

QNFCF

Quantum Nano Fabrication
and Characterization Facility

Quantum-Nano Fabrication and Characterization Facility

Annual update: Fiscal Year 2026 – (May 2025 – April 2026)



Participants discuss electrical characterization during the Testforce/TQT/QNFCF hosted electrical characterization seminar (May 2025)

Nathan Fitzpatrick

Director, Quantum-Nano Fabrication and Characterization Facility

1. INTRODUCTION

The operational milestones and data for the Quantum-Nano Fabrication and Characterization Facility (QNFCF) for fiscal year 2026 have been summarized in this annual report. For more background information regarding our lab, operations and governance structure, please refer to our website:

<https://uwaterloo.ca/quantum-nano-fabrication-and-characterization-facility/>

2. OPERATIONAL HIGHLIGHTS

The Quantum-Nano Fabrication and Characterization Facility (QNFCF) is an ever-evolving resource which changes to meet the needs of our community of lab members. Some operational highlights for the 2025/26 year include:

- **May 2025:** The QNFCF co-hosted an electrical characterization seminar with support from Testforce and Transformative Quantum Technologies (TQT). Over 30 attendees including students, staff and post docs learned best practices for sensitive electrical measurements, such as measurement techniques for removing contact and lead resistance, and achieving low current measurements by minimizing leakage current, and noise. Representatives from Keithley also provided a full overview of the Keithley 4200A system, including a live demo. Throughout the event, attendees were encouraged to come forward and get hands-on experience with the Keithley systems and engage in discussions about details of how to set up and correctly use electrical testing equipment to minimize or eliminate noise and other effects which obscure the intended measurement.
- **May 2025 – April 2026:** Greg Holloway integrated new features into the QNFCF's NEMO lab equipment scheduling platform. The most notable new feature added was the integration of temperature and relative humidity sensors from across multiple QNFCF labs, including the QNC Cleanroom. The integration of these sensors enables the entire community to review the performance of these critical environments. With this feature, we aspire to instill confidence in the community that their sensitive fabrication processes can be accomplished reliably without risks imposed by poor temperature or humidity control.

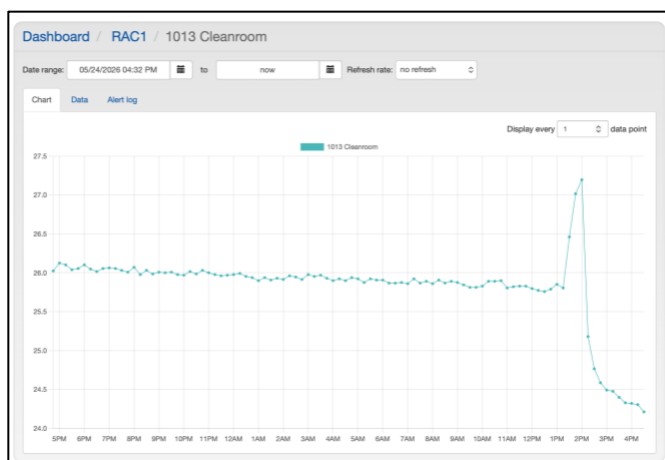


Figure 1: Temperature record in RAC1 1013 during initial testing of environmental sensors.

- February 2026:** A [Bruker Senterra-II Raman microscope](#) was installed in the RAC1 Inert Atmosphere Fabrication Lab. This flexible and powerful tool for nondestructive chemical analysis of solid samples is available to the entire community. The system has been specially equipped to enable rapid characterization of air sensitive 2D materials. This new equipment was contributed to the community through support from Transformative Quantum Technologies (TQT).



Figure 2: Bruker Senterra-II Raman microscope in RAC1 2003 Inert Atmosphere Fabrication Lab

- February 2026:** The QNFCF [led a project](#) with support from TQT and the University of Waterloo [Sustainability Action Fund](#) to upgrade QNFCF's MA6 mask aligner from a mercury arc lamp to a UV-LED light source. By replacing the mercury arc lamp the QNFCF eliminated our stream of mercury-contaminated solid waste in the QNC cleanroom, reduced staff time devoted to regular lamp changes and is poised to save an estimated \$10,000 CAD/year in consumable parts, electricity and gaseous nitrogen.



Figure 3: SUSS MA6 mask aligner with Idonus UV-LED control panel installed

- **March 2026:** A new Bruker Dektak Pro-S stylus profiler was installed in the QNC Cleanroom, replacing an older Veeco Dektak 150 which had become difficult to support. This new equipment was contributed to the community through support from Transformative Quantum Technologies (TQT).
- **April 2026:** The QNFCF installed an [Angstrom thermal evaporation system](#) for indium films in the RAC1 cleanroom lab. The system is designed to enable the deposition of high aspect ratio indium bumps for chip-chip and wafer-wafer bonding. This project was enabled through support from CFI John R. Evans Leaders Fund (JELF) project #42248, led by Dayan Ban.



Figure 4: Angstrom indium evaporation system in RAC1 1013.

In terms of staffing, the following personnel changes occurred in the 2026 fiscal year.

- **Nicki Shaw**, Senior Facility Microscopist, resigned from the QNFCF in October 2025. **Sandra Gibson** transferred into the Senior Facility Microscopist role formally in January 2026.

3. LAB DEMOGRAPHICS AND TRENDS

This section summarizes the attributes of the QNFCF lab member population. The population of lab members in this discussion refers to the number of active users who register *at least one* instance of equipment use within the fiscal year. For the 2026 fiscal year, the QNFCF registered 295 active lab users, reflecting an 11% increase from the previous fiscal year. The graph below represents this trend over time:

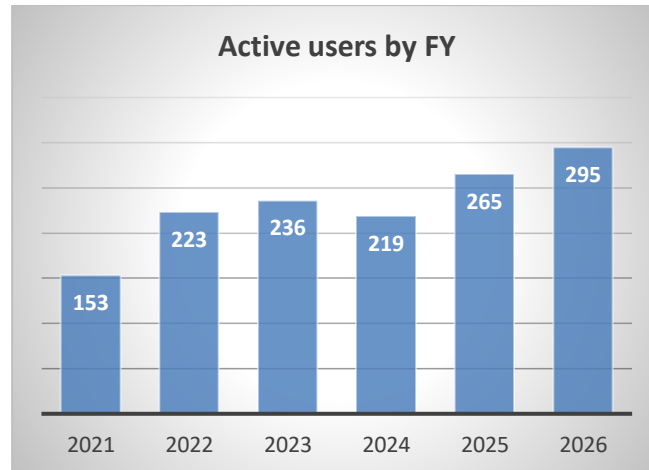


Figure 5: Bar graph of active QNFCF users for the fiscal year 2026 and the previous 5 years

If we investigate the data for the 2026 fiscal year, the QNFCF user population can be broken down by affiliation. The lab users are typically grouped by faculty if they are within the University of Waterloo and into the categories of “*external academic*”, “*government*”, and “*industry*” if they are external to the University. The following pie chart provides an overview of the QNFCF’s user population by affiliation:

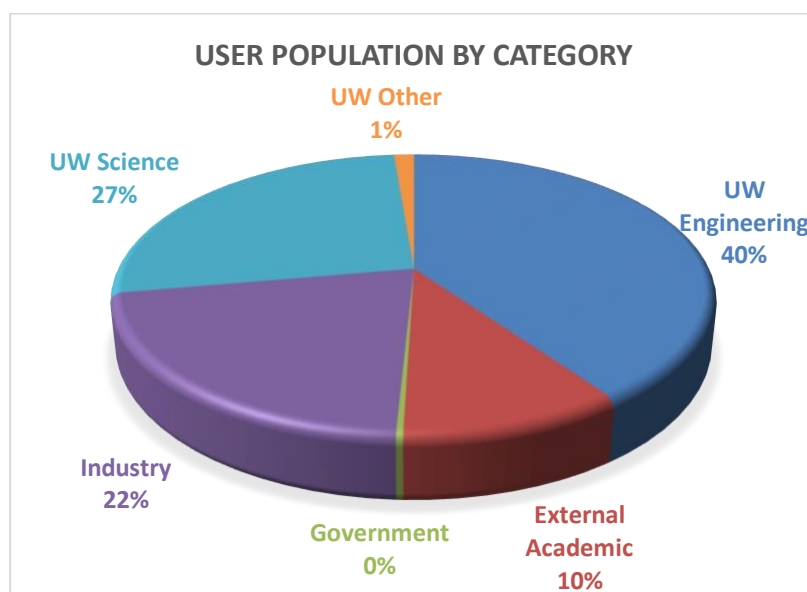


Figure 6: A pie chart depicting the affiliations of the QNFCF user community for fiscal year 2026

All user accounts within the QNFCF are associated with an account holder, the principal investigator (PI). The population of principal investigators showed a modest increase during the year, from 102 in the previous year to 109 in the current year. A graph of this population over time is included below:

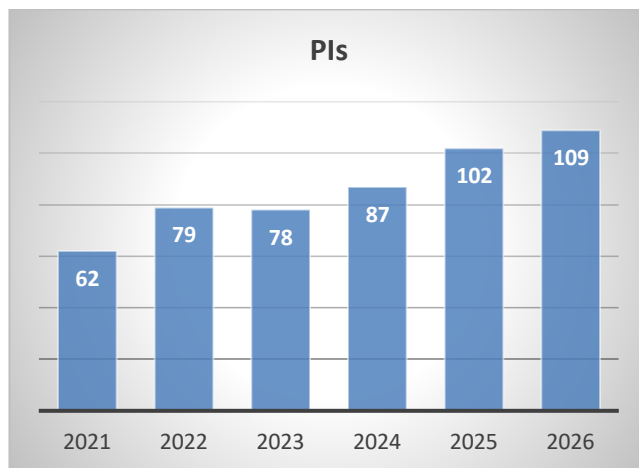


Figure 7: Bar graph of active QNFCF PIs for the fiscal year 2026 and the previous 5 years

If we investigate the data for the 2026 fiscal year, we can apply the same internal and external affiliation categories to the PI population. The following pie chart provides an overview of the QNFCF's PI population by affiliation:

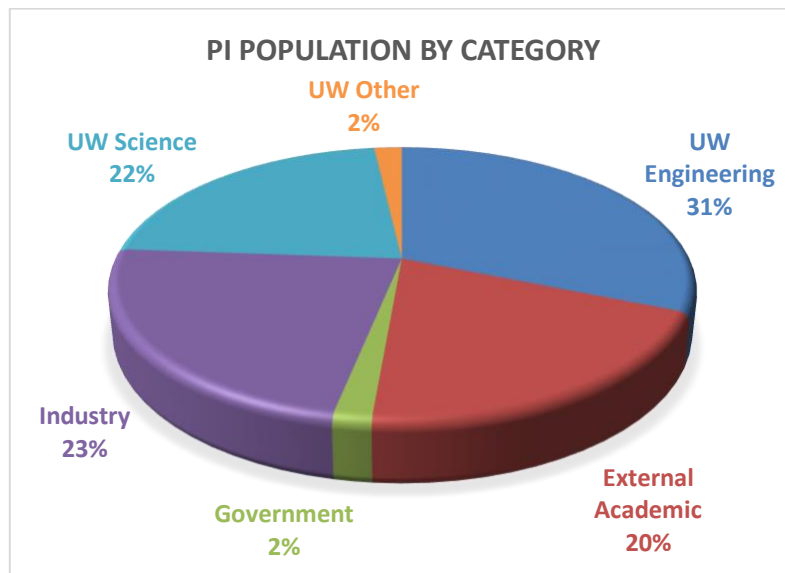
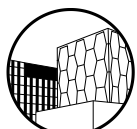


Figure 8: A pie chart depicting the affiliations of the QNFCF PI community for fiscal year 2026

Brief comments regarding the QNFCF lab demographics for the 2026 fiscal year:

This year's growth in PI and user population appears to be driven by significant increases in external academic and in industrial groups. Industrial groups were far and away the fastest growing cohort with 22 new users and 6 new PIs, a 49% and 32% increase respectively.



Increases in the population of groups who are not affiliated with the University of Waterloo speak to the value these groups get out of interactions with the QNFCF. These groups are not incentivized to perform their device fabrication or characterization here and they are choosing to travel to the QNFCF or set up their own base of operations in the Region of Waterloo. We believe this is an endorsement of the quality of the service at the QNFCF and the unique and relevant capabilities that are not available elsewhere. This increase in the external to University of Waterloo community at the QNFCF supports the conclusion that our facility is becoming a mature nationally relevant host of fabrication and characterization resources which serves to attract users from outside our region. Simultaneously it's important to keep in mind that the external to UW cohort is less bound to Waterloo and more likely to disengage with the lab if critical equipment falls into disrepair due to a failure to plan for replacement.

4. EQUIPMENT USE AND EQUIPMENT REVENUE TRENDS

The QNFCF's mandate is to provide a world-class nanofabrication and characterization facility to our stakeholders in the University of Waterloo community. The annual volume of equipment use is a key performance indicator demonstrating the impact of the QNFCF on the University of Waterloo community. To measure the usage of the QNFCF equipment, we rely on our NEMO lab management software. It is important to note that NEMO features both equipment reservation tracking and equipment use tracking. The graphs in this report are based exclusively on the equipment use data that indicate actual activity on our toolset and are not based on the equipment reservations that tend to be higher due to missed appointments or other inefficiencies inherent in equipment scheduling.

A figure representing the number of equipment use hours that have been invoiced per fiscal year is included below (Figure 9). The 2026 fiscal year showed 20% reduction in hours of equipment use, the facility's first such reduction in activity since the COVID-19 impacted year of 2021. A deeper dive into this reduction in activity was conducted and it showed that activity in the RAC1 1013 Clean Assembly lab was lower by approximately 9700 hours, while most other lab spaces showed consistent or increasing activity. We have inferred from this data that there has been a significant reduction in ion trap assembly activities taking place in this lab. Fortunately, ion trap assembly has a low impact (approx. 1-2%) on the revenues of the QNFCF since the relevant assembly equipment costs little to operate and has very low fees associated with its use.

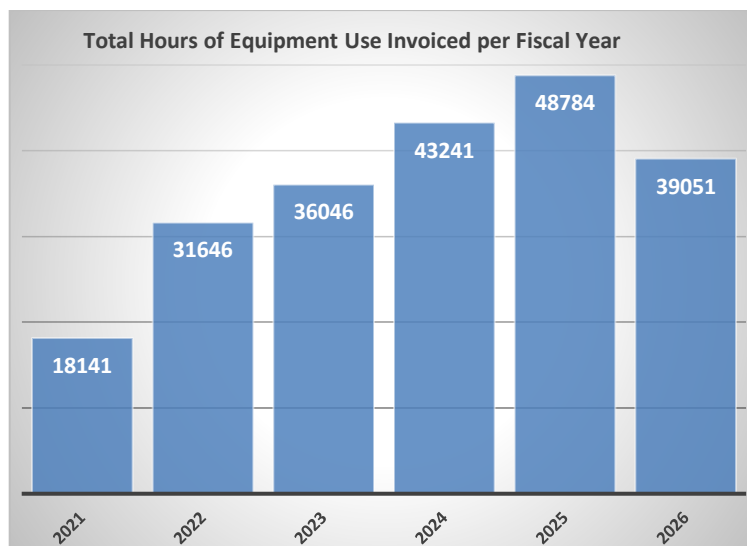


Figure 9: Bar graph of hours of equipment activity registered across the QNFCF toolset for the fiscal year 2026 and the previous 5 years

The following pie chart represents the equipment use as a function of the affiliation categories.

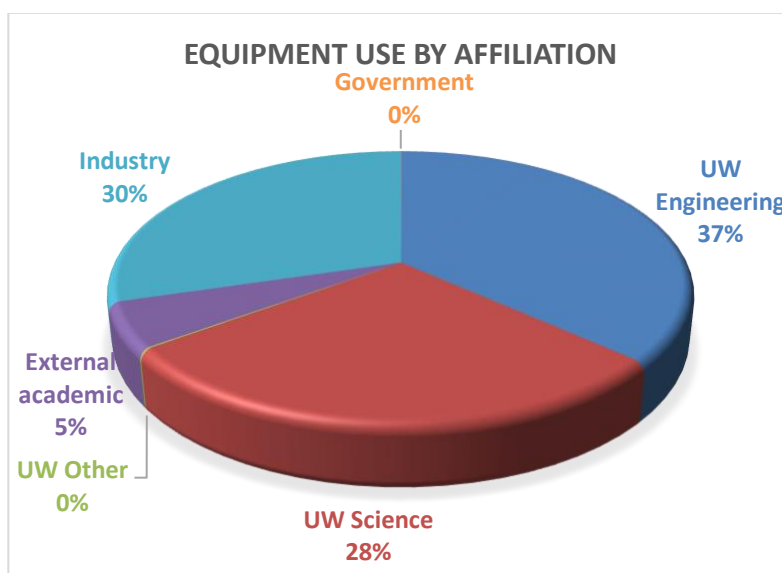


Figure 10: A pie chart depicting invoiced equipment use by different affiliation groups within QNFCF community for fiscal year 2026

If we compare the pie chart of equipment use in Figure 10 with the lab user population data in Figure 6, we observe that internal UW users make use of equipment roughly in proportion with their respective population sizes. Continuing to compare these pie charts we see that external academic users consume fewer equipment hours per capita and industrial users consume the highest amount of equipment hours per capita.

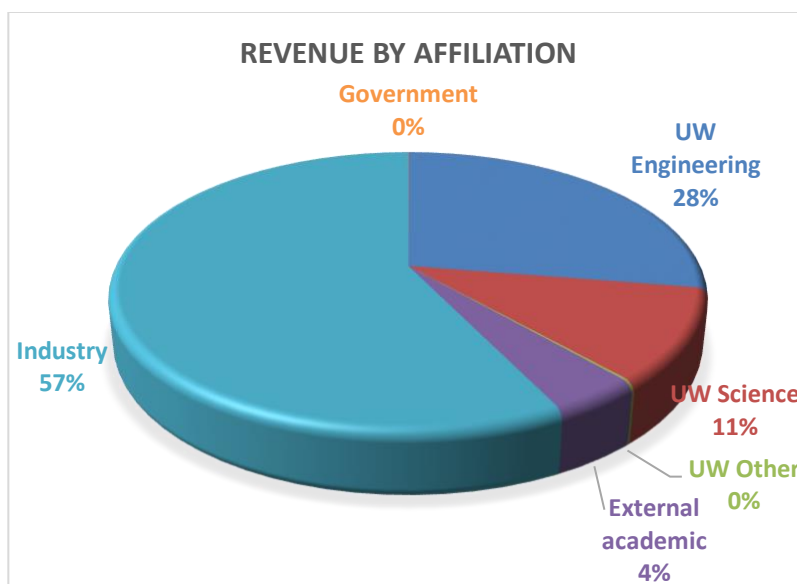


Figure 11: A pie chart depicting lab revenue invoiced to different affiliation groups within QNFCF community for fiscal year 2026

Figure 11 represents the components of the QNFCF's total equipment revenue as a function of the affiliation categories. The pie chart above shows stark differences when compared with the pie charts that represent the equipment use in Figure 10 and the user population in Figure 6. We can see that once again in 2026 lab revenue from industrial users forms the largest portion of the QNFCF revenue. Industrial equipment fees are three times higher than the partially subsidized fees for the academic user community, so robust equipment use from this cohort of users should be expected to lead to a disproportionate contribution to the facility's revenue.

Individual tool trends:

The following figure shows the top 20 pieces of equipment, in terms of the hours of use in the 2026 fiscal year:

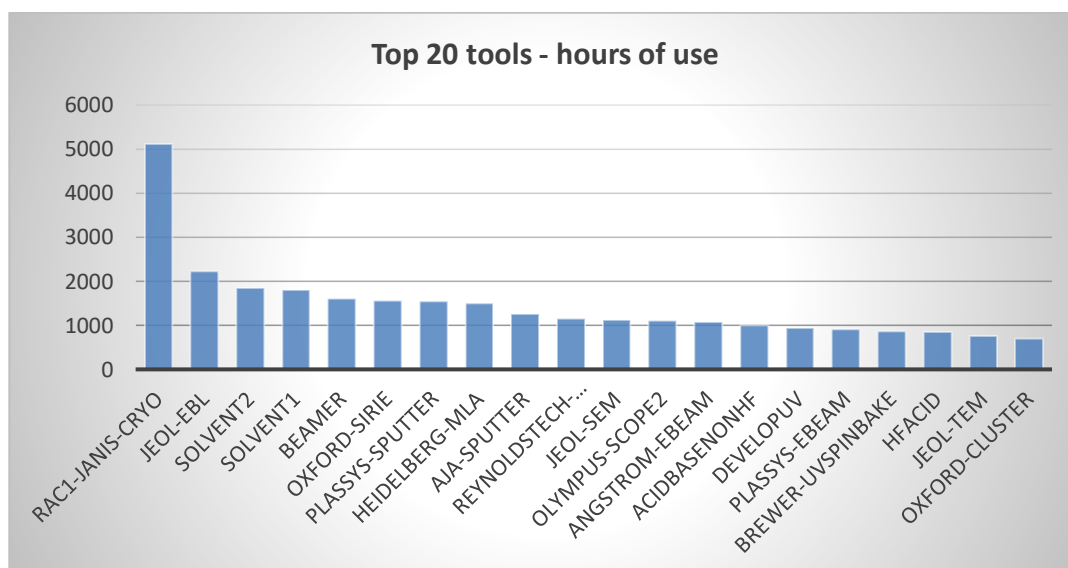


Figure 12: Bar graph of hours of equipment activity registered by the 20 busiest tools in fiscal year 2026

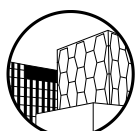


Figure 12 demonstrates that the most popular tools in terms of use are largely located in the QNC cleanroom lab and split between the “workhorse” types of tools that might be found in many microelectronic cleanroom labs (wetbench tools, lithography, plasma etch) and unique tools with a narrow, dedicated following, such as the Plassys superconducting deposition tools. Notably the RAC1-JANIS-CRYO, cryogenic testing platform in RAC1 was far and away the busiest tool and a notable outlier in this list.

The following figure represents the top 20 pieces of equipment in terms of the invoiced revenue in the 2026 fiscal year:

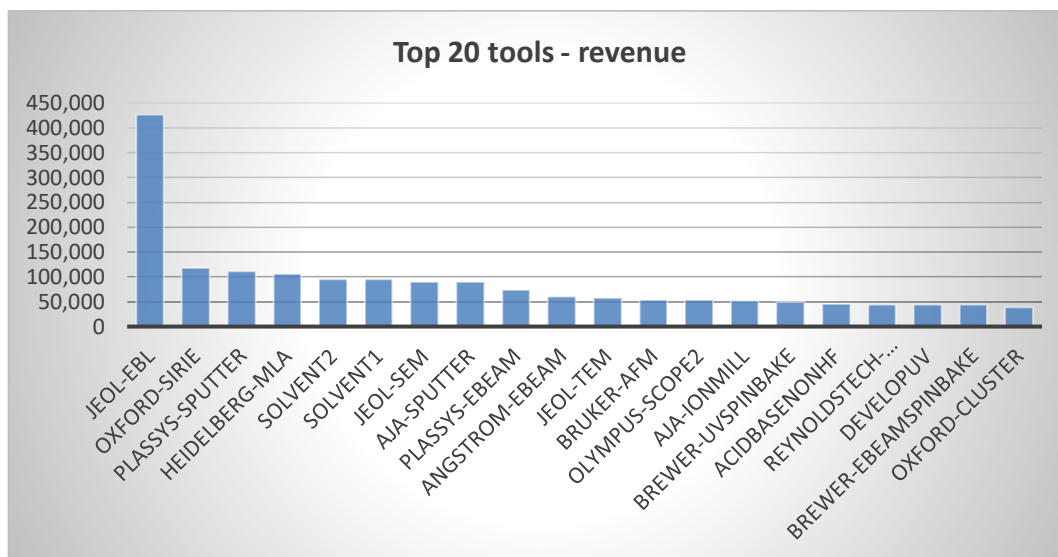
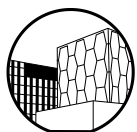


Figure 13: Bar graph of the 20 highest revenue generating tools within QNFCF for fiscal year 2026.

The pieces of equipment with the highest levels of invoiced revenue in the QNFCF are primarily located in the QNC cleanroom and are heavily biased towards the equipment with higher operating costs. The QNFCF maintains service agreements for seven pieces of equipment, and six of these pieces of equipment (Oxford, JEOL and Heidelberg tools) are included in this graph. The simpler tools on this list, including the solvent and development wetbenches, resist spinners, and optical microscopes may have lower equipment hardware maintenance costs, although their use factors heavily into the pre- and post-lithography processing of samples. The UV and electron beam lithography processes rely heavily on costly and proprietary chemicals, the cost of which must be borne by these relatively simple tools and their presence on this list is therefore appropriate.

Brief comments regarding the QNFCF equipment usage hours for the 2026 fiscal year:

As mentioned earlier, the 2026 fiscal year showed a 20% decrease in equipment use hours as compared to 2025. Much of this decrease can be attributed to the toolset in the RAC1 Clean Assembly lab which saw a reduction of approximately 9700 hours of activity. The RAC1 Clean Assembly lab hosts a variety of resources notably equipment and space for ion trap assembly activities. The significant reduction in equipment activity as well as the absence of ion trap



assembly tools (AssemblyStation1-R1, AssemblyStation2-R1, TESTEQUITY-TChamber-R1) from the list of the busiest 20 tools point to a significant reduction in this category of activities. Most other areas within the QNFCF saw stable to modestly increasing equipment use, including the QNC cleanroom which had a record equipment activity of 29,829 hours of equipment use in 2026 (up 4.7% from 2025).

5. TRAINING

To benefit our stakeholder community at the University of Waterloo, the Quantum Nano Fabrication and Characterization Facility has always had a strong focus on training our lab members to operate the fabrication and characterization equipment themselves. We pride ourselves on providing helpful standard operating procedure manuals (SOPs) for every piece of equipment and conducting one-on-one, hands-on training for almost every piece of equipment in the laboratories. We hope that this focus on training highly qualified personnel will contribute to the success of the University of Waterloo's researchers, as well as the Waterloo technology ecosystem. The following graph represents the equipment training hours that have been logged during the previous fiscal years.

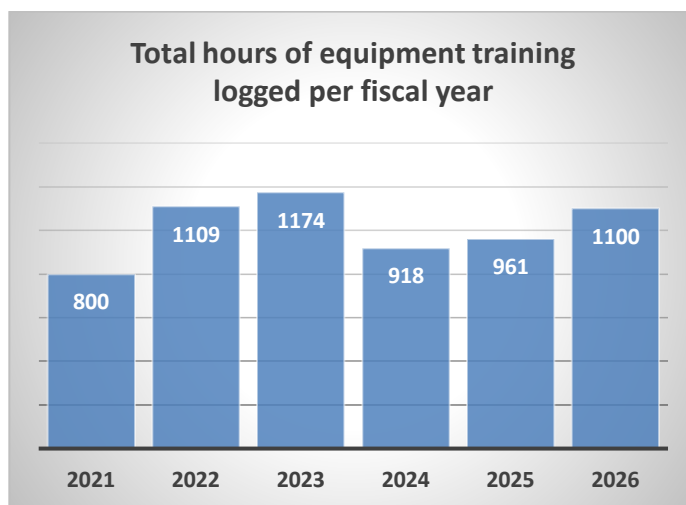
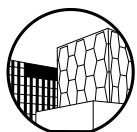


Figure 14: Bar graph of invoiced equipment training hours within QNFCF for fiscal year 2026.

The graph of the total equipment training hours shows that for the 2026 fiscal year, the equipment training hours were increased significantly from 2025 and are above the average from the previous 5 years which was 992 hours. This year's 14% increase in training hours is approximately aligned with the 11% increase in the number of lab users. We believe this consistent increase in both metrics supports the inference that new users are seeking access to a broad swath of QNFCF resources, whereas previous major increases in the QNFCF user base in 2025 were more focused on the newer S/TEM and associated capabilities.

Since the commissioning of the relatively complicated JEOL F200 S/TEM in October 2023, staff operator service hours have been an increasingly relevant statistic to track. Figure 15 is a bar



graph of staff operator service hours across the QNFCF toolset for the fiscal year 2026 and the 5 previous years. We can see from this figure that staff service time is slightly below the amount for 2025 and has effectively levelled off. It is possible that this levelling off represents a new steady state for the facility as our toolset and staff resources have not changed significantly this year.

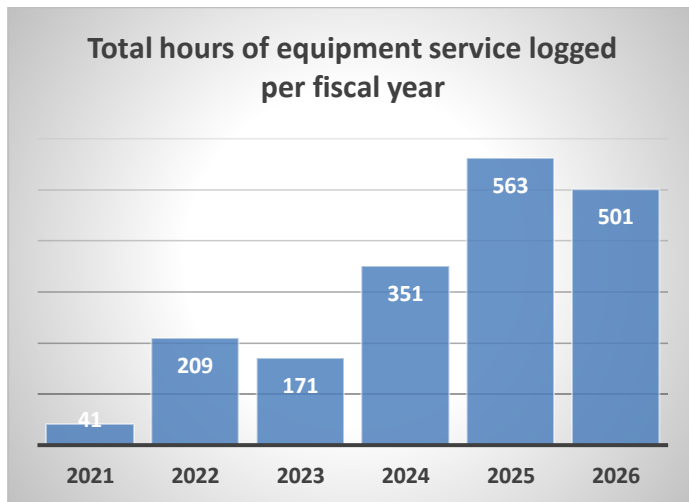


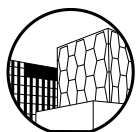
Figure 15: Bar graph of invoiced staff service hours within QNFCF for fiscal year 2026.

6. FINANCIAL SUMMARY

For more than 10 years, the Quantum-Nano Fabrication and Characterization Facility (QNFCF) has published a financial summary to report the laboratory expenses, user fee revenues and the financial support that has been received from various sources. An updated summary of the 2026 fiscal year is included below:

	2021	2022	2023	2024	2025	2026
Salaries	\$ 1,681,851	\$ 1,690,106	\$ 1,360,802	\$ 1,441,602	\$ 1,580,573	\$ 1,502,436
Supplies, Maintenance & Repairs	\$ 1,034,485	\$ 1,082,626	\$ 1,307,433	\$ 1,545,732	\$ 1,458,638	\$ 1,481,630
Total Expenses	\$ 2,716,336	\$ 2,772,732	\$ 2,668,235	\$ 2,987,334	\$ 3,039,211	\$ 2,984,066
User fees	\$ 877,024	\$ 1,320,204	\$ 1,522,381	\$ 2,060,129	\$ 2,238,727	\$ 2,441,382
Funds from CFREF-TQT	\$ 605,646	\$ 589,698	\$ 769,324	\$ 829,005	\$ 802,663	\$ 573,246
Funds from IQC	\$ 259,412	\$ 321,377	\$ -	\$ -	\$ -	\$ -
Funds from CFI-IOF	\$ 661,320	\$ 312,465	\$ -	\$ -	\$ 50,908	\$ 43,938
Project based funding	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 106,495
Matching Funds for ALE JELF Project #46384	\$ -	\$ -	\$ -	\$ -	\$ -	\$ (116,209)
Ongoing operating budget - Nitrogen	\$ 142,998	\$ 145,858	\$ 122,474	\$ 93,873	\$ 81,213	\$ 101,648
Ongoing operating budget - Salaries	\$ 181,271	\$ 183,814	\$ 235,037	\$ 292,655	\$ 236,131	\$ 300,233
Total Revenue	\$ 2,727,671	\$ 2,873,416	\$ 2,649,216	\$ 3,275,663	\$ 3,409,643	\$ 3,450,733
Net Cash Flow	\$ 11,335	\$ 100,684	\$ (19,020)	\$ 288,328	\$ 370,432	\$ 466,667
% of Contributions						
User fees	32%	46%	57%	63%	66%	71%
Funds from CFREF-TQT	22%	21%	29%	25%	24%	17%
Funds from IQC	10%	11%	0%	0%	0%	0%
Funds from CFI-IOF	24%	11%	0%	0%	1%	1%
Project based funding	0%	0%	0%	0%	0%	3%
Matching Funds for ALE JELF Project #46384	0%	0%	0%	0%	0%	(3%)
Ongoing operating budget - Nitrogen	5%	5%	5%	3%	2%	3%
Ongoing operating budget - Salaries	7%	6%	9%	9%	7%	9%

Figure 16: Annual financial summary of the QNFCF.



In the 2026 fiscal year, the overall expenses for the QNFCF are very similar to fiscal 2025 having declined by a modest 1.8%. The total expenses have been categorized by *Salaries*, which have decreased by 5.0%, and *Supplies, Maintenance & Repairs*, which have increased by 1.6%.

The reduction in *Salaries* expenses for 2026 is partially attributable to the resolution of one temporary contract in March 2025, and the resignation of the *Senior Facility Microscopist* in October 2025 which led that position to be vacant for much of this past year.

The increase of 1.6% in *Supplies, Maintenance & Repair* costs is modest considering the headwinds of an ageing toolset, inflationary pressures and tariff expenses being imposed by many suppliers who warehouse materials and equipment within the United States. The achievement of this low level of cost increase is reflective of ongoing successful efforts across the QNFCF team to contain costs within their individual equipment responsibility areas.

The *User Fees* that were collected by the QNFCF increased by 9.1% despite invoiced equipment hours being lower by approximately 20%. The increase in *User Fees* revenue has been driven primarily by continued modest growth of activity within the QNC Cleanroom lab (up 4.7%), and an increase in the proportion of this activity (up from 19% to 29%) that is registered by our *industrial* user community who pay differential and higher fees. Despite the robust increase in *User Fees* revenue total revenue only increased by 1.2% which is mainly attributable to a reduction in grant support for QNFCF salaries from the TQT program. It is expected that this grant support will be reduced further in the coming years as financial support from the Canada First Research Excellence Fund for the TQT program winds down.

The 2026 *User Fee* revenue represented approximately 71% of the *Total Contributions* for the facility, which is a new record for this performance metric. The *User Fees* as a percentage of the *Total Contributions* is well above the average of 53% from the previous 5 fiscal years. A comparison of the QNFCF's *User Fee* revenue to the *Total Expenses* demonstrates that the revenue has grown to offset 82% of the *Total Expenses* in the 2026 fiscal year. The gap between the QNFCF's *User Fee* revenue and the laboratory expenses has historically been bridged by robust support from several partners across the University of Waterloo, effectively subsidizing the costs of operations for the benefit of the community. Significant ongoing sources of support for the QNFCF have been received from the Canada First Research Excellence Fund – Transformative Quantum Technologies program, the Office of the Vice-President, Academic and Provost, the Office of the Vice-President, Research and International.

Finally, it should be noted that the financial support discussed in this section was limited to the support for the ongoing lab operations. As such, we have not included the financial contributions that have funded the acquisition of new tools and equipment, although the constant renewal of lab equipment is vital to ensuring that the QNFCF continues to be relevant and beneficial for the University of Waterloo community.

7. INFRASTRUCTURE RECAPITALIZATION NEEDS

As noted in the 2025 annual report, the QNFCF continues to rely heavily on equipment that was acquired in its first few years of operation. This initial toolset is approximately 15 years old and has reached a point where the vendor has declared these systems to be “end of life” with support to be provided on a “best effort” basis. Equipment at this stage in its lifecycle include:

- OXFORD-metalRIE – Cl chemistry ICP reactive ion etch tool
- OXFORD-SiRIE – F chemistry ICP reactive ion etch tool
- OXFORD-cluster – PECVD and plasma assisted ALD capability
- INTLVAC-Ebeam – Ion assisted E-beam deposition tool
- ZEISS-FIBSEM – Focused Ion Beam, Scanning Electron Microscope

These are still valuable and useful resources for the QNFCF community. These systems have no equivalent capability within the QNFCF or elsewhere on the University of Waterloo campus and their age and increasing unreliability presents a significant risk to the research productivity of our community. It is essential that the University of Waterloo regularly pursue large grant opportunities to replace ageing capital equipment within the QNFCF if we are to maintain the facility’s baseline of capabilities and maintain the financial sustainability of our user fee supported operational model.

This year we performed a depreciation analysis of the top 50 revenue generating tools in the QNFCF. This was an effort to quantify the ongoing capital needs for the maintenance of core facility capabilities. These top revenue generating tools were selected because revenue is a reasonable metric that highlights equipment that is both costly to maintain and highly used. The analysis involved estimating a current replacement cost for this equipment and assigning an estimated equipment lifetime, typically between 15 and 30 years. This analysis showed that on average the QNFCF requires approximately \$1.7M CAD (\$2025) in funds to adequately recapitalize equipment that reaches its projected end of life.

It is important to understand that the annual figure of \$1.7M CAD (\$2025) is only an average and that due to the timeline of the initial outfitting of the lab, QNFCF’s need for recapitalization is characteristically “lumpy”. If we express the need for recapitalization funds on a year-by-year basis we arrive at the following graph:

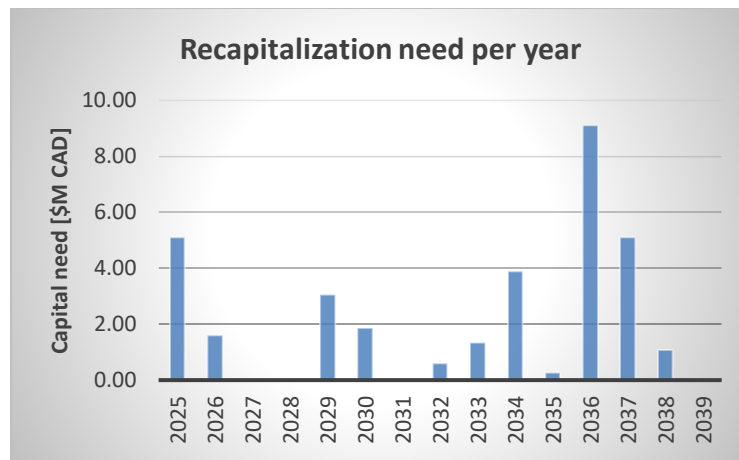


Figure 17: Estimated recapitalization needs for QNFCF's top 50 revenue generating tools.

Figure 17 shows that the QNFCF has significant initial capital needs in 2025-2030 to enable the replacement of many of the lab's first pieces of equipment (Oxford toolset, Zeiss FIB, etc.), which were obtained through a CFI grant awarded in 2008. There is another major cluster of replacement dates in the 2034-2037 timeframe representing equipment from a variety of funding sources including the initial CFI grant, IQC equipment support and the CFREF-TQT grant. The scale of these ongoing infrastructure requirements suggests we should pursue a strategy of targeting large-scale infrastructure grants like CFI Innovation Fund at regular intervals to stay ahead of equipment degradation. Indeed, peer organizations like the [University of Alberta nanoFAB](#) and [Université de Sherbrooke's 3IT](#) have successfully pursued this strategy in years past including the [2025 Innovation Fund](#) competition round.

In this discussion of equipment degradation and replacement it is important to remember that semiconductor and quantum device fabrication processes are essentially sequential. The loss of one or two key capabilities can cascade to prevent the fabrication of many types of devices. The potential failure of these tools presents a risk to the research productivity of many groups, as there are no local alternatives. Also, it is important to note that the majority of the QNFCF's user fee revenue is generated by industrial and external academic cohorts who often travel to Waterloo to make use of our facility. This demographic is likely to depart in the face of long-term equipment failures, and this represents a major financial risk to the operations of the QNFCF.

In summary, there is a significant ongoing need for equipment recapitalization within the QNFCF. The scale of this need is approximately \$1.7M CAD annually in 2025 dollars, though it is not evenly distributed. The scale of this ongoing need points towards the need to pursue large scale infrastructure grants such as the CFI Innovation Fund at regular intervals. Without regular and significant recapitalization, the University of Waterloo risks significant losses in research productivity from the QNFCF community and the QNFCF risks significant reductions in the user fee revenue that serves to sustain the operation.

8. CONCLUSIONS AND KEY TAKE AWAYS

The 2026 fiscal year was an eventful year for the Quantum-Nano Fabrication and Characterization Facility, with many community building events and continued improvements in majority of the metrics that are recorded by the lab. This year, the QNFCF set new records for the number of **active users and PIs**. The hours of invoiced equipment activity saw a significant reduction of 20%, but this reduction in activity was attributable almost entirely to a small handful of tools for ion trap assembly. A point form summary of the performance metrics is included below:

- Lab user population (active users per year) increased by 11% to 295, a **new all-time high**.
- PI population (the number of different research groups) increased by 7 to 109, a **new all-time high**.
- Logged equipment hours decreased from over 48,000 hours to approximately 39,000 hours. This decrease is isolated to a reduction in activity on equipment in the RAC1 Clean Assembly lab. Equipment use in other parts of the QNFCF was stable and this overall reduction in equipment hours had a negligible impact on overall user fee revenues.
- The cost of operations has decreased by 1.8% relative to the prior year, which is attributed to some reduction in staff salaries coupled with efforts to contain supplies, maintenance and repair costs for our ageing toolset.
- The user fee revenue for the QNFCF has increased by 9.1% to \$2.44M CAD, representing 71% of the total revenue. This is a **new all-time high**, in terms of the percentage of the total contributions.

Acknowledgements:

The Quantum-Nano Fabrication and Characterization Facility gratefully acknowledge contributions to our operations from the following partners:

- The Canada First Research Excellence Fund – Transformative Quantum Technologies program
- The University of Waterloo Office of the Vice-President, Academic and Provost
- The University of Waterloo Office of the Vice-President, Research and International
- The Institute for Quantum Computing
- The Canada Foundation for Innovation, projects 39548, 38914 and 42248