on research vessels operated as part of international research infrastructure initiatives. Australian researchers are at the forefront of efforts to explore the origins of life on Earth and beyond. They are doing this through refining methods to obtain pristine samples of sediment and rock from the subsurface and by developing novel biomarkers of ancient life in sediments and rocks under the ocean floor and beneath the Antarctic ice sheet. This leadership is evidence of the Australia's readiness to benefit from long-term NRI investment in memberships to international research infrastructure initiatives that are expanding from terrestrial to extraterrestrial exploration.

Q27.

Environment and Climate

Sampling of sediments in ocean basins and lakes has been instrumental in demonstrating past climate change. There is still a role for the subsurface sampling that constrains the pace of climate change, including climate tipping points, and informs strategies to mitigate the effects of future change. Information about past extreme climates and rates of change are required to test climate and ocean models, such as those delivered by ACCESS NRI, to examine future climate scenarios. For Australia to remain at the forefront of climate change research, future NRI must maintain mechanisms that facilitate access to a capable and accessible research vessel fleet and membership in international research infrastructure initiatives like the International Ocean Discovery Program and the International Continental Scientific Drilling Program. Australian access to this large-scale and high-cost subsurface sampling infrastructure, core repositories and databases, which are beyond the individual financial capacity of most nations, has been through membership arrangements that involve contributing a fixed annual sum that effectively buys places for Australian scientists on scientific drilling expeditions at sea or projects on land. Further, implementing scientific drilling projects for subsurface sampling, which individually cost millions of dollars (generally >$20m in the oceans), requires multi-year lead times for planning. Hence, longer-term commitments of NRI funding would allow Australia to provide international partners with the certainty needed for planning projects that mostly take longer to implement than the duration of granted funding. This means that NRI funds assigned to membership in international research infrastructure programs would achieve the best value if provided as ongoing operational funds rather than shorter term (few years) project-linked funds. In Australia, with new NCRIS-supported membership in the International Continental Scientific Drilling Program (ICDP), a new impetus for subsurface sampling beneath lakes is emerging. Sampling below lakes, both dry and wet, has contributed essential data to understanding past changes in continental climate, landscape and ecosystems (e.g. rainfall patterns, monsoon behaviour, soil erosion, vegetation and fire). To date, readily accessible research infrastructure for lake drilling has limited sampling to depths of tens of metres. This facilitates access to climate records back only thousands of years. Research infrastructure capability that facilitates sampling to greater depths (hundreds to thousands of metres) and hence further back in time (hundreds of thousands to millions of years) is limited, but the opportunity exists to leverage international expertise and infrastructure through Australia's new NCRIS-supported membership in the ICDP. Opportunities in subsurface sampling beneath lakes using scientific drilling is highlighted by the ICDP Lake Drilling Strategy released in late 2024.

Q28.

Frontier Technologies and Modern Manufacturing

Q29.

2.2 The 2024 statement of National Science and Research Priorities (NSRPs) includes outcomes linked to each priority to assist in identifying critical research needed in the next 5 to 10 years.
Consider the priority statements and, with respect to one or more of the 5 priority areas as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or
- not at sufficient scale and describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities, and where relevant, refer to the underpinning outcomes and research identified in the NSRPs document.

Q30.

Transitioning to a net zero future

Critical minerals are key to transitioning Australia to a net-zero future because they provide the resources needed for the renewable energy industry. Scientific drilling supported internationally by global research infrastructure collaborations and nationally by the Cooperative Research Centres program (e.g. MinEx CRC) has provided valuable analogues for Australia's critical mineral deposits and for the formation and deposition of critical minerals in environments that were once marine. NRI that maintains the ability to access subsurface sampling technology through membership in international research infrastructure initiatives is essential to progressing our understanding of these deposits and identifying the most prospective regions for future exploration. Access to scientific drilling is also important for obtaining subsurface samples that constrain the suitability of subsurface reservoirs for geological sequestration of carbon dioxide. Furthermore, subsurface samples are needed to improve our understanding of the potential for enhanced rock weathering and ocean alkalinity as possible drawdown technologies for hard-to-mitigate carbon dioxide emissions. To do this, Australia's NRI landscape must include an appropriately capable research vessel fleet that is available for the science needed to study these processes and to ensure that Australia is undertaking the fundamental research that informs our understanding of the risks from these new technologies before they are deployed commercially. Improved understanding of our offshore seafloor is critical for planning for offshore infrastructure such as pipelines, cables and renewable energy such as wind turbines. This requires a knowledge of the sea floor stability and hazards to ensure that such infrastructure is resilient to earthquakes, landslides and volcanic eruptions (such as the eruption of the Hunga-Tonga volcano that cut numerous undersea cables).

Q31.

Supporting healthy and thriving communities

Access to scientific drilling infrastructure is essential for understanding groundwater resources that Australian cities heavily rely on as a source of fresh water. In many cases, stressed onshore aquifers – that are reasonably well understood due to their relatively easy access – extend offshore under the continental shelf. However, knowledge of these sub-seafloor fresh groundwater resources is very poor. In many cases, models built to understand groundwater volumes and flow behaviour in response to onshore extraction have no hard constraints. If we are to effectively manage rather than blatantly exploit this precious resource, access to research infrastructure that facilitates subsurface sampling is essential. International scientific drilling consortia, of which Australia is member, have recognised the need to better understand offshore aquifers filled with fresh groundwater – a project to examine aquifers beneath the continental shelf of the northeastern United States will take place in mid-2025. This US$25m project relies on international contributions and if Australia is to benefit from the knowledge gained by such efforts, we need to be involved. This example demonstrates the ongoing need for NRI that supports membership in international research infrastructure consortia at a level that allows a meaningful Australian contribution, involvement of Australian researchers, and contributions over a timeframe that gives our international partners the certainty needed to plan these major undertakings (noting that the 2025 project in the northeastern US has been in planning for more than five years). NRI for subsurface sampling also provides the opportunity for advances in biotechnology, environmental DNA, and medical fields based on studies of life in extreme subseafloor and subsurface environments. Surprising discoveries around the extent of the deep subsurface biosphere generate the potential for the discovery of new species that may offer opportunities to develop novel pharmaceuticals.

Q32.

Elevating Aboriginal and Torres Strait Islanders knowledge systems

NRI focussed on subsurface sampling is well placed to lead in establishing inclusive relationships with First Nations communities and scientists. Subsurface sampling facilitates the generation of time-series datasets that tie to Aboriginal and Torres Strait Islander knowledge systems. Similarly, there are opportunities for capacity building through direct knowledge input from traditional owners into research on climate history, natural hazards, resources and archaeology across the Australian landmass and out onto the continental shelf. Australian membership in international research infrastructure initiatives also generates opportunities to extol the benefits of inclusive science that recognises and learns from Aboriginal and Torres Strait Islander knowledge systems. Experience from recent and planned scientific drilling projects in the Pacific indicates that Australia has a leading role in global efforts to acknowledge and recognise the benefits that stem from First Nations knowledge systems. This is perhaps an unrecognised leadership opportunity stemming from NRI that facilitates Australian membership in international research infrastructure initiatives.

Q33.

Protecting and restoring Australia’s environment

Protecting and restoring Australia's environment benefits from NRI that facilitates long-term membership in international research infrastructure initiatives that enable subsurface sampling via scientific drilling. As outlined elsewhere in this response, analysis of sediment samples provides essential paleo-environmental information that tells us what the environment and climate were like prior to anthropogenic climate change. This provides a baseline to inform efforts to mitigate against climate change and to aid in protecting and restoring our environment. With focus shifting to mitigating future climate change, there is new impetus for sampling that provides data of sufficient resolution to constrain the rate at which the inevitable changes will occur. These tipping points are more difficult to mitigate against, but maintaining access to international research infrastructure that facilitates the necessary subsurface sampling improves Australia’s chances of determining the timeframes over which mitigations must be implemented. Seafloor and subseafloor sampling also have a key role to play in advancing our immature understanding of sensitive marine ecosystems close to shore and particularly in the deep ocean. The hard constraints provided by analysing physical samples can support the development of national and international policy that will secure the protection of sensitive ecosystems such as the Great Barrier Reef. The same applies to Australia’s internationally recognised continental aquatic ecosystems, including numerous RAMSAR listed wetlands, economically important hydrological systems (e.g. the Murray Darling Basin) and sites of significant cultural heritage for Aboriginal and Torres Strait Islander peoples. For Australia to remain at the forefront of climate change mitigation and protecting sensitive marine and onshore ecosystems, future NRI must maintain access to a capable and accessible research vessel fleet and to mechanisms that facilitate membership in international research infrastructure initiatives like the International Ocean Discovery Program and the International Continental Scientific Drilling Program. Implementing multi-million-dollar scientific drilling projects for subsurface sampling under these programs requires multi-year lead times for planning. Hence, longer-term NRI funding commitments would position Australia as a more attractive international partner that is better able to influence decisions on subsurface sampling locations. This in turn would enhance opportunities to obtain data that is of greater direct value to Australia and its contribution to global climate mitigation efforts.

Q34.

Building a secure and resilient nation

A secure and resilient nation needs to be adept at recognising and mitigating natural hazards. For Australia, some of these hazards are linked to processes under the sea, e.g. tsunami triggered by submarine landslides or by distant earthquakes. The potential for submarine slides on the Australian continental margin has long been recognised, but this is an often-overlooked threat to coastal communities and infrastructure. Submarine landslides can generate destructive tsunamis with little warning, endangering lives and property. These events also threaten undersea cables, which are vital infrastructure for global communications. Damage to these cables risks severe economic disruption and threatens national security. The development of meaningful strategies to mitigate undersea hazards can benefit from Australian researcher access to an expanded and modern multi-platform research vessel fleet and from membership in international research infrastructure initiatives. Supporting access to national and international research infrastructure leverages the application of advanced technologies to study and manage these hazards. This support also creates opportunities for capacity building through involvement in studies elsewhere in the world and ultimately creates the only opportunity to bring the focus of these long-term, costly international research infrastructure initiatives to our coastline.

Q35.

2.3 The case for a new NRI capability, or enhancements to existing capabilities, typically emerges through advocacy from research communities clustering around rigorously identified needs and goals. Such a concept could respond to a requirement for novel or expanded capacity within a domain, or across domains, and must be such that it could only be made available with national-level investment.
If you have identified such a requirement, briefly describe the need, the proposed infrastructure capability, the medium-term goals, impacted research communities, and the timeframe over which you advocate its establishment. Your response can include links to relevant existing reports.

The examples provided in this submission demonstrate the important role for subsurface sampling NRI in tightening constraints on the pace of past climate change and establishing environmental baselines, facilitating resource discovery, understanding offshore fresh groundwater aquifers before they are exploited, and in allowing a full appreciation of the mechanisms controlling natural hazards that may impact the Australian coastline. To maintain this ability to acquire subsurface samples, it is critical for NRI to facilitate long-term Australian membership in international research infrastructure initiatives like the International Ocean Discovery Program and the International Continental Scientific Drilling Program. Whilst Australia currently has NRI that provides membership into international subsurface sampling programs (i.e. the Australian and New Zealand International Scientific Drilling Consortium, funded by ARC LIEF to 2024 and by NCRIS from 2024 to mid-2027), there is a need to expand this NRI to support greater continuity in funding and to provide international partners with longer-term planning certainty for projects that can take up to 10 years to implement. In addition, research infrastructure for subsurface sampling, particularly in the ocean, is expensive (US$20 million or more per expedition). These costs are steadily increasing and Australian NRI needs to be funded at levels commensurate with international partner expectations. Additionally, access to a well-equipped, modern and capable research vessel fleet is essential for collecting the seabed data and samples that guide efforts to pin down the ideal locations at which to target acquisition of the subseafloor samples that allow thousand- or million-year time-series datasets to be established. Given the size of Australia's maritime jurisdiction, our research vessel fleet should include: an expanded, multi-vessel Marine National Facility that increases the at-sea time available for science and training; a modernised coastal research vessel fleet available for studies of the entire Australian continental shelf; and an additional Antarctic ice breaker that is free from resupply constraints and available for meaningful science to be undertaken in the polar region, a region that is particularly important because it arguably holds the key to understanding the implications of future climate change. An expanded and fully capable research vessel fleet also positions Australia to be a direct contributor to international research infrastructure initiatives. For example, an ice breaker dedicated to science would allow Australia to provide a much sought-after platform for rapidly advancing seabed drilling infrastructure. An infrastructure contribution of this nature would position Australia as a leader in international efforts for land-to-sea drilling initiatives that combine million-year ice core drilling initiatives with offshore scientific drilling to collect samples that more thoroughly constrain the history of Antarctic ice sheet stability. Given that the Australian coastline stands to be most affected by, among other impacts, sea level rise resulting from melting ice sheets and expanding oceans, damage to infrastructure from natural hazards, and ecosystem harm through potential exploitation of subseafloor groundwater resources, there is considerable benefit in a combined NRI focus on the coastal zone. Considerable momentum has built in this space in recent years through planning for the CoastRI initiative. Future NRI would be wise to build on this start to establish CoastRI as a long-term initiative that will help build community resilience, protect and restore ecosystems, and provide a platform for elevating Aboriginal and Torres Strait Islander knowledge systems. With new NCRIS-supported opportunities for Australian-led subsurface and subseafloor sampling in partnership with international scientific drilling programs (both marine and terrestrial), Australia's NRI should also include a vision for a national research core and sample repository. This repository would not only ensure that subsurface samples are well curated and perpetually accessible, without need for duplication, but would also potentially provide a means for Aboriginal and Torres Islander peoples to maintain access and oversight of materials collected on Country.

Q36.

Part 3: Industry perspectives

This section is seeking input specifically from industry-based respondents. Other respondents can skip this section.

Recommendation 6 of the 2021 Roadmap related to improvements in industry engagement with NRI. To complement work on this topic that has occurred since then, we are seeking additional advice on NRI requirements as perceived by current or potential industry-based users.

Q37.

3.1 Have you (or your organisation) interreacted with or used Australia's NRI?

- ◯ Yes
- ◯ No

Q38.
3.2 If so, please briefly outline the NRI capabilities you (or your organisation) have interacted with or used. Do not limit your response to NCRIS capabilities.

This question was not displayed to the respondent.

Q39.
3.3 Please indicate your (one or more) primary reasons for interacting with NRI:

This question was not displayed to the respondent.

Q40.
3.4 If you answered no, please indicate your (one or more) primary reasons:

This question was not displayed to the respondent.

Q41.

Part 4: Other comments

4.1 Please elaborate on any of your above responses or add any other comments relevant to the development of the 2026 Roadmap. Your response can include reference or links to existing reports that you recommend be considered during the 2026 Roadmap development process.

In summary, the key points of this submission are: 1) that future NRI must maintain recognition of the value in funding membership in international collaborative research infrastructure initiatives 2) the need for longer-term funding surety (operational-style funds) that give international research infrastructure collaborators greater certainty in planning major projects that have multi-year lead times 3) the capability gap filled by NRI that facilitates subsurface and subseafloor sampling of sediments, rocks, fluids and microbes, and the long-term curation and stewardship of those samples 4) the value in both a modern, multi-capability and fully utilisable research vessel fleet, and in focussed NRI initiatives, such as CoastRI, that facilitate cooperation between multiple NRI entities with overlapping capabilities and goals 5) the opportunities that international research infrastructure collaborations provide in supporting the development of skilled scientists that are trained to address Australia's most important challenges The following documents are recommended for consideration: United States National Academies Sciences, Engineering and Medicine "Forecasting the Ocean: The 2025–2035 Decade of Ocean Science": released Feb 2025. https://nap.nationalacademies.org/27846 National Marine Science Committee "National Marine Science Plan (2025–2035)": due for release in late 2025, with a range of white papers – including one on research infrastructure – due for release in mid-2025. https://www.marinescience.net.au/ "Future DEEP" report of Australia New Zealand International Scientific Drilling Consortium: includes science priorities for subsurface sampling under this NRI supported by NCRIS (through AuScope) to mid-2027. https://my.visme.co/view/ep31pnv1-future-deep-report#s1 "Exploring Earth by Scientific Ocean Drilling: 2050 Science Framework": an internationally developed document that guides multidisciplinary subseafloor research into the interconnected processes that characterize the complex Earth system and shape our planet's future. https://iodp.org/2050-science-framework International Continental Scientific Drilling Program "Science Plan 2020-2030". https://www.icdp-online.org/fileadmin/New_ICDP_website/downloads/Strategy_Documents/Update2023_ScPlan_LowRes.pdf International Continental Scientific Drilling Program "Lake Drilling Strategy": released late 2024. https://www.icdp-online.org/all-events/detail/news/icdp-lake-drilling-strategy/

Q49.
4.2 Optional Document Attachment.
Note: Our strong preference is that answers are provided against the relevant questions in the survey. However, this file upload option is available for submissions in file format, where needed. Please ensure the document includes your name or organisation.