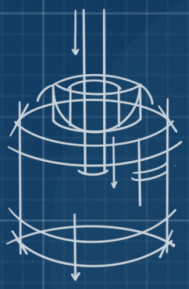
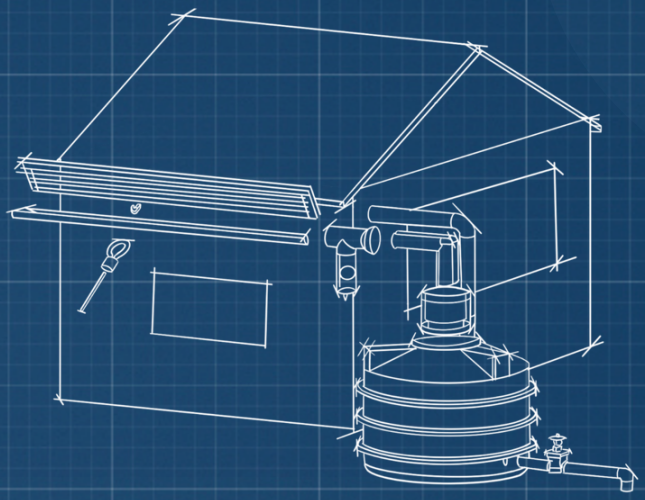
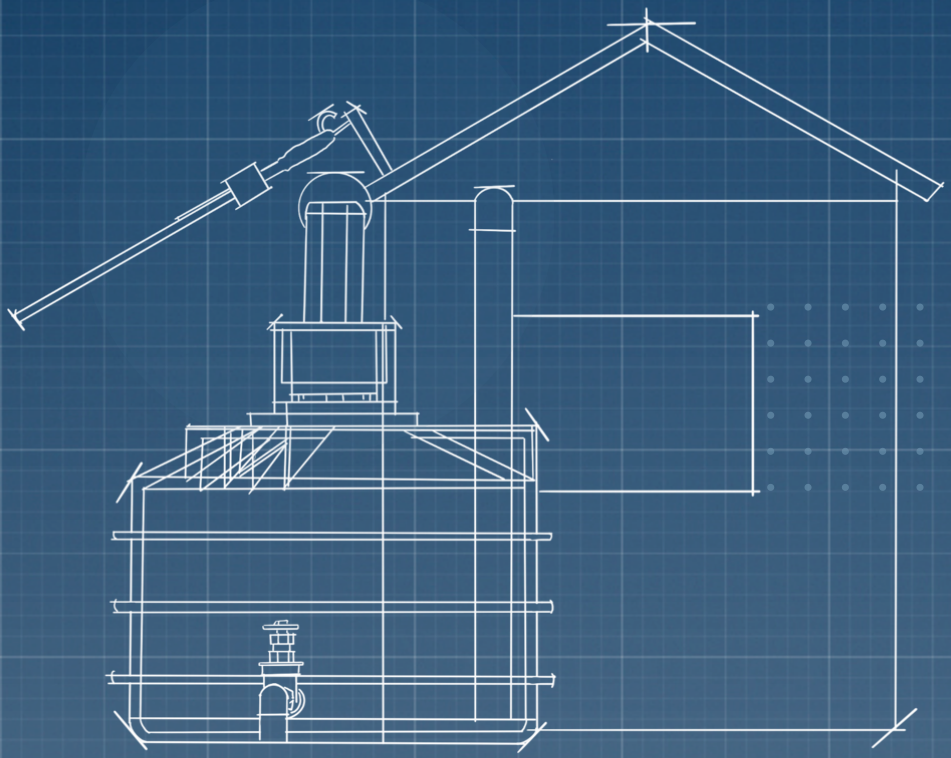
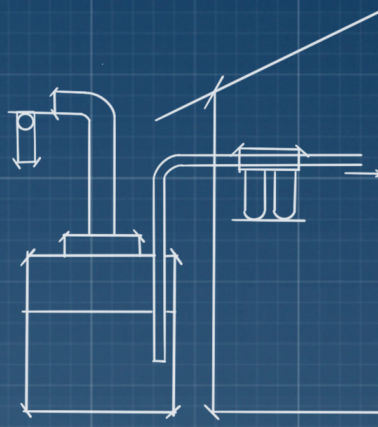
FROM CONCEPT TO **CREATION**

A CASE STUDY OF USER-FOCUSED DESIGN IN A STUDENT-LED RAINWATER WATER HARVESTING PROJECT









SUSTAINGINEERING

PRESENTED BY THE RAINWATER HARVESTING IMPACT ANALYSIS TEAM

From Concept to Creation: A Case Study of User-Focused Design in a Student-Led Rainwater Water Harvesting Project

Presented by the UBC Sustaingineering's Rainwater Harvesting Impact Analysis Sub-team:

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Disclaimer: The identity of the community and associated representatives liaising with UBC Sustaingineering through the Builders Without Border Foundation (BWBF) are not disclosed throughout this publication.

Technical note: In this publication, the term "stakeholder" refers to any party that benefits from Sustaingineering's projects, or any parties that hold weight in decision-making around project development. These include both user groups and public/private sector partners of UBC Sustaingineering. **"Stakeholders" are distinct from "rights-holders".** While rights-holders may also derive benefit from project implementation, they possess constitutionally protected rights that must be acknowledged in design and engagement processes [1]. In Canada, these include the right of Indigenous peoples to use, control, and manage the land, and to reap economic benefits of the land and its resources. We make this distinction to practice respect towards the rights held by the Indigenous communities Sustaingineering's projects apply to.

Layout & Design
Maia Rankine-Griffith

April, 2023

Acknowledgements

This report has been made possible by the effort, input, and contributions of individuals representing several organizations.

The IA RWHS sub-team would like to extend special thanks to **Karl Zimmermann, Keyvan Maleki, and Jim Brown** at the RESEAU Centre for Mobilizing Innovation for graciously taking the time to share their vital expertise and feedback. Their guidance has impacted the members of this sub-team deeply, and has helped in envisioning the future of the RWHS Project.

We are also grateful for the contributions made by **Akhil Reddy**, a Sustaingineering Alumnus, who provided extensive background information regarding the RWHS project and its origins.

Additionally, a sincere thank you to **Maya Nathani-Sim** (RWHS Project Manager), **Megan Dale** (IA Team Lead), **Mona Berhouzian** (UBC Sustaingineering Management Lead), and **Cara Chapman** (UBC Sustaingineering Co-captain) for their guidance and support in relationship-building with the RWHS project's key partners. We also thank them for patiently editing the report alongside **Adriana Diaz** (incoming IA Team Lead).

We are grateful for all others, including the talented members of the RWHS technical team (**Kajal Mishra, Tony Ryu, Sarah Luo, Emma Foresberg, Laura Dalkie, and Melissa Elmer**), the Alpha Lab, the Kaiser Fund, and the Electrical and Computer Engineering Department at UBC for their contributions in making the RWHS come to life, and for providing the space to create this publication.

Land Acknowledgement

We acknowledge that UBC Sustaingineering convenes on the traditional, ancestral, and unceded territories of the xʷməθkʷəy̓əm (Musqueam) Nation.

In our efforts, we intend to pay respect to the long history of Indigenous peoples and their enduring relationship with this land. It is our duty to recognize such relationships as we strive for sustainability in each of Sustaingineering's projects, honoring their legacy in our work.

Image: Reconciliation Pole, installed on the University of British Columbia's Vancouver Campus. Retrieved from https://ctlt.ubc.ca/2020/11/24/edubytes-the-indigenous-strategic-plan-overview/.

CONTENTS

EXECUTIVE SUMMARY

User-focused, participatory design is crucial in developing inclusive, meaningful, and accessible solutions for the future.

In this spirit, members of UBC Sustaingineering's Impact Analysis (IA) Team, the authors of this report, have sought out varied approaches to incorporate end-user interests into the design of a Rainwater Harvesting System (RWHS). This was done with the challenge of being unable to communicate with end-users directly, due to the various socio-political complexities of Indigenous community engagement. This publication summarizes the lessons learned in this process and aims to set a baseline for student-led engineering design projects of the future.

In Part 1, we discuss the evolution and current state of Sustaingineering's RWHS Project, drawing on insights provided by Akhil Reddy, a Sustaingineering alumnus and key player in the project's conception. Following this, an exploration of the path forward in Part 2: how we have, and intend to approach the challenge of restricted end-user communication in the context of the RWHS Project. **Here, we present three solutions**, developed in consultation with public and private sector partners working in the rural and Indigenous water-health environment. These solutions aim to highlight the roles of innovation, secondary research, and visualizations in user-focused design and technical information sharing.

In presenting this knowledge, we hope to encourage other design teams and student groups to exercise creativity in incorporating end-user needs, interests, and preferences into their own projects.

PART 1:
THE **RAINWATER HARVESTING PROJECT**

UBC SUSTAINGINEERING &
THE RAINWATER HARVESTING PROJECT

Sustaingineering is a product of innovation.

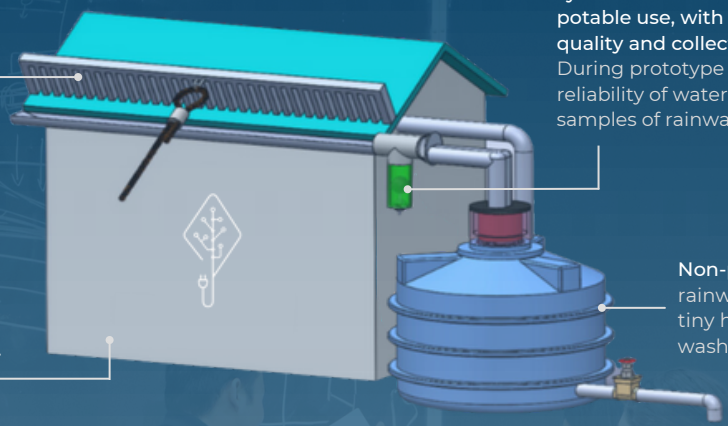
As a multidisciplinary, student-led engineering design team at the University of British Columbia, we are dedicated to developing sustainable solutions for implementation in communities in B.C. and around the world. Sustaingineering is run completely by volunteers, and our work is funded entirely through fundraisers and grants.

One of the core projects underway involves the development of a **Rainwater Harvesting System** (RWHS), initially designed to provide sustainable access to safe, non-potable water to a community located on B.C.'s West Coast. As of April 2023, the RWHS Technical Team has designed the first iteration of the system in collaboration with the Builders Without Borders Foundation (BWBF).

Six major areas were selected as foci of the RWHS design process:
water testing, filtration, prototype design, construction, piping, and material selection.

Rainwater that runs through gutters is first filtered to remove debris. Following initial collection and filtration, water is stored temporarily in the collection tub.

The RWHS team developed filters and gutter systems to transform rainwater for non-potable use, with the goal of optimizing water quality and collection efficiency. During prototype testing, the purity and reliability of water supply were monitored using samples of rainwater pre- and post-filtration.



Non-potable water uses: collected rainwater will be pumped into the tiny home primarily for clothes-washing and toilet flushing.

The RWHS system will be integrated into low-carbon, portable tiny homes. Sustaingineering is currently in the process of constructing the first prototype of the tiny home.

***Pictured:** The RWHS's first prototype model*

***Sustaingineering's Impact Analysis (IA) Team** ensures the design meets the highest standards of the environmental, economic, and social sustainability. The IA Team employs a weighted framework composed of qualitative and quantitative performance indicators to set these standards, ultimately determining the direction of project development in support of Technical Team members. More information on the current IA framework can be found in Appendix I.*

THE CONCEPTION & EVOLUTION OF THE RAINWATER HARVESTING PROJECT

Akhil Reddy, a former RWHS Technical Lead, shares his insight on how the project came to be:

*"Over the summer of 2020, I began exploring the depths of my own Indic Indigenous culture and ancestry and saw many parallels between Eastern Indigenous cultures and communities and the Indigenous Peoples of Canada. After several conversations with UBC Indigenous organizations and Faculty, I came across Elder Albert Marshall's concept – **Etuaptmumk**, or Two Eyed Seeing – which bridges Indigenous and other ways of knowing and being to create equitable, sustainable, and integrated communities."*

The prevalence and impact of Marshall's words inspired Reddy to propose to UBC Sustaingineering the creation of a multidisciplinary group, whose aim was to encourage Indigenous learning within engineering design. He spent this summer learning more about the history, cultures, and impositions of colonizers and engineers alike, seeking mentorship and guidance from organizations like UBC Indigenous Research Support Initiative and the RESEAU Centre for Mobilizing Innovation (RESEAU CMI), in addition to UBC leaders including Assistant Professor Pamela Wolf and PhD student Danilo Caron. Later, he approached Brian Boone, the president of the **Builders Without Borders Foundation (BWBF)**, with the idea to bridge Indigenous learning with engineering design. His first project culminated in the creation of a research document recommending the design and installation of residential heat pumps in Indigenous communities of Central B.C.

The recommendation was well received by BWBF and a representative of the project's intended community, and was thus implemented in eight, newly constructed 'Tiny Homes' in this community.

He then recruited 12 engineering students to a newly-formed Indigenous Engagement Team, which later became the Civil & Materials Team under Sustaingineering. He developed workshops and case studies, coaching the team on inter-cultural communication, approaches to complex cultural sensitivities, as well as engineering for society design-based thinking. Ultimately, they were able to generate a database addressing Indigenous history, resource and infrastructure disparities, regional environmental analyses, social governance, housing, and accessibility, as well as cultural, economic, and political systems.

Members of the team also monitored community consultation survey data from the intended community's Clean Energy Committee, and assessed the state of the community's existing energy infrastructure.

In Phase 2 of this project, the team developed a framework for a water management system involving water filtration, grey-water recycling, fog harvesting, irrigation, and rainwater harvesting. This work received interest from several Indigenous communities to integrate the rainwater harvesting framework into sustainably-built tiny homes. Over the summer of 2021, Reddy approached Sustaingineering executives with the water project, as well as the idea of Indigenous Tiny Home construction. This eventually led to a team-wide Tiny Home Campus Project, allowing students from all sub-teams to integrate their technologies into this first iteration.

To this day, BWBF continues to serve as a mediator between the Sustaingineering's RWHS Team and the project's proposed end-users, in addition to providing technical expertise in design.

THE PATH **FORWARD**

Despite cultural sensitivity workshops and stakeholder research having been carried out at the onset of the RWHS Project, many students have graduated out of the team over the past three years, causing disruptions in the sharing of this key knowledge. As a result of this knowledge gap, current technical members highlighted feelings that user needs and perspectives were not adequately considered in the design stages of the project, stating that potentially inaccurate generalizations had to be made based on the limited information about the intended community.

This represents a major area of focus for the RWHS Impact Analysis (RWHS IA) Team moving forward.

RESEAU
centre for mobilizing innovation

KARL ZIMMERMANN

Karl Zimmermann is a 2020 Vanier Scholar and PhD candidate in Chemical and Biological Engineering at the University of British Columbia. His work as a research scientist at RESEAU CMI involves bringing clean drinking water to indigenous and non-urban communities around the world.

STAKEHOLDER ENGAGEMENT: TYPICAL APPROACHES

To better integrate end-user needs into the project, RWHS IA sat down with **Karl Zimmermann**, an expert in water-based community partnership building, to learn about the typical approaches to stakeholder engagement in water-related projects.

Zimmermann explains that when it comes to assessing water needs for targeted communities, **the baseline is drawn by the UN Declaration of Human Rights** [2], which asserts that all individuals require access to safe water and sanitation. This simply means that the central goal of any project must be to make clean water available on the premises at all times. Any subsequent Needs and Capacity Assessments involve discussing with community representatives to gauge their water uses, needs, preferences, acceptable levels of risk, and the technical capacities of the community in managing the solution at hand. The fundamental solutions *approach* must always be driven by the direct participation of end-users—**and there are no shortcuts or substitutes for this.**

This is particularly significant in Canada, as the management of water resources is a highly politicized matter that intersects deeply with issues of environmental and social injustice. Zimmermann explains that this is why larger authorities, including Indigenous Services Canada [3] and numerous other organizations, are often consulted in the development of community water projects to first understand rights-holders' needs for selected communities.

PART 2:
CHALLENGES & **SOLUTIONS**

THE **CHALLENGE**

More detail on the reasons behind UBC Sustaingineering restricted community engagement can be found in Appendix II.

Acknowledging the many socio-political complexities involved in direct Indigenous engagement, it is clear that this is better done by those who are equipped with the appropriate language, expertise, and community relationships to do so. As students, we now understand we have much to learn, and that we are, by no means, experts. For this reason, we were **unable to reach out to our intended user community directly** throughout the RWHS's design, and all communications were instead directed exclusively through BWBF.

Closing the gap • As a part of the engineering design team community at UBC, we recognize other student groups on campus and beyond may face the same challenge of not being able to directly communicate with the communities they intend to serve, despite intentions to incorporate end-user needs into their respective projects. As such, we present our experiences and the lessons learned in the design of Sustaingineering's Rainwater Harvesting System. In doing so, we wish to offer three solutions to address our challenge:

1. **Maintaining innovation** as a focal point of project design
2. Conducting thorough and targeted **secondary research**
3. **Leveraging the power of visuals** in technical communication

These solutions have been developed in consultation with public and private sector partners working in the rural and Indigenous water-health environment. In sharing, we hope to highlight the importance of, and inspire solutions-oriented decision-making that puts the end-user at the forefront of engineering design.

KEYVAN MALEKI & JIM BROWN

The IA RWHS sub-team discussed with RESEAU CMI's Executive Director Keyvan Maleki and Indigenous Water Infrastructure Advocate Jim Brown, who shared valuable insights regarding rights-holder engagement in Canadian water resource development projects.

More information about RESEAU CMI, as well as their Community Circle™ Framework, may be found at https://www.reseaucmi.org/

SOLUTION I:
INNOVATION AS A FOCAL POINT

As the cultural, geographical, and historical contexts of communities across British Columbia are incredibly diverse, standardized rubrics, benchmarks, and approaches do not work for all communities uniformly. This highlights once again, **the fundamental and impervious importance of direct consultation**. In addition to this, having never seen, been a part of, or interacted with the indigenous communities that BWBF intends to share our designs with, we must also be mindful of the language we deploy. Using terms such as “helping” or “engaging with community members" would be a false and dangerous depiction of the project’s true objectives.

Instead, we must take an alternative approach. Although the RWHS project originated from the initial intention to be implemented in one community, its wide array of potential benefits is borne out of the spirit of innovation – that is, the creativity that led to the project’s conception and development. Instead of targeting a specific community, we must **focus on our own innovation first** to demonstrate the strength and merits of our proof-of-concept to a broader audience, and ultimately present our solution to the broader public. This way, any community that views the project as a potential solution that fits their respective water development needs may engage it through their own agency. Based on this approach, Maleki and Brown suggested bringing the RWHS’s core designs to local schools in potential end-user communities, presenting them to students and teachers, as a means of gauging general community interest.

This fits into Sustaingineering’s long-term vision of partnering with universities across the world to create a cumulative database of innovative, technological designs, thereby supporting students in working to meet the energy, water, and social needs of their own communities. As of today, Sustaingineering has already built such a relationship with the Monterrey Institute of Technology and Higher Education (Tecnológico de Monterrey).

SOLUTION II:
RESEARCH, RESEARCH, RESEARCH

To better understand the potential communities in which the RWHS could be of use, a primary course of action for IA is to do our due diligence. Previous research entailed reading news articles about our initial target community, consulting the Alma Mater Society (AMS) Indigenous Committee at UBC, as well as resources drawn from various organizations including The Assembly of First Nations (AFN)[4] and RESEAU CMI (with a specific focus on their Community Circle framework) [5]. As we intend to propose our solution to the broader public, we aim to conduct research to gauge the general range of these end-user communities; *who* they are, *where* they are, and *what use* the project may have in their respective contexts.

In the case that a specific community is targeted nevertheless, Zimmermann recommended **leveraging community similarities in research** to understand the one at hand. This entails finding other communities of similar sizes, household densities, levels of geographical isolation, and water uses; and researching their water needs to gauge those of the intended community. In this approach, we acknowledge that **no two communities are identical**. Instead, the purpose is to simply provide a foundation of understanding upon which any subsequent research would lie. Ultimately, this approach should be applied in tandem with direct end-user engagement to draw a full, accurate picture of stakeholder/rights-holder needs and interests.

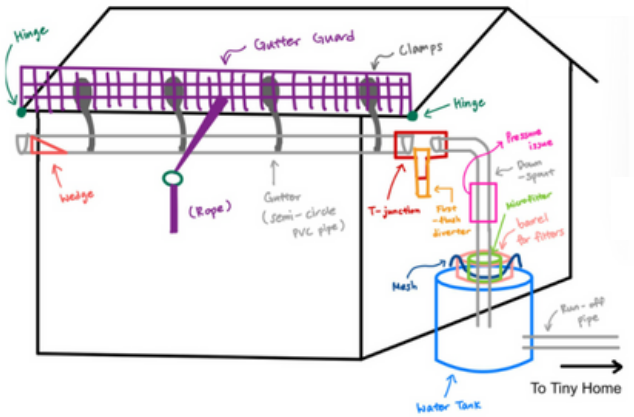
Finally, external factors that may modify the long-term trajectory of anticipated project impacts must be equally considered. In the case of the RWHS, these would include changing climatic conditions and regional precipitation patterns, among many others. Relevant scenario analyses based on previous research must therefore be conducted in conjunction with impact assessments to ensure that all extraneous factors are adequately considered. This represents another major area of focus for IA moving forward.

SOLUTION III:
THE POWER OF VISUALS

When it comes to engineering design, **images are often more powerful than words.** As such, communicating visually through functional/structural models, sketches, diagrams, videos, and photos ensures that the project is as accessible as possible to the broader public. In many cases, aggregates of visuals are naturally created throughout the design process, and the only work that must be done entails making them digestible for the audience in question.

The RWHS Technical Team is in the process of compiling all rainwater data, graphics, pictures, sketches, simulations, and 3D schematics into a cohesive, visual package to share with schools in potential user communities across British Columbia. In doing so, we aim to seek feedback on the system based on their respective interests, subsequently generating tailored iterations to maximize the system's benefits upon community-led implementation (if decided upon by community representatives). **We note that visuals alone may only aid this to a certain extent.**

However, they serve as an effective starting point in technical communication and work well in the unique circumstances of restricted end-user communication.



Initial sketch of the RWHS: Illustrated by Tony Ryu (RWHS Technical Lead)

FINAL **WORDS**

This publication navigated the ways we approached decision-making around the RWHS's objectives and design while being unable to directly communicate with the system's intended end-users.

Through discussions with Akhil Reddy, Karl Zimmermann, Keyvan Maleki, and Jim Brown, it has become evident that user-oriented design thinking is imperative in creating meaningful and culturally-sensitive solutions. In presenting this knowledge, we hope to encourage other design teams and student groups to exercise creativity in incorporating end-user needs, interests, and preferences into projects of their own.

User-focused, participatory design is crucial in developing inclusive, meaningful, and accessible solutions – and this is not limited to the scope of engineering design. Inclusive decision-making is one of the most fundamental aspects of our path forward as a society as we attempt to challenge problems relating to the socio-environmental sphere.

We hope that our experiences inspire investment in community involvement as a foundation for strengthening student-led engineering design projects of the future.

APPENDIX

Appendix I: The Current Impact Analysis Framework

The IA Framework employs quantitative metrics and sub-metrics to identify environmentally and socially conscious alternatives throughout the design process. Specific 'best' and 'worst' case scenarios, based on primary, secondary, and tertiary impacts are established to support this. The following is an example of one of the framework's evaluation metrics:

Pillar	Metric	Goal	Sub-metric	Contributing Metrics
Environmental Impact	Material Sourcing	To use materials within 50km of the site	Materials used	Distance from source (km) Mass of waste produced (kg)

'Best Case Scenario'
Materials are sourced from within 5km of the site, or within the boundaries of the intended community.

'Worst Case Scenario'
Materials are sourced from outside a 500km radius of the intended community.

Justification: using materials sourced locally or found second hand would reduce the carbon footprint of the system, by avoiding long-distance transport and the manufacturing of new materials. This would involve reusing older pipes, clay containers or clamps if available, or simply buying components locally.

As we attempt to decolonize our design approaches, the IA Framework will continue to be revised.

Appendix II: More reasons for restricted community interaction

Respect: To ensure our interactions are as respectful as possible, experience, ethics reviews, education, and relevant engagement training must come first. As volunteer students, it is out of our ability and scope to ensure this on our own.

Long-term Connection: Sustaingineering is run by student volunteers, with many participating for only one to two years before graduating. This inhibits our ability to create a valuable, long-term connection with communities, and to provide a main person of contact for the stakeholder.

Intention: It is not our intention to enter a community and claim that they 'need our help', and that we are there to solve their problems for them. This is a fact that must be acknowledged as we attempt to decolonize our design processes.

Liability and Safety: Although designs and suggestions may be shared with communities, engineering student teams at UBC are restricted from providing physical products (including prototypes) to their clients due to issues with liability.

- *Mona Behrouzian; UBC Sustaingineering Management Lead*

REFERENCES

[1] More information on the distinction between stakeholders and rights-holders can be found here: https://globalforestcoalition.org/stakeholders-rightsholder-conflicts-interests-agenda2030/

[2]: "The Universal Declaration of Human Rights (UDHR) is a milestone document in the history of human rights. Drafted by representatives with different legal and cultural backgrounds from all regions of the world, the Declaration was proclaimed by the United Nations General Assembly in Paris on 10 December 1948 as a common standard of achievements for all peoples and all nations." Taken from: https://thinkhumanrights.ca/general-questions/

[3]: "Indigenous Services Canada (ISC) works collaboratively with partners to improve access to high quality services for First Nations, Inuit and Métis. Our vision is to support and empower Indigenous peoples to independently deliver services and address the socio-economic conditions in their communities."
Taken from: https://www.canada.ca/en/indigenous-services-canada.html

[4]: "The Assembly of First Nations (AFN) is a national advocacy organization that works to advance the collective aspirations of First Nations individuals and communities across Canada on matters of national or international nature and concern." Taken from: https://www.afn.ca/about-afn/
AFN's National Water Engagement Documents can be found here: https://www.afn.ca/policy-sectors/housing-infrastructure-water-emergency-services/water/

[5]: "The Community Circle™ is built on Indigenous pedagogical and andragogical strategies (Talk Story) that utilizes Elders' knowledge passed down from previous generations' dialogue with listeners to build collective understanding, allowing participants from diverse knowledge systems, to contextualize theory with their life experiences to build group consciousness:"
Taken from: https://www.reseaucmi.org/work/community-circle