Feasibility Study

Geology on SIKU:

The Indigenous Knowledge Social Network

March 2022

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1. Introduction To SIKU:

Thank you for your interest in SIKU: The Indigenous Knowledge Social Network!

SIKU is a web platform and mobile app, by and for Inuit, that was developed by the Arctic Eider Society in close collaboration with Inuit. The Arctic Eider Society (AES) is an Inuit-led charitable organization that was established in 2014 to support Indigenous self-determination in research, education and land stewardship. AES is based out of Sanikiluaq, Nunavut and consists of a team of experienced, passionate and committed staff spread across the country, from coast to coast to coast.

Extensive community consultations guided the evolution of early prototypes of the platform and funding from the Google.org Impact Challenge Award helped realize the technical requirements to bring the vision of SIKU to life. SIKU was officially launched in 2019, garnering significant national and international acclaim and broad uptake across Arctic communities and within regional organizations. Using SIKU, Inuit can digitally document and share their observations on the land so that they can mobilize their own knowledge systems and approaches to environmental observations and monitoring - alongside western science to advance Indigenous priorities.

Today, SIKU has over 10,000 users in over 50 northern communities in Canada, and interest is growing in southern Canada and internationally. The tools and services on SIKU are being used to support diverse projects and knowledge exchange initiatives that contribute to Indigenous food security, safe travel, guardian programs, monitoring programs for wildlife, contaminants, sea ice and climate change, language preservation, and resource management decisions. SIKU has been carefully designed to respect and protect Indigenous data sovereignty through its Terms of Use, and data privacy and stewardship options.

SIKU is growing in response to community needs. In the coming years and under the guidance of Indigenous users, AES will be expanding SIKU to include Indigenous knowledge systems for snow, permafrost, weather, women's knowledge and climate change indicators. SIKU's digital infrastructure has been designed to facilitate ease of expansion into both new geographic regions and new areas of Indigenous knowledge.

Check out these short videos to learn more about SIKU's services and tools, and how communities and organizations are using SIKU to share knowledge and support their projects:

SIKU Promotional Video:
https://vimeo.com/376408459

2022 SIKU and SmartIce Ice Watch Challenge:
https://vimeo.com/679003568

SIKU Project Updates for 2021:
https://www.youtube.com/watch?v=pZrbCTtFnoo&t=1s

2. Feasibility Study Overview

In this Geology Feasibility Study, we will walk you through how SIKU would be expanded to include rock and geological information to achieve the following goal:

To facilitate 'geo' observations in the north by northerners through support/modification of existing, user-friendly, non-specialist apps and platforms, so that Indigenous peoples can help conceptualize and solve northern geoscience questions on their own terms in the Western Hudson region.

Within this study, the Arctic Eider Society has been asked to assess the feasibility of a number of tasks:

1.	a) feasibility of importing regional digital geological map data into SIKU from various sources.
	b) all specifications related to a digital geoscience map suitable for incorporation into SIKU, including but not limited to format, GIS polygons, etc.
	c) technical feasibility of enabling geoscience map units to display a name/label when clicked/selected.
	d) technical feasibility of enabling geological units, when selected, to display a representative photograph of the relevant geoscience feature (by links with educational/information module), with technical specifications for the photographs.
2.	a) technical feasibility of creating a geoscience observation module, similar to the existing Wildlife and Sea Ice modules whereby SIKU users can input their own geoscience observations. The observation input module would permit inclusion of multiple types of geoscience information for the observation site including, but not necessarily limited to: notes, photographs, structural measurements (azimuth and dip angle) taken directly from the mobile device's on-board compass (may need a how-to guide).
	b) technical feasibility of creating a layer of publicly-visible "sites of geoscience interest" that could include more detailed geological maps and routes (or "trips" in SIKU nomenclature) with observation sites of particular geological interest (e.g., geology, surficial features, fossils, geo-walking tours of communities).
3.	a) feasibility of creating an educational module consisting of text and diagrams (e.g., the rock cycle, types of rocks and/or minerals and/or carving stone and/or landforms and/or permafrost features).
	b) advice on the architecture within the mobile platform of a geoscience educational module consisting of multiple components.
	c) feasibility of a photo glossary of geological terms/rock types/mineral identification where the photos are linked to text in the educational module (3a) and to the rock types identified in the map legend (see also 1d above) and all specifications related to such a glossary.

To approach this assessment in the most productive manner, we have organized it based on the SIKU infrastructure and logical steps to implementing geological features on the web and mobile platforms, which does not necessarily follow the same order as the above priority areas identified by NRCAN. We have therefore reorganized the NRCAN priorities into the various sections below and, while covering them all, they are based on alignment with SIKU features and presented from most feasible to more complex development. We use examples of existing features on SIKU to illustrate what the end products for geological observations (rocks, minerals, carving stone, landforms) would look like and how they would function. To this end, each of the sections of the Feasibility Study is structured in the following manner:

i) Task - which of the NRCAN tasks listed above are addressed in the section;

ii) Existing Framework - illustrative examples pulled from the SIKU such as those features for documenting wildlife and ice observations that best align with the proposed geological features and provide a starting point to build on;

iii) Geology - how SIKU would be adapted and developed to include geological features, services and share educational information;

iv) Technical Considerations - how the existing technical infrastructure would be used to support the geological expansion and any new features and developments required

v) Financial assessment - a cost and time estimate for AES to add the specific geological tools and features to SIKU

It should be noted that throughout this feasibility study we have focused on assessing the feasibility of developing tools and features on SIKU and have not assessed the cost and time required for content creation and curation. Based on discussions, we have assumed that content such as photos, geological descriptions, artwork and other content will be provided by others; the tools and features we develop will allow those with appropriate permissions granted on the SIKU web platform to upload, edit and create content for the various geological entities, profiles as well as help files and educational materials using the SIKU content management system.

3. SIKU Profiles

i) Task

3.	c) feasibility of a photo glossary of geological terms/rock types/mineral identification where the photos are linked to text in the educational module (3a) and to the rock types identified in the map legend (see also 1d above) and all specifications related to such a glossary.

ii) Existing Framework

Profiles are the foundation of entities and features on SIKU. There are a wide diversity of profiles on SIKU that include Wildlife, Ice Types, User Profiles, Organizations, Projects, Points of Interest, Traditional Place Names, Research Tools, Regions and others that are leveraged across web and app platforms to deliver services, information and facilitate user ability to easily create content in a systematic manner. Most relevant to the current discussion are profiles for Wildlife and Ice that are taggable and used frequently by SIKU users to share knowledge.

For 'Wildlife Observation', close to 200 profiles have been developed; each profile corresponds to a different species and are organized into filterable taxonomic groups including mammals, plants, insects, invertebrates and birds. Similarly, over 60 profiles have been developed for Sea Ice based on Inuktut classification systems that knowledge holders in workshops conducted across Inuit Nunangat shared for use on SIKU, or from primary literature.

Each 'Wildlife' and 'Ice & Snow' Profile is accompanied by a photo and description. The 'Wildlife' photos and descriptions are typically pulled from a variety of sources including locally sourced photos and content from community-based programs, and, as species profiles have rapidly expanded, more generic sources like wikipedia or citizen scientist platforms including iNaturalist and E-bird that allow such licensing.

As mentioned above, Sea Ice profiles on SIKU are based on in-depth content from community and regional workshops, in some cases cross-referenced with western approaches (e.g. MANICE descriptions), however, in most cases there are no MANICE equivalents for Inuit ice types. Indigenous knowledge frameworks and classification systems are the core driver of profiles and content on SIKU, empowering users to leverage their own knowledge and language systems. Ice type categories and indeed many Indigenous climate and environmental knowledge systems are much more detailed than the western classification systems. For example, the sea ice profile on SIKU for 'Annisak' when translated into English means "Larger pieces of free-floating ice, where seals might be basking or polar bears might be found on this ice". The description that accompanies the sea ice profile for 'Sikuliak' is "Ice has thickened enough so that you can travel on it, although still very thin and can be wavy from water motion underneath".

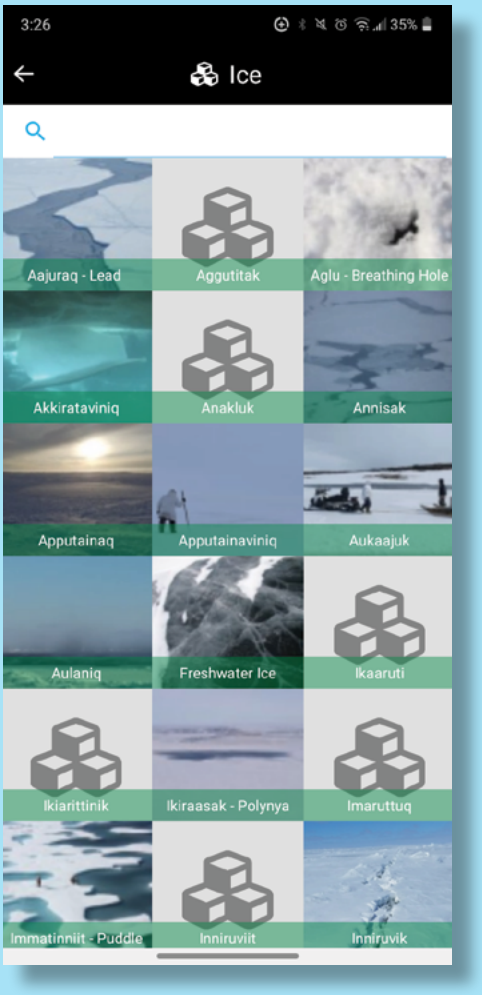
Additionally, each Profile includes translations into different Indigenous languages (ex. Inuktut, Inuktitut, Cree) and dialects (ex. Sanikiluarmiut, Nunatsiavummiutut), as available. SIKU users are able to suggest dialects for profiles where gaps exist. New dialects and languages can be added to SIKU for any type of profile on an ongoing basis by administrators. Each profile on SIKU is taggable and searchable across dialects, so that different language holders and

Indigenous groups can use their only knowledge and language for similar entities and they can be cross referenced to the common shared profiles on SIKU.

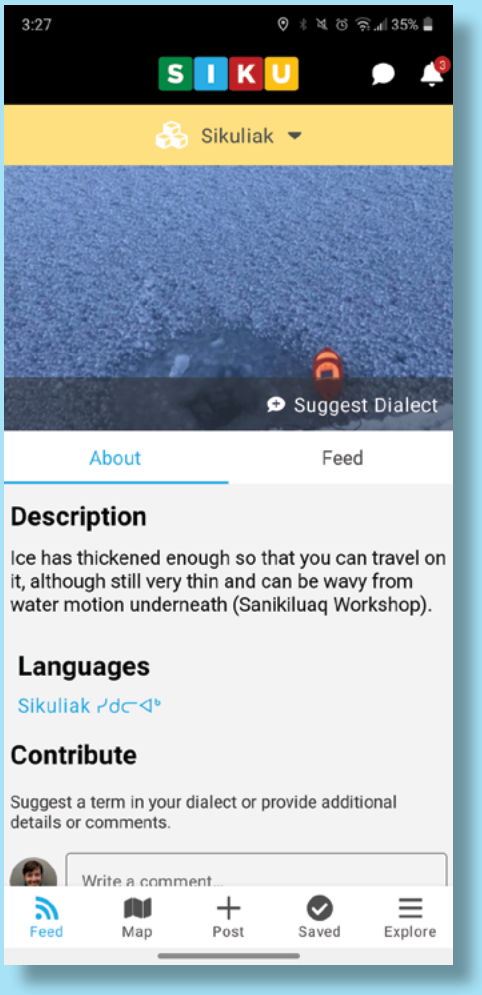
When a SIKU user wants to document a wildlife or sea ice observation out on the land, they create a Post (more on this in the next section) and tag the relevant Profile(s) within this post (if they know the species of wildlife or sea ice type observed). This tag connects Posts with Profiles and creates a growing and evolving body of knowledge for each Profile. Users can tag profiles in posts such as tagging a traditional place name or wildlife species in a story told in a social post. Users can comment on Profiles on SIKU to help improve them by, for example, suggesting local dialects or sharing relevant knowledge, which might include medicinal uses for wildlife and plants. While the Profile feature is currently implemented as a commenting and tagging system on SIKU, the long-term vision is for Profiles to evolve into Indigenous knowledge wikis that allow Indigenous users to suggest and promote content and knowledge that is then curated by Indigenous users on the platform for long-term stewardship and knowledge sharing across communities and Indigenous groups. As this approach grows and develops it will be applied across the various profile types on SIKU in a scalable and efficient manner.

Profiles are also searchable and filterable with a suite of new filters coming to mobile apps in the near future. Filter functions on SIKU allow users to search for specific Profiles so they can easily access profiles of interest to learn more by 1) reading the description, and 2) selecting and scrolling through the Feed where all Posts that SIKU users have tagged to that Profile are viewable. This supports education, knowledge transfer and language preservation.

The established framework on SIKU for Ice Posts and Ice Watch Stewardship provides a powerful demonstration of the longer term goal to link Indigenous knowledge and technology: when appropriate permissions are provided, sea ice posts made by Indigenous users on SIKU can contribute to machine learning algorithms to classify sea ice features based on Inuktitut categories. This work has already begun with funding from the Canadian Space Agency - Indigenous knowledge is helping identify features including polynyas and moving cracks within the landfast sea ice platform, that will help document ice breakup and climate change at scale while contributing to situational awareness for local communities. This illustrates the large-scale potential of mobilizing Indigenous knowledge frameworks into tagabble wiki profiles that can be applied to other features in addition to sea ice. These kinds of tools - made by and for northern communities - can help establish Indigenous communities as leaders in northern research and facilitate economic development and self-determination.



Screenshot of the SIKU mobile app showing some of the Profiles for sea ice; these Profiles can be tagged in Posts.



Screenshot of the SIKU mobile app showing the Profile for Sikuliak, including a photo, description, translations into different languages, and the 'Suggest Dialect' button. You can also see the Feed button which allows a user to view all posts that SIKU users have tagged to the Profile.

iii) Geology

A 'geology/geoscience glossary' (a collection of profiles for different rock/mineral/landform types), would be developed on SIKU using the proven Profiles framework established for Wildlife and Ice & Snow. A new overarching Profile type (rocks/geology) would be developed that allows for the creation of individual profiles corresponding to a specific rock type (or mineral or landform). The content for the individual profiles would be easily curated and could include a high quality photo as a profile picture, a description, and various names/titles for the profile with translations into different Indigenous languages and dialects, as desired by the users. The Description/About section of Profiles is currently HTML-based and, as such, allows diverse forms of content to be added including text, links, videos, and additional photos with administrative permissions for the profile type.

The new profile type would be created on each of the three platforms (iOS, Android and web) and managed by the web backend; profiles created using the SIKU web platform will become visible

and synced with the mobile applications. The process of creating new profiles is simple and intuitive (adding content using profile Edit flow. FYI we encourage documentation of source information/references for content including photos and descriptions). We also encourage consultation with Indigenous communities about what constitutes appropriate profiles/ categories/classifications, and bringing in Indigenous knowledge for the description and local dialects and terminology. Once geology profiles were developed on SIKU, users would be able to browse the profiles to learn about different rock types, add Indigenous dialects, and, using the SIKU Post tool, tag profiles to geological observations they made on the land.

This demonstrates how Profile creation and curation is the foundational step in making geoscience information available on the SIKU platform and establishes the mechanism for linking to other features including Posts, interactive maps, points of interest, and educational materials.

Mockup showing what geology profiles would look like on SIKU.

iv) Technical Considerations

Creating a geological profileType on SIKU respects and builds on the existing framework, and is therefore relatively simple to implement. It requires creating new profile "Type" and associated database tables across platforms. It would be important to document and understand any fields that may be specific and unique to geology profiles before beginning development (in addition to standard titles, categories, profile photos, etc).

Creation of a new Profile Type involves the creation of Edit View for individual profiles, Admin privileges for adding/editing (web only), an Explore menu item for discoverability, admin dashboards, and the User view for each profile (web, android, iOS platforms). It would also include adding the profile type to the search system, implementing new profile type into the syncing of profiles and content across platforms, incorporating the Indigenous dialects/language profiles for each profile, as well as various other tasks and user interfaces etc.

Adding photos and profile descriptions (content) to each profile would be independent of this technological development and would need to be managed by NRCAN or another designated group.

Additional advanced features that extend beyond what is included in the basic financial assessment may include details of creating the new profile type tagging system (see post creation), categories/groups of rock types and associated filtering by type/sub-groups, visibility of profiles and content outside the login system, etc.

v) Financial Assessment

Basic Geological Profile Features: approximately $7000 per platform = $21,000 total
It is estimated that web platform development would take about two weeks of dedicated time, with about the same (two weeks each) on each of Android and iOS mobile apps.

4. SIKU Posts

i) Task

2.	a) technical feasibility of creating a geoscience observation module, similar to the existing Wildlife and Sea Ice modules whereby SIKU users can input their own geoscience observations. The observation input module would permit inclusion of multiple types of geoscience information for the observation site including, but not necessarily limited to: notes, photographs, structural measurements (azimuth and dip angle) taken directly from the mobile device's on-board compass (may need a how-to guide).

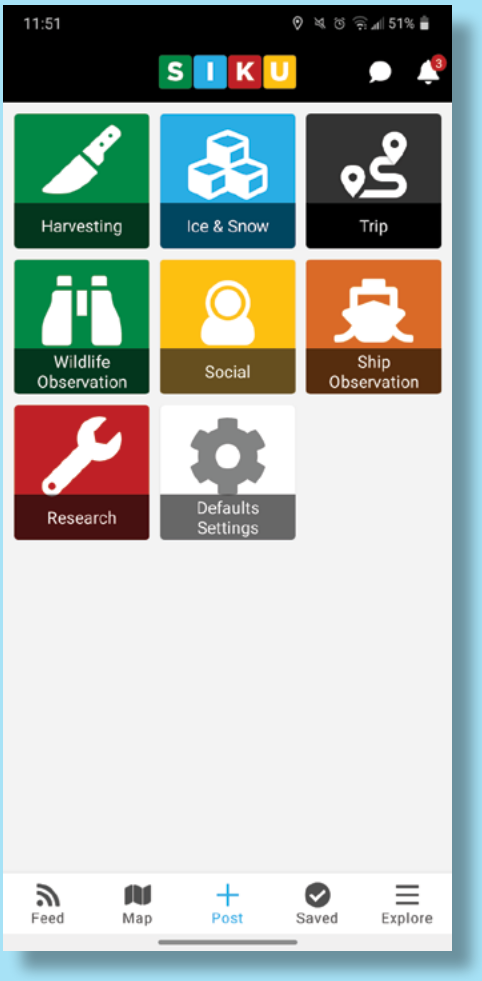
ii) Existing Framework

A key function of SIKU is to help users document and share their observations made on the land (or water or ice). The way SIKU users share their observations is with the SIKU Post tool. Currently, a number of different kinds of observations can be documented on SIKU using the Post tool, including: Harvest, Trip, Social, Ship Observation, Research, Wildlife Observation and Ice & Snow.

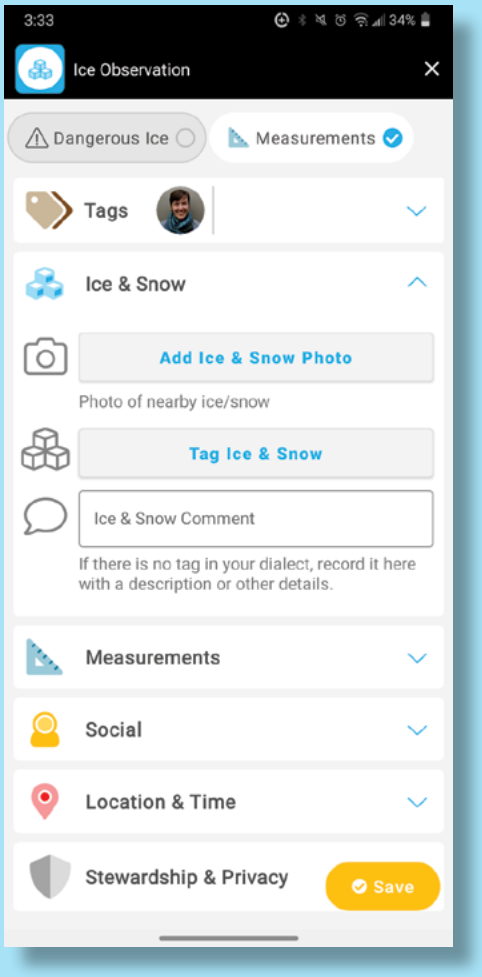
SIKU's newly updated post creation flow process, including expanded iconography, makes the process of creating a Post quick and intuitive with drop-down options and predetermined data fields that users populate with photos and other types of information.

To make a Post on the mobile app while out on the land, a user selects the relevant Post icon (ie. 'Wildlife Observation' or 'Ice & Snow'). The user is then prompted to enter into the Post a number of pieces of data. For 'Ice & Snow', these data include:

- **A photo of the ice and snow observed**
- **Tag relevant Ice & Snow profiles**
- **Add a comment about the ice or snow observed**
- **Option for flagging dangerous ice conditions**
- **Option for adding measurements (ex. ice thickness, snow depth, water depth)**
- **Add Social comment, photo and/or video**
- **Location and Time**
- **Stewardship and privacy settings**
- **Tag relevant projects (this assigns stewardship of the post data to the project managers)**



Screenshot of the SIKU mobile app showing the Post page and current selection of post tool options.



Screenshot of the SIKU mobile app showing the information fields available for a sea ice post.

The SIKU app works offline, which is critical in remote regions of the Canadian north where there are large areas of land with limited or no internet connectivity. Posts are populated with information by the user while on the land and then Saved (date, time and latitude and longitude are automatically recorded); once a user returns to town and is connected to the internet, they Upload their Saved Post(s) to SIKU and the Post becomes visible to all users on the Feed and Map based on the tags and other information contributed. Posts will be shown on tagged profiles that could include the user's profile, community profile, project profile, and geology/rock type profile. Project stewardship is based on users being a member of a project and tagging a project which assigns a non-exclusive right to the project to use that information while respecting local governance structures, permitting, etc. This framework respects Indigenous data ownership, access and control; post stewardship details will be incorporated as a key part of content creation in any new post types but will not be further elaborated on here. Feeds are a key part of the SIKU platform that show Posts associated with Profiles as well as more general feeds such as

the SIKU wide feed, community feed and profile feeds. Posts made with the app are visible in feeds in two ways: 1) a simplified Feed View that showcases the key content and photo/video, and 2) a Detailed Post View and associated Map view available by clicking the "more details' button where content is organized into various panels that are visible based on what the user has added in the Post Creation flow. An Edit View is also available on mobile apps, currently before posts are uploaded, and online after posts are uploaded (edit view after upload will eventually be made available on mobile as well).

It is noteworthy that a new Custom/Content Management System (CMS) has been created for Wildlife Profiles that allows specifying that certain fields and panels be prioritized and/or hidden on a profile by profile basis, allowing advanced customization in a common framework - in the case of wildlife species this allows certain fields to only be shown where relevant such fields associated with eggs only being accessible for birds (taxonomic level CMS), or certain measurements being shown for specific species. This would eventually be possible for other types of profiles but would require additional development and is not currently included in the present feasibility study.

iii) Geology

A similar approach for Post creation on SIKU would be taken for geoscience observations. A new Post tool would be created which would include a 'Geology' Post icon on the SIKU Post page or as a part of a "Research Tool" post type. A SIKU user would select this Geology Post option and then be prompted to populate the Post with core information, which could include:

- Photos of the geological observation and surrounding habitat
- Tag relevant geological profiles
- Add a comment about the feature or landscape observed
- Add Social comment, photo and/or video
- Stewardship and privacy settings
- Tag relevant projects (this assigns stewardship of the post data to the project managers)

Based on similar frameworks for wildlife, ice and tool post creation on SIKU, aAdditional more advanced fields could be added such as measurements and "unique" or "unusual" fields like identification of an observation as a fossil. A wide range of custom fields and panels could be made available as desired with additional complexity adding to the time and costs of development on each platform. The most basic form of post creation would be a starting point as outlined above, and would be similar to the "Ice Post" currently available on SIKU or as a Research Tool such as the 'insect observation' tool.

Even in a basic form, a simple Post creation tool for geological observations would provide a powerful means for northerners to document geological observations as a part of programs. Often, 'simple' is better in terms of user experience, training and outreach and will make the new geological post creation tools more accessible and more likely to be used on SIKU once developed and implemented.

iv) Technical Considerations

Basic Post Features: Photo, Date/Time/Location, Permissions, Stewardship/Tags, Rock Tagging System

Create Post Creation Flow, Edit Flow, Feed View, Map Drawer View, Upload process for geological post types on SIKU that include basic metadata (date, time, location, permissions, stewardship/ tags, photo/videos, rock type tagging system). For clarity this includes creating, editing, viewing and managing posts across platforms in the following frameworks:

1. Post Creation View
2. Post Details Sheet View
- From Saved Tab on apps
- From Feed View
- Details View (on clicking "More Details" opens post as its own entity separate from Feed)

3. Post Editing View
4. Saved Posts Tab (mobile apps) with Upload Support
5. Map View, Map Icons, Map Filtering System (online)
6. Notifications System (tagged in post, etc).
7. Creating a Feed on each Geological Profile to support showing posts tagged with that profile type
8. Adding geological post types to admin, project and user data management dashboards
9. Visual iconography for various fields and panels associated with geology post creation as well as for viewing posts on feeds and maps.

Additional data fields that could be considered once the core data fields outlined above were established include:

- Option for adding sample information if collected

- Option for adding measurements (ex. structural measurements like azimuth and dip angle taken directly from the mobile device's on-board compass) could be added as manual entry fields without too much additional work; however, incorporating direct use of the mobile device compass, GPS and accelerometer to automatically achieve these measurements directly integrated into SIKU while likely possible would require additional details and technical assessment beyond basic post creation and is not within the scope of the current feasibility work.

v) Financial Assessment

Implementation of basic post creation, edit, view across platforms and integration across SIKU is estimated at three weeks to one month on each platform at about $31,500-42,000 total depending on specific feature requests.

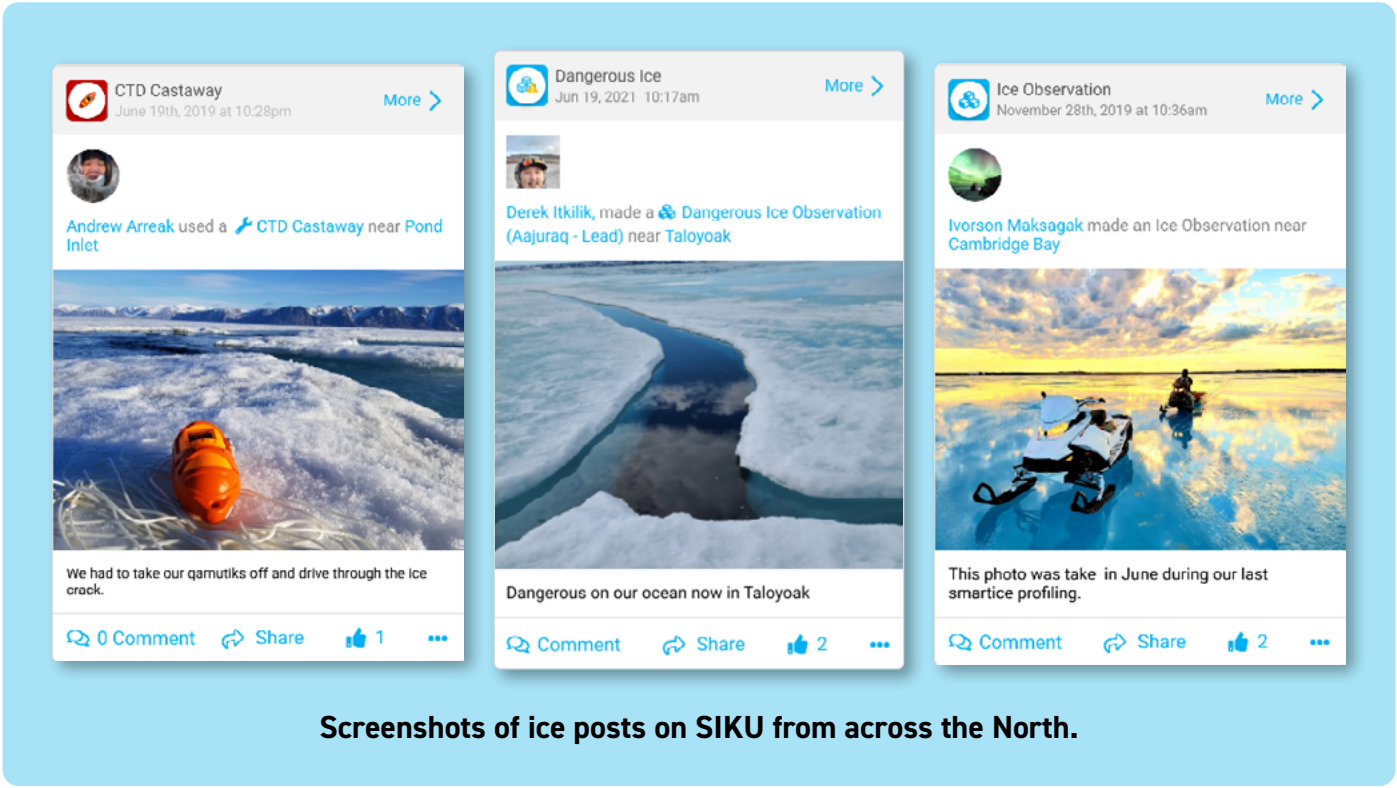
5. SIKU Geological Map Layer

i) Task

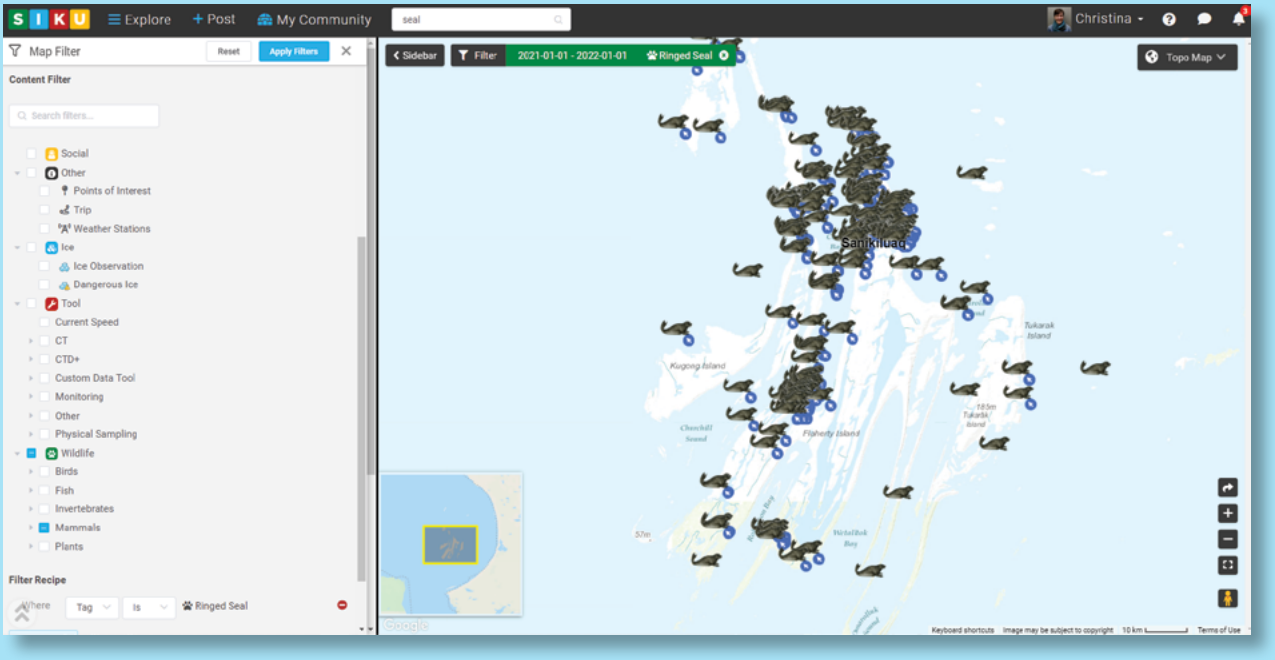
1.	a) feasibility of importing regional digital geological map data into SIKU from various sources.
	b) all specifications related to a digital geoscience map suitable for incorporation into SIKU, including but not limited to format, GIS polygons, etc.
	c) technical feasibility of enabling geoscience map units to display a name/label when clicked/selected.
	d) technical feasibility of enabling geological units, when selected, to display a representative photograph of the relevant geoscience feature (by links with educational/information module), with technical specifications for the photographs.

ii) Existing Framework

Once a Post is Saved and Uploaded on SIKU it appears in both the SIKU Feed and can be overlayed on various SIKU map and satellite layers. Basic view of the Posts on maps is included with Post creation above; however, more advanced map filtering for geological entities would require some additional development. For example, on the web platform it is possible to currently filter the map by species, ice types, tools and other profiles and this could be added for geological features as well; depending on requirements this may involve filtering by geology Posts overall, by categories or by individual Profile type.



Screenshots of ice posts on SIKU from across the North.



Screenshot of the SIKU web platform showing a map of the locations of Nattiq (Ringed Seal) observations from the last 16 months. The map is zoomed to Sanikiluaq, Nunavut. The Map Filter can be seen on the left side of the platform. In this example, Ringed Seal has been selected from within the Wildlife section of the Filter; the other content available is visible in FIlter.

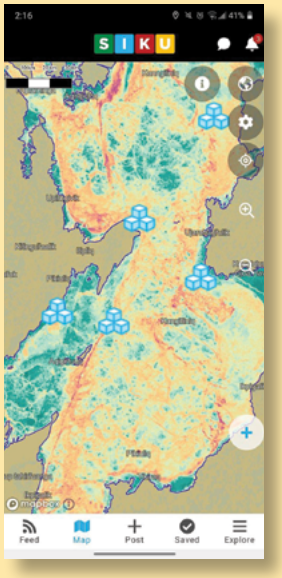
SIKU users can access a number of other map and satellite layers on the SIKU web platform and mobile app. Until recently, many of these maps were only available on the SIKU web platform; a major update has now made all maps accessible on the mobile app, with some core maps such as the SIKU base map being accessible offline by downloading tiles for the users region.

Other maps available on the SIKU app and web platform:

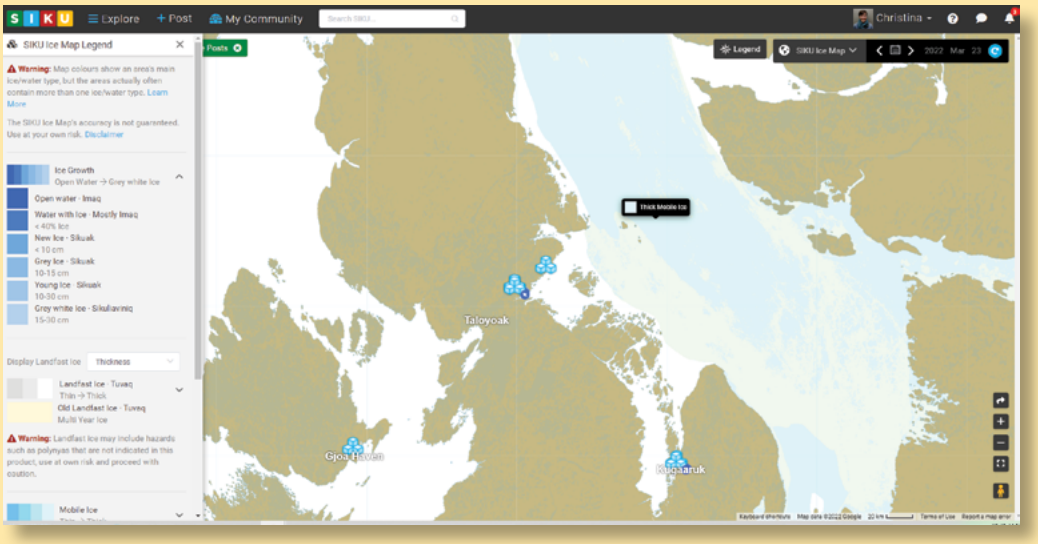
- Satellite high resolution cloud free Mosaic (Google/Mapbox)
- Near real-time Satellite imagery from NASA and the European Space Agency
- SIKU Base Map (combines topographic and ocean charts for Indigenous communities)
- SIKU Ice Map (combines ice charts from the Canadian Ice Service, satellite imagery and Ice & Snow Posts)

SIKU Ice Map

The SIKU Ice Map is a custom map layer that pulls data from the Canadian Ice Service and Sentinel 2 satellite imagery to show ice/water types and the roughness of landfast ice, as well as the location of Ice & Snow Posts. This map is automatically updated as new data comes available. The mobile version of the SIKU Ice Map does not display a name/label when a unit is selected, however this feature is supported on the web platform and is being considered for future development on mobile platforms.



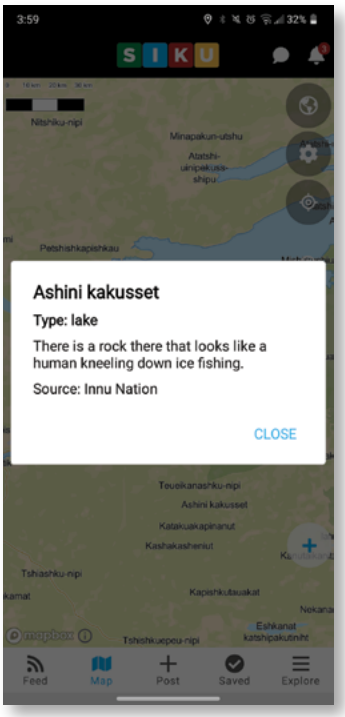
Screenshot of the SIKU Ice Map on the mobile app showing different levels of roughness in the Landfast Ice around Gjoa Haven, Nunavut, March 22, 2022. Blue icons are the locations of observations made using the Ice & Snow Post tool. A legend for the map is accessed by clicking on the Information icon.



Screenshot of the Ice Map on the SIKU web platform showing how a name/label is displayed when a unit is selected. The Legend is shown on the left side of the platform. In this example, a unit has been selected north east of Taloyoak, NU and the label displayed indicates the area is composed of Thick Mobile Ice.

Traditional Place Names

Another popular map layer on SIKU is Traditional Place Names. With the support of Indigenous governments and organizations, AES has populated the SIKU map with Traditional Place Names in Indigenous languages for Nunavut, Nunavik and the Innu Nation. This feature on SIKU supports language preservation and knowledge transfer as Indigenous place names often contain detailed cultural information about the weather, landforms and wildlife of the area, among other things. The Traditional Place Name layer can be turned 'on' or 'off' on the SIKU mobile app or web platform. When 'on', users can select a name on the map and read a description in a pop-up box that provides additional information about the place. Profiles for Traditional Place Names are based on either point data or polygon data, and as such could provide a means for including labels for geological regions as polygons that are clickable and open a description and other content for geological data.



Screenshot of the SIKU mobile app showing a pop-up box associated with a Traditional Place Name in Innu-aimun, the description and source.

iii) Geology

In addition to viewing geological Posts on various SIKU map and satellite layers, the addition of geological Profiles to the map filter system on the web platform allows for very tailored search and view options, particularly for project managers. Observations made by users could be filtered by type as well as by date to help contribute to showcasing geological data on SIKU.

There are several approaches that could support the creation of a geological map layer on SIKU. The SIKU Ice Map is currently the most similar approach where polygons covering the marine regions show mutually exclusive categories of ice types in various colors that are clickable and incorporate a legend. The SIKU Ice Map is updated on an ongoing basis dynamically with new data from users and the Canadian Ice Service; however, a geological map would be relatively static (only manually updated occasionally vs dynamically changing), and come from a single source, making this simpler to develop than the existing SIKU Ice Map. The selection of the geological map could be approached as an entirely new map layer accessible in the layers picker, or possibly as an overlay on existing maps such as an overlay on satellite imagery or the SIKU basemap layer. The latter would be similar to the current Parks Data layer on the SIKU mobile apps that can be toggled on or off imagery as an overlay. We suspect that a separate geological layer or development of a more general terrestrial features map would be the appropriate approach, with the latter building in flexibility for other types of terrestrial data such as biogeographic/ecoregions, terrestrial hazards and otherwise. In either instance, additional discussions could determine the most appropriate approach to meeting NRCAN's needs for a geological map and the future needs and simplicity for northern users. The geological base map would providmeans for SIKU users to explore their regions and learn more about geology, and provide a reference for geological work and contributing posts. The map could be made accessible offline using existing SIKU frameworks which would depend on the approach implemented as outlined above.

The ability to tap the map to reveal the type of geological feature region (1c above) could also take several approaches to implementation, similar to that available for the SIKU Ice Map online (clicking anywhere on the region) or through clickable labels for each region (e.g. as per how details of Traditional Place Names are currently viewed on mobile apps). 1d (loading associated profiles for the feature type) would also be possible such as including a profile picture and a link back to the full profile for the geological feature type. There are several outstanding questions here that would require further consideration, in particular what types of content would be available online vs offline (e.g. the label and short description for the region is easier and requires less bandwidth and syncing to make available offline than it would be for making a full profile and associated content (photos, videos) accessible offline. Various combinations of online/offline content could be possible and should be evaluated based on both technical and usability considerations (such as northern bandwidths, which are evolving).

iv) Technical Considerations

This assessment assumes that the geological map product would be provided by NRCAN for incorporation into SIKU and there are a number of technical considerations that would determine the technologies and approaches appropriate to use. Key considerations include whether this would be a raster or vector product, if it would be standalone as a map product or visible as an overlay on other basemaps. Hosting, offline tile system, mechanisms to click on regions vs labels would all be dependent on these details. As such, the delivery of a geology map layer on SIKU is certainly feasible from a technical standpoint; however, additional work remains to assess the exact needs and most appropriate technical approach to implementing this feature that would require additional work beyond this feasibility study. However, we are still able to assess an overall idea of timelines and cost based on our existing work on similar features on SIKU and have a good idea of the types of considerations that are important to identify early on in developing such features. We have a cartographer and map developers on staff and existing supporting features to leverage making a new map available to users across platforms in an efficient and cost-effective manner that leverages years of existing feature development.

Additional considerations for map development include a User Interface for choosing/toggling layers, updates to existing UI for discoverability of the geological map, any other layers or labels that would need interface elements to be toggled, map legends, and if any future layers may be dynamic instead of static. Additionally, it should be considered that there are relatively separate approaches and tech stacks for developing the map layer on web and mobile apps and these could be done independently. Any new map layer will substantially benefit from the newly created SIKU Mobile Apps map system/offline maps system which took over 2 years to develop.

The scale and extent of the map should be also considered. For example, would this be limited to Canada or the North, or a global product? The source files provided may need various levels of stylizing and rendering for various platforms such as generation of map tiles, hosting of tiles, etc. that all require additional consideration.

v) Financial Assessment

Timelines and cost are highly dependent on specific requirements following further consultation and evaluation of what content is provided as source files for a geological map. We conservatively estimate that the most basic features leveraging existing map frameworks and assuming content sent in a form that requires little additional processing and would involve some user interface work on mobile apps but predominantly backend work across platforms that would start at about $20,000 - 25,000 as a rough estimate. This relatively low cost is based on over $500,000 in development of cross-platform map work already completed on SIKU, demonstrating the scalability of working with SIKU as an existing platform and indicating the level of work that would otherwise be necessary to deliver complex features on and offline like this that are provided in kind.

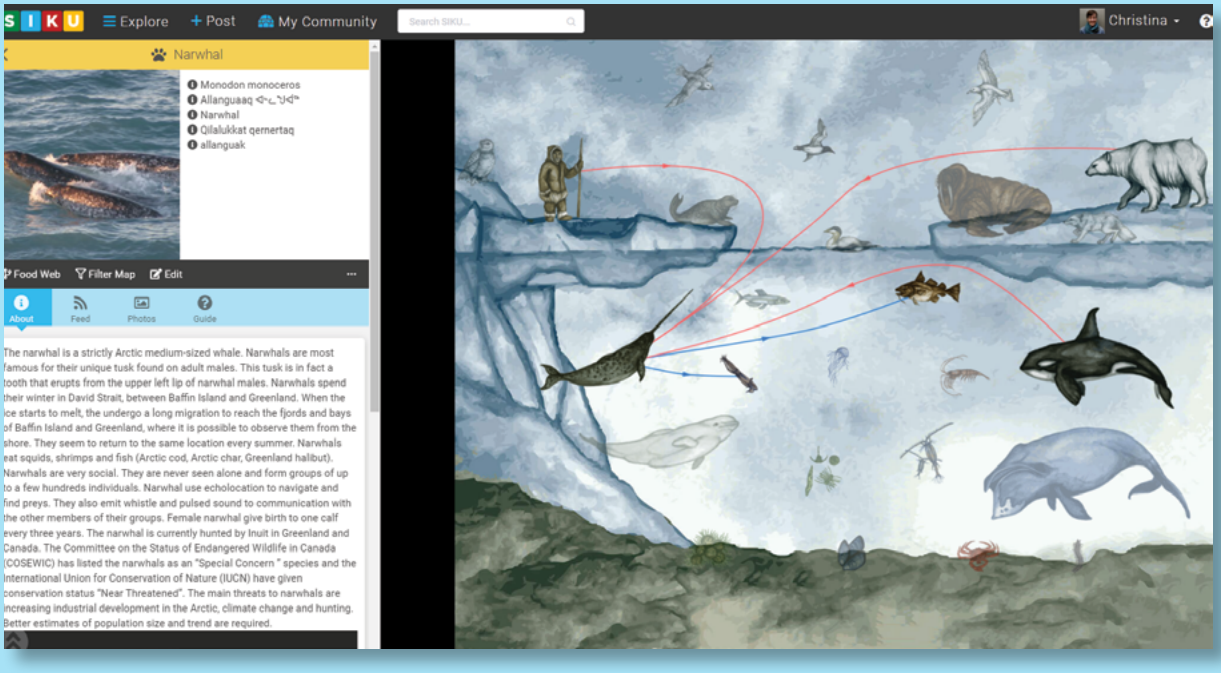
6. Interactive Geological Education Features

i) Task

3.	a) feasibility of creating an educational module consisting of text and diagrams (e.g., the rock cycle, types of rocks and/or minerals and/or carving stone and/or landforms and/or permafrost features).
	b) advice on the architecture within the mobile platform of a geoscience educational module consisting of multiple components.

ii) Existing Framework

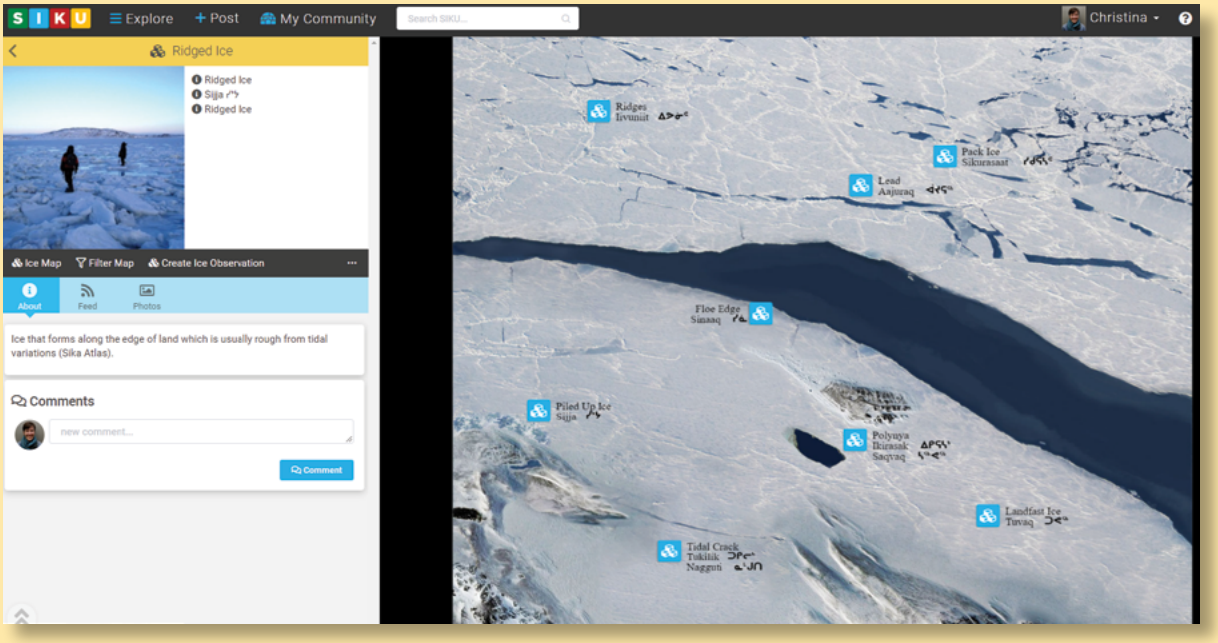
SIKU currently incorporates several interactive elements that support education and learning resources for SIKU users including students, teachers and the general public. For example, the SIKU Foodweb, accessed via the web platform through the explore menu and linked to the Wildlife Profiles, is an illustrated and interactive image that shows the energy flows between different wildlife species present in the Arctic, including humans. Users click on a species of interest in the image which triggers the appearance of the unique energy flows between that species and others around it. In the example below, the narwhal has been selected, which has brought up the narwhal profile on the left side of the platform and highlighted (in blue and red) the energy flows between the narwhal, human, polar bear, arctic cod and squid.



Screenshot of the SIKU web platform showing the interactive Arctic Foodweb; the narwhal has been selected which has highlighted the energy flows between the narwhal and other creatures; on the left side of the platform you can see the Profile for narwhal.

An interactive ice schematic has also been created on the SIKU web platform to teach people about different ice types using the SIKU Ice & Snow Profiles. Below, you can see the blue sea ice icons on the SIKU map (overlaid on a satellite image); each icon can be selected to bring up the associated Profile on the left side of the platform. These Profiles each contain a description of the ice type based on Indigenous knowledge systems, translations into different Indigenous languages and dialects, and the option to select the Feed which brings up all Posts tagged to that Profile so the user can view other examples.

These features currently exist only on the web platform, they have not been implemented on the mobile apps.

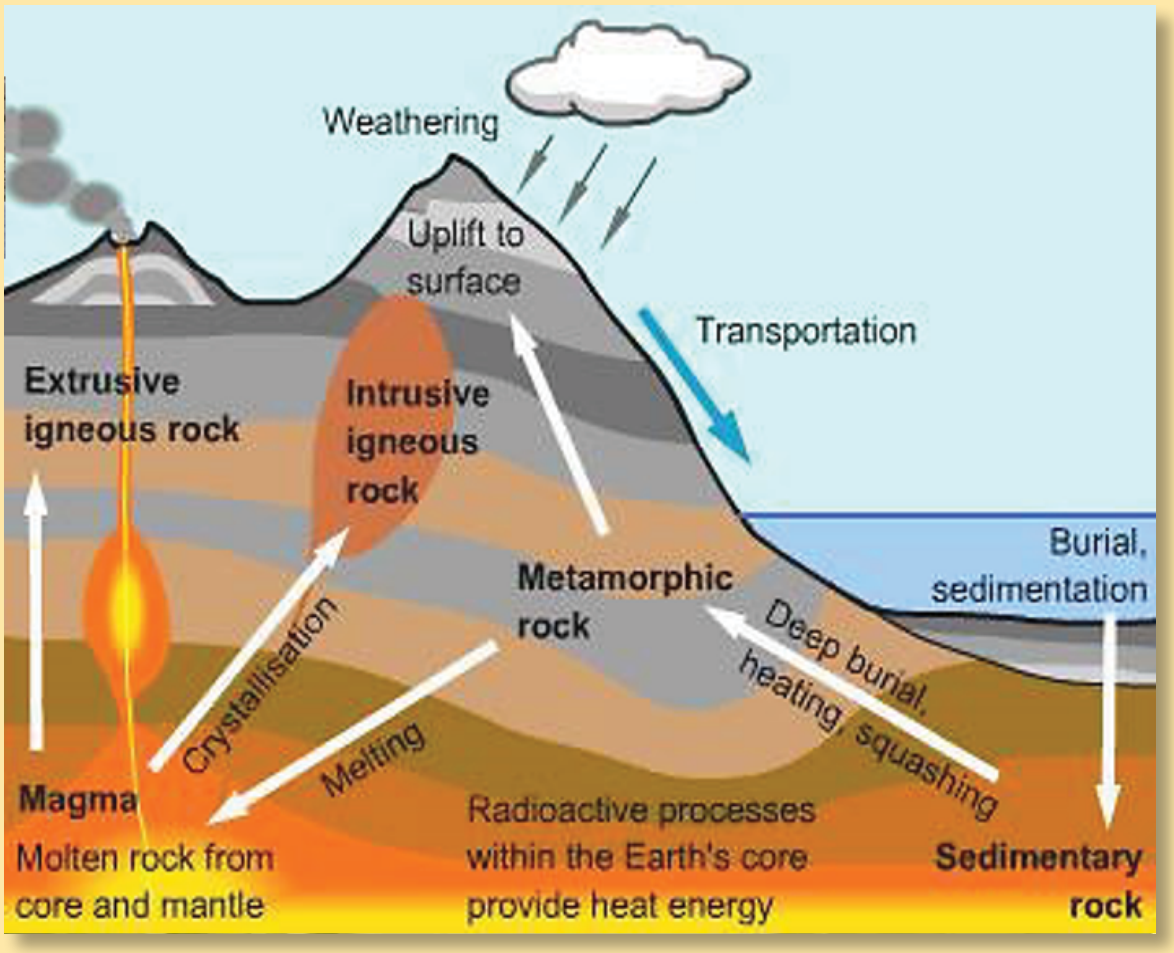


Screenshot of the SIKU web platform showing the ice schematic. Sea Ice Posts are the blue icons on the satellite image; selecting an icon will populate the left side of the platform with the corresponding Profile. The Feed in the Profile can be selected to see all Posts (and accompanying observational information) tagged to that Profile.

iii) Geology

A similar approach could be taken for an interactive education module for rocks and geology. For example, the rock cycle could be illustrated in a similar way to the Arctic Foodweb example provided above; clicking on each stage of the cycle would highlight the different physical changes—such as melting, cooling, eroding, compacting, or deforming—that are part of that particular stage. This assumes that the clickable entities would be linked to existing profiles (above) created on SIKU. The relevant geological profiles at each stage would be selected as users click through the cycle. If clickable entities require different profiles from those in the Geological Profiles (above) it could be possible to create new profiles specific to this interactive element but not otherwise accessible in the same manner for post creation on SIKU.

There are many possibilities to consider how this would work, such as animating elements such as lava flows, weathering, etc or if this would be a static element. These various choices would determine the scope and extent of the work and appropriate technological tools to use.



Mockup showing an interactive map of the rock cycle.

iv) Technical Considerations

The Arctic Foodweb and ice schematic are currently only available on the SIKU web platform and leverage map tile systems to function; an interactive geological rock cycle would be possible but likely it would be worth developing this on mobile first vs web first to better adapt to multiple device types. This would leverage the profiles (above) that could be clicked and trigger profile sheet views for different geological features. The specific features would be dependent on the content provided. We are considering game technology to render a 2d or 3d environment to be more responsive and immersive. Development would include additional graphic design work in addition to programming. This feature would make for a nice demo/showcase and promotional videos for the new rock features on the app. If budget allowed, it could include animations (e.g flowing lava, moving clouds, etc.) to increase the user experience.

v) Financial Assessment

This would be a new system and approach on SIKU mobile apps and is more difficult to estimate at this stage. We would work to identify a cross-platform engine to help streamline development and that could be deployed across web, android and iOS platforms simultaneously. Additional time would be required to better estimate the costs for this feature, however we consider about $30,000 as a reasonable estimate, subject to further exploration and more detailed specifications.

7. Points of Interest and Interactive Tours

i) Task

2.	b) technical feasibility of creating a layer of publicly-visible “sites of geoscience interest” that could include more detailed geological maps and routes (or ”trips” in SIKU nomenclature) with observation sites of particular geological interest (e.g., geology, surficial features, fossils, geo-walking tours of communities).

ii) Existing Framework

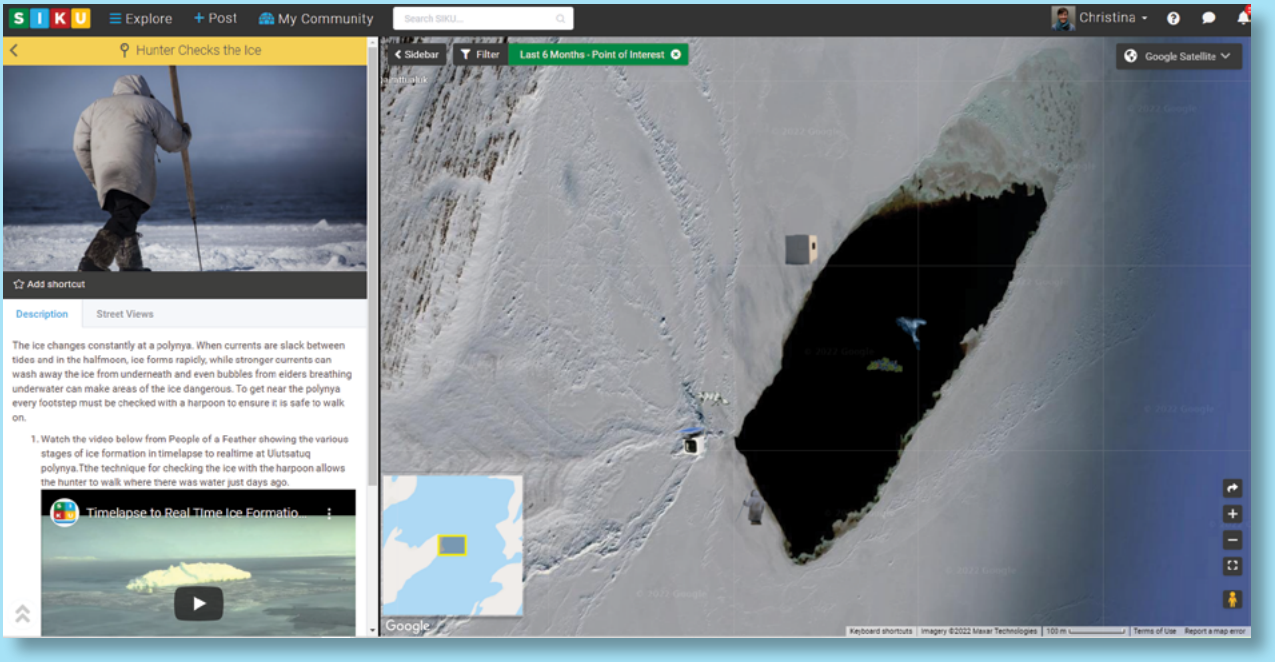
The SIKU web platform includes a ‘Points of Interest’ feature. Each point of interest is similar to a profile and can include location, photos, description and otherwise. They have been developed as a means to provide interactive tours on SIKU which to-date have just been developed for Sanikiluaq from an early SIKU prototype in 2015. The development of Points of Interest can of course be created anywhere and including any form of content (they currently even allow interactive virtual reality content such as Street View to be linked). They are on the road map for development on mobile apps as well associated with other features such as waypoints, Inuksuit, Markers, Cultural Sites and other entities for online/offline use.

When the Points of Interest layer is turned on, unique icons appear on the SIKU base map at different geographic locations on the islands. Each icon is associated with a point of interest that includes any cultural, wildlife or other landmark. When a particular Points of Interest icon is selected, a corresponding profile appears in the left column of the web platform with a photo, detailed description and short video or other content as desired. For example, in the southern region of Sanikiluaq, SIKU users can select Points of Interest to learn more about Snowy Owls and Eiders, and watch excerpts from the film ‘People of a Feather’ of a Snowy Owl hunting and flocks of Eider ducks taking off from the floe edge.

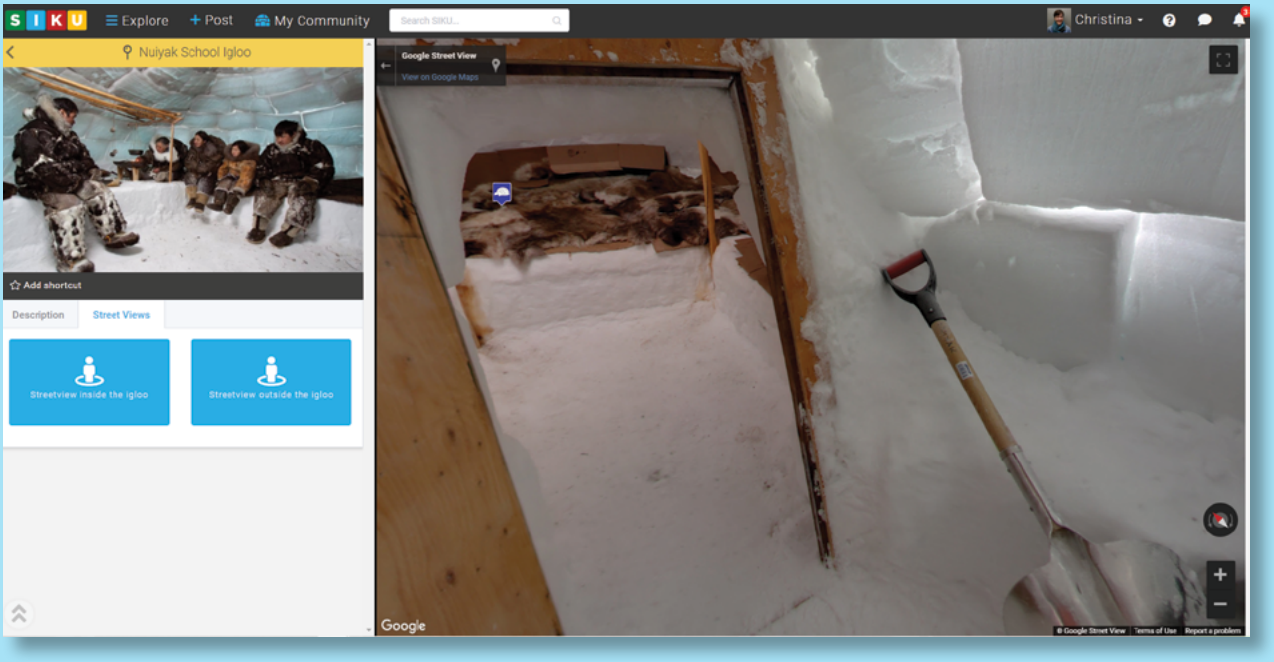
Google Street View is available for all of these Points of Interest, which allows SIKU users to take 360 degree tours of the town of Sanikiluaq and a polynya in the eastern region of the islands. SIKU users can cruise through the streets of the town of Sanikiluaq and click on Points of Interest as they tour around, including the Airport, Co-op Store, Museum and Municipal Office and the igloo recreated by the local school each year. Users can also head out of town to the floe edge or Ulutsatuq polynya and travel around the polynya while learning about how Arctic Foxes hunt Eider ducks, or how researchers use time-lapse photography to understand sea ice changes over time. These points of interest therefore provide a key feature to support education resources and a building block of interactive tours.

Currently a “Presentation” system on SIKU provides a means for users to start a guided tour through SIKU which leverages the SIKU URL tracking system. A Presentation or Tour can be created that can list the various stops or points of interest on SIKU and essentially links together various profiles, map views (e.g. satellite layer, zoom level, location) and other content on the platform in a curated way that allows taking users step by step through content on the platform without having to locate each entity themselves. This provides a powerful

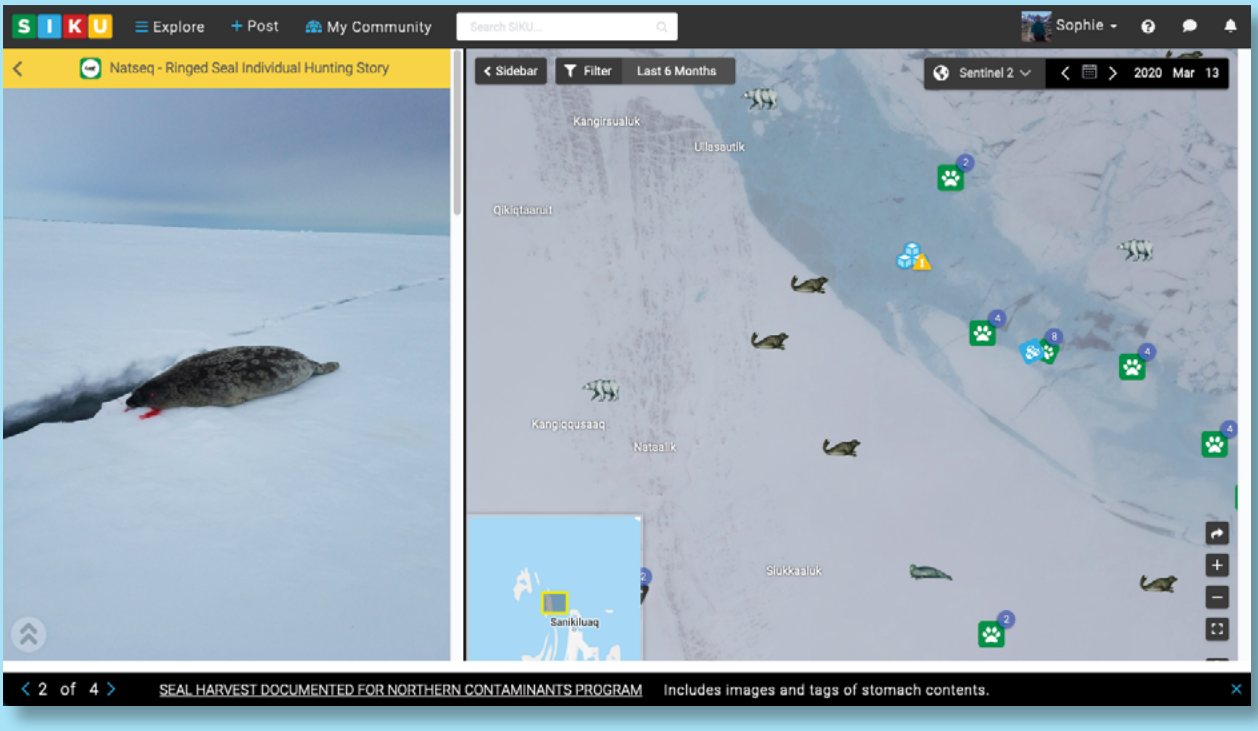
framework for interactive educational and interpretive experiences on the SIKU platform that is available online and could be used out of the box to create learning resources. These features have not yet been developed on mobile apps.



Screenshot of the SIKU web platform showing the Points of Interest associated with the Ulutsatuq polynya, Sanikiluaq, Nunavut. The different icons are located around the polynya; detailed descriptions and short videos can be accessed by clicking on each icon. Google Street View is available to tour around all these Points of Interest.



Screenshot from the SIKU web platform showing the Google Street View inside an igloo, built by the Nuiyak School in Sanikiluaq, NU as part of their cultural education programs.



Screenshot from the SIKU web platform showing slide 2 of 4 from the Presentation about Seal Harvest for the Northern Contaminants Program.

iii) Geology

Geoscience Points of Interest could be developed for publicly-visible "sites of geoscience interest". These Points of Interest could be overlayed on various map layers and linked together in interactive tours online using the Presentations feature on SIKU. Creation of Presentations is currently limited to SIKU users given appropriate administrative permission but can be shared with any users through a simple link.

The idea of bringing in tracks such as those created on SIKU for Trips could also be considered if interactive walking tours were desired. SIKU trips currently link together tracks and posts associated with those trips for each user. The creation of trips and posts would be separate and is therefore an analogous feature available on the apps but would require new development to leverage the approach for Points of Interest and walking tours. The mobile apps would indeed benefit from the inclusion of Points of Interest and this is on the SIKU roadmap, content could be created online using existing features now that would then be accessible on mobile apps when the feature development is complete. It would require additional work to allow users to download Points of Interest for Offline use on mobile apps.

The Presentations feature currently online that links POI into guided tours would not easily be adaptable as is for mobile and new frameworks

and tech workflows would be needed to consider to implement a comparable approach for iOS and Android. While not currently available on mobile apps, these would be desirable features for future development in a more general framework that we could help define in a geological use case scenario.

iv) Technical Considerations

While not currently available on mobile, these features would be ideal to develop for mobile app users. Currently the SIKU web platform supports Points of Interest and "Presentations" that guide users to different points of interest/profiles/etc. and provide a basis for early development and exploration of this feature. Points of Interest are on the roadmap for mobile development already and some refinements to the existing system could be done without too much effort.
While Trips with Linked posts provides a visual example of how tours could work, additional work would be necessary to download the POI and tracks. A new mobile framework for "presentations" needs to be considered for mobile apps that requires unique considerations for each platform and doesn't easily make the web content for presentations directly available to the apps (i.e. URL tracking online used to link views would not work on mobile, and other frameworks would need to be considered). These are possible and desirable and could be developed after other requested features on mobile.

Advanced features might include proximity alerts i.e. POI notification load when in the vicinity if the tour is installed. A "tour mode" framework could need to be implemented and consideration of downloading tours for offline use.

v) Financial Assessment

Points of Interest and Presentations could be leveraged online without much additional work. Points of Interest upgrade and migration to mobile apps would be viable - $7000 per platform.
Tour system and downloadable/offline system (profiles, tracks) for mobile is roughly estimated at $25,000 which likely would be supplemented by in kind support from SIKU towards a more general framework for tours with a savings passed on to geological tour features. More detailed information and specific requirements would be required for a detailed evaluation of interactive tours.

8. Technical and Financial Summary

Overall the requested features for geology respect, leverage and build on existing SIKU frameworks and technological development. This means that the majority of requested features are feasible in relatively short timeframes at low cost.

We recommend working on core features at the same time, in particular outlining the scope of work and timelines for Profile Creation (3 above) and Post Creation (4) together to provide some efficiencies and allow for a more comprehensive minimum viable product (MVP) for geological features on SIKU. Additional more advanced work could then be defined following delivery and use of these core features. This is outlined in the "Stage" column of the attached summary table. Steps 3 and 4 could come in either order but generally would require the development of Steps 1 and 2 to be completed.

STAGE	Feature Type	Estimated Time	Estimated Cost	Complexity/Feasibility
STEP 1	Geological Profiles	6 Weeks	$21,000	Feasible, respects existing frameworks
	Geological Post Creation/Edit/View	3 months	$31,500-$42,000	Feasible, respects existing frameworks
STEP 2	Geological Maps	1 month	$25,000	Feasible, requires additional information to evaluate best approach
STEP 3	Interactive Graphics	2+ Months TBD	~$30,000	Feasible, leverages existing web but requires new mobile features, details TBD
STEP 4	Points of Interest and Geological Tours	3+ months	~$39,000	Builds on existing and planned features (Points of Interest), requires additional new development

While the above estimated timelines provide an overall sense of development needs, it should be noted that these do not necessarily reflect timeframes for planning, implementation and delivery. For example, it is not necessarily possible to work exclusively and continuously on geological features back to back while balancing other features, bug fixes and priority requests for SIKU platforms. The three year timeframe proposed to spread out the development of these features does provide a reasonable window for their development.

The above estimates are primarily based on consideration of developers working across platforms on each feature. It assumes that content is provided and profile content would be uploaded and curated by others. Additional costs may be required for design, layout or other considerations related to content. It should also be noted that the estimates do not include overhead costs of administration, meetings and project management that should be considered if a contribution agreement is to be developed. A further important consideration is ongoing

maintenance, upgrades and sustainability. Core features such as profiles would be more easily maintained to be robust to new devices and device operating systems as well as various changing technologies, while other more custom features might require upgrades from time to time as technology changes.

The SIKU platform helps alleviate what would otherwise be substantial costs of maintenance, overhead and sustainability; however, we recommend budgeting for an ongoing contribution to overhead and maintenance of features developed on SIKU with assurances that this will be substantially more cost efficient than other approaches due to the shared sustainability and maintenance of features on SIKU across partners and the scalable approach developed to-date.

9. Conclusion

The incorporation of geological content and user contributed content using the existing SIKU platform is feasible and relatively straightforward for most requested features using the scalable architecture of SIKU and built-in flexibility of the platform. Over 5 years of work have gone into developing complex tech stacks for SIKU across platforms that allow unique features such as use online and offline, syncing across platforms and data stewardship frameworks, all provided at substantial cost and effort that can be leveraged to create a geological framework on SIKU in a considerably efficient and cost effective manner. Furthermore, the SIKU team has and continues to contribute considerable time and resources to providing training and outreach across northern Indigenous communities that would support the use of new features. Over 10,000 northern users that are already using the platform across the north represent one of the most valuable assets of SIKU and the new geological features would be made accessible to this existing user base in a framework they are already familiar with, providing considerable benefits for delivery of geological information, services and community engagement in the north.

The sustainability of the SIKU platform is a key consideration for creating geological features with SIKU instead of a standalone geological app. Considerable efforts across a whole-of-government approach are helping ensure a shared investment in overhead, maintenance and ongoing updates to new technologies across communities, academic projects, regional Indigenous organizations, non-profits, industry and all levels of government. This includes work with a broad range of federal departments including Environment and Climate Change Canada, Fisheries and Oceans, Crown-Indigenous Relations and Northern Affairs Canada, Canadian Coast Guard, the Canadian Space Agency, Transport Canada, NRCAN and others. This extensive network of partners helps streamline delivery of tools and services in a common place via SIKU for northern Indigenous communities, and contributes to self-determination in research and environmental stewardship, development of local conservation and subsistence economies and facilitates safety and situational awareness while further ensuring a long and sustainable lifetime for the technological infrastructure.

SIKU also provides key features for accountability and impact tracking, helping quantitatively measure both tangible and intangible benefits

of investing in northern Indigenous communities for research, monitoring and environmental stewardship. This is particularly apparent in the recently commissioned Social Return on Investment work that the Arctic Eider Society has been able to provide to Inuit Tapiriit Kanatami as a basis for assessing federal investments in northern protected areas and stewardship. This impact measurement and assessment framework would also be leveraged for geological features implemented on the SIKU platform.

Overall, the biggest bottleneck for incorporating new features on SIKU is less about what is technically possible, and more around competing timelines and development prioritization given new SIKU features are in high demand. The proposed multi-year timeline for incorporating geological features on SIKU in a progressive stepwise manner, and the time taken in advance to do this feasibility study gives us confidence in a considerate and appropriate approach to new feature development that can be met and respected if you choose to work with SIKU for delivery of geological tools and services. As such we would be happy to undertake work with NRCAN to develop these features on SIKU for the benefit of northern Indigenous communities.

Report Prepared by the Arctic Eider Society for NRCAN - March 2022

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