ESR

PRIME MINISTER'S SCIENCE PRIZE WINNER 2018

Science for Communities

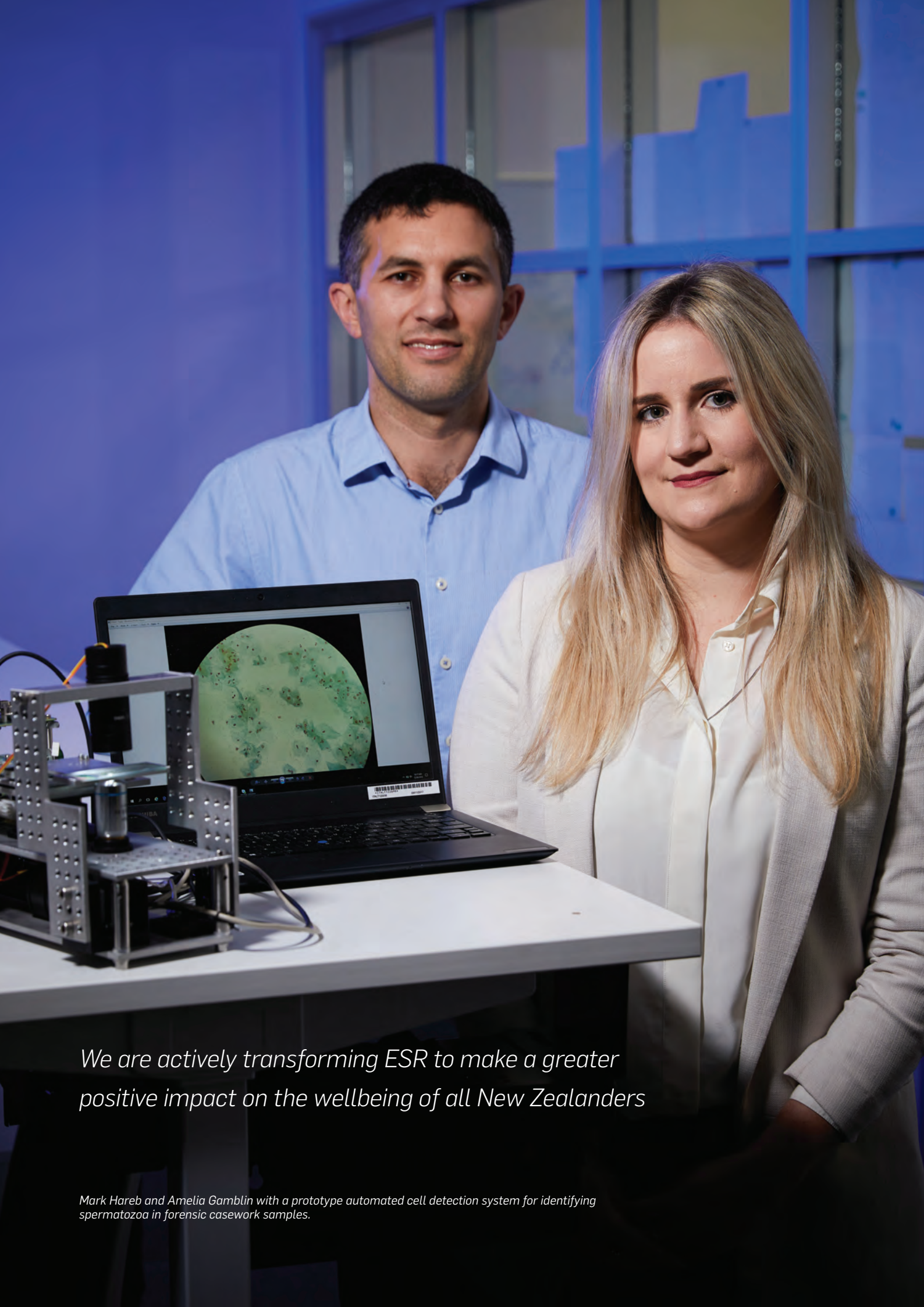
HEALTHIER COMMUNITIES

SAFER COMMUNITIES

SAFER FOOD

A CLEANER ENVIRONMENT

ANNUAL REPORT 2019



We are actively transforming ESR to make a greater positive impact on the wellbeing of all New Zealanders

Mark Hareb and Amelia Gamblin with a prototype automated cell detection system for identifying spermatozoa in forensic casework samples.

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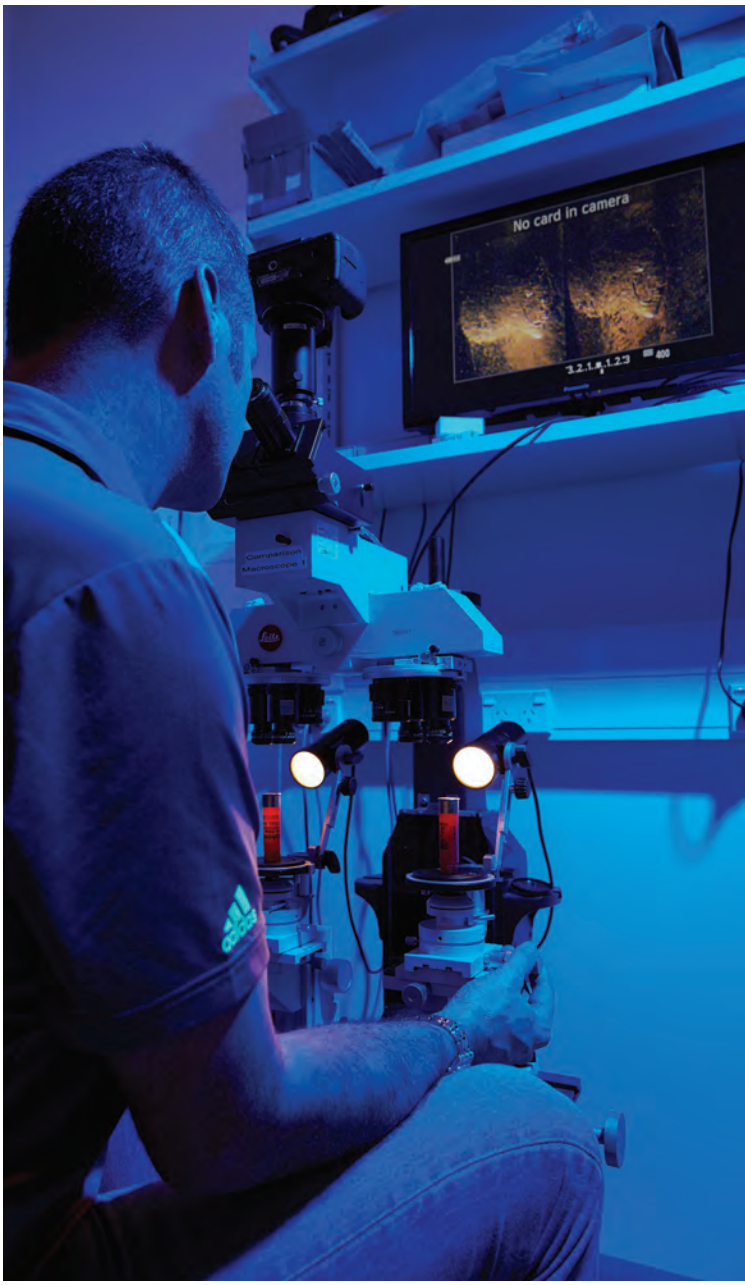


ESR (the Institute of Environmental Science and Research) is New Zealand's Crown Research Institute specialising in science relating to people and communities.

It's our science that helps to safeguard people's health, provides expert forensic analysis to the justice system, protects our food-based economy, and improves the health of our water and natural environment.

Chair and Chief Executive's review

This year we continued ESR's transformative journey.

We are proactively transforming ESR to ensure our science continues to deliver value for New Zealand and improves the wellbeing of New Zealanders.

Our *Great Plan for Science* is a comprehensive programme of work. This will ensure ESR confidently adapts to rapid advances in science and technology, and continues to support existing and future customers' changing needs. In the 2018/19 year we invested $2.2 million in strategic initiatives to position ESR for ongoing success – growing our data science capability and modernising our science facilities.

Our net profit after tax was lower than last year's at $1.9 million. This reflects our increased investment in strategic initiatives and the challenges we face in our operating environment. These challenges include improving the sustainability of contracts with government agencies and a relatively low level of strategic science investment funding, which constrains the strategic investments we can make.

ESR had many great results this year. An immensely proud moment for all of us was seeing ESR staff on stage at the Beehive being awarded the Prime Minister's Science Prize. This prestigious award recognised the outstanding innovation and dedication of the team that developed our world-leading DNA-based forensic software STRmix™. Initially developed to solve crimes in New Zealand, the software is now widely used by forensic laboratories around the world.

Our strong international connections enable us to tap in to global science expertise in everything from new psychoactive substances (NPSs) making their way across our border to the latest strains of harmful infectious diseases. We have a reputation for being highly successful at adapting new developments in science to the New Zealand context and then sharing our science solutions internationally – partnering to find impactful ways to connect our expertise with global communities.

Safer communities, healthier communities and a cleaner environment

What sets ESR apart is that all our science directly contributes to the wellbeing of all New Zealanders. Our deep scientific expertise contributes to safer communities, healthier communities and a cleaner environment.

Our world-leading scientists were at the forefront of some of the most difficult issues New Zealanders faced in the past year.

On 15 March this year, ESR expert forensic scientists rapidly mobilised to assist New Zealand Police in the immediate aftermath of the Christchurch terror attacks. An analysis of the forensic evidence collected will be vital for informing investigations and court proceedings.

ESR staff generated valuable information for government agencies on illicit drugs causing serious harm in our New Zealand communities. For the first time in New Zealand's history, ESR has developed an accurate picture of the actual quantity of drugs consumed in each region across the country. Using a novel yet practical approach we tested drug concentrations present in wastewater. This data informs the targeted actions taken by Police and other agencies to address the drugs causing most harm in New Zealand communities.

ESR's forensic casework plays an important role in New Zealand's criminal justice system. This year we analysed more than 50,000 pieces of forensic evidence, assisting Police to solve criminal cases and presenting expert evidence in court.

Our work in protecting public health may be less well known, but is vital for keeping New Zealanders healthy. This year our nationwide disease surveillance system identified nine

separate measles outbreaks and a virulent outbreak of Group W meningococcal disease (Men W). ESR scientists provided the Ministry of Health with New Zealand-wide information on the epidemiology of the disease, and advice on how best to limit the spread of these harmful diseases.

The disease surveillance data collected by ESR provides a wealth of information on the health of all New Zealand communities. This year we developed an online dashboard to bring the data to life and show how each notifiable disease is trending. The dashboard makes the data readily available to the Ministry of Health, district health boards and health researchers.

To improve the quality of our rivers, streams and groundwater, our environmental scientists trialled an innovative woodchip-based 'bioreactor'. This strips out nitrates from farm run-off to prevent them entering our waterways. ESR scientists also joined forces with Waikato iwi and community volunteers to plant 40,000 native plants, restoring and cleaning up Lake Waikare. The purpose of this field trial is to discover how mānuka's antimicrobial properties could be used to reduce pathogens and nitrate loads in water.

Our *Great Plan for Science*: transforming ESR for further success

To meet current and future challenges and to identify and harness the many opportunities we know exist, we are working quickly to transform our business. Our current model is under significant pressure. To counter this we are transforming what we do and how we do it – to deliver our vision of healthier and safer New Zealand communities and a cleaner environment for everyone. Our *Great Plan for Science*, which was launched at our all-staff conference, provides a strategic focus to transform ESR. Lightning talks presented by our people demonstrated many areas where we are already making progress. We are actively planning and progressing our future, and we are already well on the way!

The *Great Plan for Science* has three key pillars for transformation. ESR is developing new capabilities and adapting existing capabilities to transform our science. We are generating more revenue and becoming more competitive to grow our business. Underpinning our ambitious change agenda are our talented people.

Together, we are driving a new culture, improving our ability to lead and manage and embrace and enable new ways of working.

Making it happen together

People are the heart of any successful transformation programme, and culture is key. We've already embedded change champions across the business to help encourage, model and implement our cultural change approach. Good progress is being made, with more to come.

Our people have been given a Licence to Act, empowering them to step up and identify business innovation in their areas and implement changes with confidence and commitment.

ESR's Kenepuru Drive facility in Wellington.

One of the areas where our people have already taken this initiative in taking action to strengthen our sustainability practices.

Both technology and our working environment are key enablers for cultural change. This year we trialled new data solutions that will help support better file sharing, enhanced communications, and better sharing of our research data. There is more to come, with technology helping us to find ways to collaborate and learn.

Many of our facilities are ageing and no longer fit for purpose. We are designing modern, technologically advanced and collaborative spaces that can be configured for the science of the future. This year we made progress on addressing the difficulties we face with ageing facilities. This included better understanding our future footprint at Kenepuru, and developing a workplace strategy that sets out the modern work environment we need to provide at all our sites.

Transforming our science

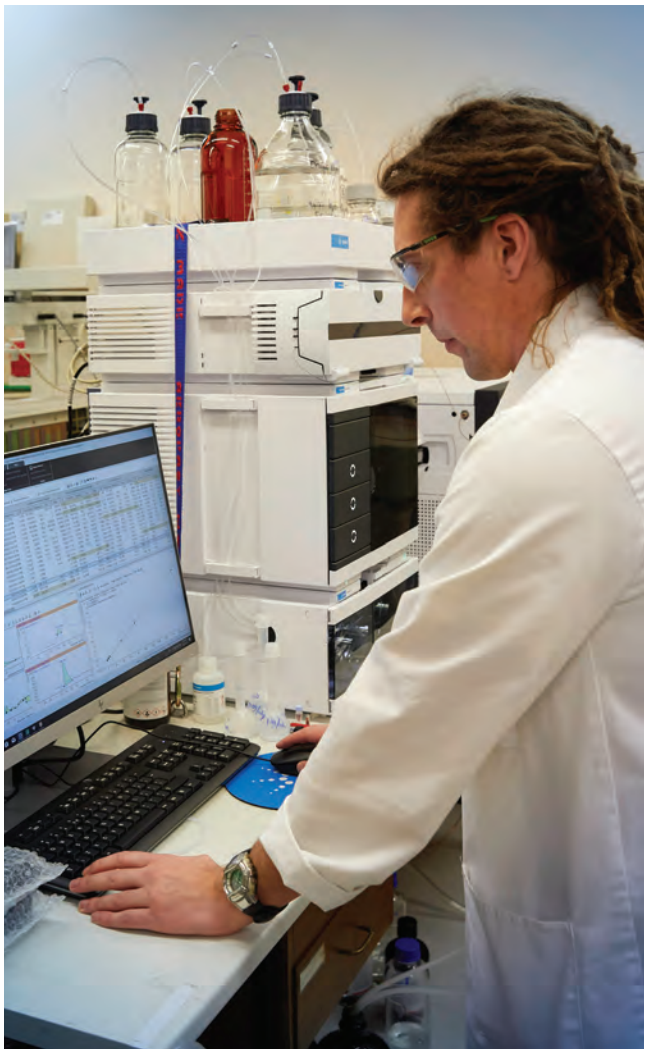
Our agility and ability to adapt constantly to our changing and challenging environment will help us understand and meet the needs of our clients and New Zealand. A comprehensive review of the science capabilities we need for the future is underway. We are making progress, growing our expertise in data science and our Māori engagement capability.

Developing our data science capability was the largest investment we made this year. Data science has quickly become essential for providing our clients with deeper insights to inform their decision-making. We have trained more than 25% of our people in data science and have put in place increased processing power, storage and data visualisation tools.

Weaving together Māori knowledge and western science is an important way we can make a greater difference to mātauranga Māori, wellbeing and the environment. We are building our internal capability and increasingly partnering with Māori, leveraging science to further advance social, cultural and economic development. Our increased commitment to working with Māori is visible in 11 Vision Mātauranga projects.

These projects are wide ranging, from working to clean up our waterways to ensuring gathered kai is safe to eat.

At ESR we strongly believe that our science isn't finished until it is communicated and shared. This year we shared many insightful stories with the public, demonstrating the impact of our science. Our stand at the Mystery Creek Fieldays shared what we do with the farming and rural sectors, alongside other Crown Research Institutes (CRIs). ESR, together with Scion, AgResearch and Manaaki Whenua, won the Fieldays 2019 Supreme Site Award from more than 1,000 exhibitors.



Monitoring illicit substances in wastewater.

Growing ESR

We are investing in our science to ensure that ESR remains at the forefront of complex issues facing New Zealand communities.

We generated international revenue of $12.4 million from our commercial products this year. We will continue to increase our investment in innovative research through our Pioneer Fund, to grow our pipeline of new products and services.

Increasing the amount of research we do is another area for growth. This year we began researching the impacts of microplastics and the threat to New Zealand's ecosystems, flora, fauna and people. This multi-year, $12.5 million Endeavour Fund project is the largest single research grant received in ESR's history. Globally microplastics are a significant issue and New Zealanders need to understand how these affect their daily lives.

To be competitive when bidding for science services and research, we will reduce our overheads and improve our efficiency. We are becoming a more commercially focused organisation, freeing up as much of our funding as possible, to invest in science.

Good progress is being made towards actively transforming ESR through our *Great Plan for Science*. The plan addresses the challenges we are facing to create a bright future for ESR and its contribution to the wellbeing of all people of Aotearoa.

Denise Church QSO, CFInstD
Chair

Keith McLea
Chief Executive

The Prime Minister's Science Prize

Winning the Prime Minister's Science Prize for our innovative forensic software STRmix™ was a highlight for ESR and its people this year.

ESR's expertise in forensic DNA analysis led to the development of STRmix™, world-leading software that has revolutionised the interpretation of complex criminal evidence and won us the country's top science prize in April 2018.

STRmix™ separates up to six individuals' DNA, which may be present in samples of complex DNA mixtures found at crime scenes.

Originally developed for New Zealand Police, the software was part of ESR's drive to increase the effectiveness of its forensic science services, to help prevent and solve crime. It was subsequently commercialised and is now used by more than 60 forensic labs in a number of countries around the world.

This award shows that ESR is already at the cutting edge of DNA research, and STRmix™ reinforces that New Zealand is a leader in the world in forensic science.

Rt Hon Jacinda Ardern, Prime Minister presents the top science prize to leaders of the STRmix™ team Jo-Anne Bright, left and Björn Sutherland.

The STRmx™ team from left: Hannah Kelly (holding baby Freddie), Catherine McGovern, Duncan Taylor, Forensic Science South Australia, (co-developer) Maarten Kruijver, Kevin Cheng, Jo Bright, Rena Lawless, Hon Dr Megan Woods, Minister of Research, Science and Innovation, Rt Hon Jacinda Ardern, Prime Minister, Bjorn Sutherland, Meng Lin, Laura Russell, Judi Morawitz and Stuart Cooper. Front kneeling: Richard Wivell, Xinlong Zhang and Zane Kerr. Absent: John Buckleton Principal Developer and Adam McCarthy European representative.

Our purpose

ESR is a CRI entrusted with using the power of science to tackle critical challenges facing New Zealand in the areas of public health, crime, food safety and water quality.

Our point of difference is that our science services and research are focused on keeping communities safe and healthy, which is essential for the wellbeing of all New Zealanders.

ESR's high-calibre teams provide independent, authoritative and trusted science solutions. We are particularly recognised for our advanced science capabilities in microbiology and DNA and our ability to solve complex problems.

We maintain nationally critical science capabilities that are used when responding to matters of national significance such as food contamination threats and major disease outbreaks. ESR's science capabilities include health science, forensic science, food and water science, radiation science, social systems and workplace drug testing. Our deep expertise in these important fields is what sets us apart.

Statement of Core Purpose

ESR's Statement of Core Purpose sets out our mandate from shareholding Ministers:

To deliver enhanced scientific and research services to the public health, food safety, security and justice systems, and the environmental sector to improve the safety of, and contribute to the economic, environmental and social well-being of people and communities in New Zealand.

ESR provides research and scientific services and knowledge transfer in partnership with key stakeholders including government, industry and Māori to:

- Safeguard the health of New Zealanders through improvements in the management of biosecurity and threats to public health
- Increase the effectiveness of forensic science services applied to safety, security and justice investigations and processes
- Enhance protection of New Zealand's food-based economy through the management of food safety risks associated with traded goods
- Improve the safety of freshwater and groundwater resources for human use and the safer use of biowastes.

How our outcomes contribute to wellbeing

	ESR'S OUTCOMES	THE TREASURY'S LIVING STANDARDS FRAMEWORK
	Safeguard the health of New Zealanders through improvements in the management of biosecurity and threats to public health.	**Natural capital** This refers to all aspects of the natural environment needed to support life and human activity. It includes land, soil, water, plants and animals, as well as minerals and energy resources.
	Increase the effectiveness of forensic science services applied to safety, security and justice investigations and processes.	**Human capital** This encompasses people's skills, knowledge and physical and mental health. These are the things that enable people to participate fully in work, study and recreation and in society more broadly.
	Enhance protection of New Zealand's food-based economy through the management of food safety risks associated with traded goods.	**Social capital** This describes the norms and values that underpin society. It includes things like trust, the rule of law, cultural identity, and the connections between people and communities.
	Improve the safety of freshwater and groundwater resources for human use and the safer use of biowastes.	**Financial/physical capital** This includes things like houses, roads, buildings, hospitals, factories, equipment and vehicles. They are the things that make up the country's physical and financial assets, which have a direct role in supporting incomes and material living conditions.

Our teams contribute to reducing the burden of infectious diseases and other health threats

Healthier communities

We safeguard the health of New Zealanders through improvements in the management of biosecurity and threats to public health.

ESR's team of expert scientists provides insight and advice to help prevent and reduce the harm and cost of public health threats. Our laboratory expertise and extensive health surveillance and intelligence networks allow us to rapidly identify and alert health authorities to public health threats and assess the effectiveness of interventions, thus protecting the health and wellbeing of all New Zealanders.

Our scientists provide domestic and international disease surveillance, research, laboratory services and expert advice on a wide range of health threats including measles, influenza, antimicrobial resistance, gastroenteritis and vaccine-preventable diseases.

We identify and recommend interventions across the New Zealand health sector including to the Ministry of Health, public health units, district health boards and primary care providers to support national, local and regional public health policies.

Our teams contribute to reducing the burden of infectious diseases and other health threats, improving New Zealand's readiness and response to public health threats, improving human biosecurity, mitigating risks to human health from radiation, improving the safety of medicines, and improving the understanding of complex and challenging public and environmental health issues.

ESR analyses and reports on data from monitoring New Zealand drinking-water suppliers' regulatory compliance, in the form of an annual water quality report for the Ministry of Health.

ESR's Pharmaceutical Programme contributes to the ongoing safety of medicines and other therapeutic products on the New Zealand market through the provision of testing services benchmarked against international quality and safety standards.

Working primarily with the Ministry of Health, the Pharmaceutical Programme undertakes routine testing of medicines, as well as complaint investigations such as those based on manufacturing failures and quality concerns.

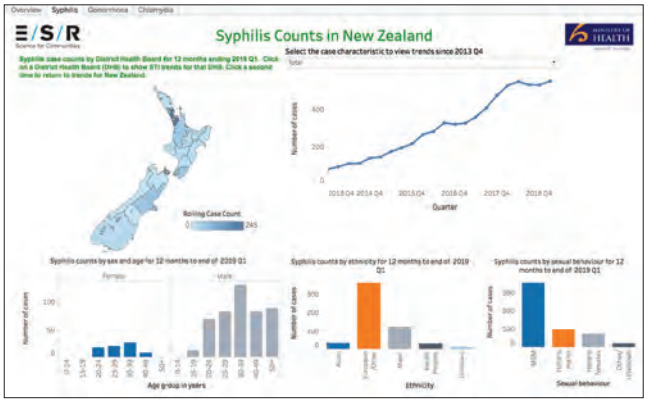
In addition, in the past year ESR has contributed to approximately 60 investigations by the Ministry of Health into counterfeit medicines and other products suspected of being adulterated with undeclared medicines.

New disease surveillance dashboard

Our scientists collect and analyse a wide range of data on diseases present in New Zealand. The data sources we collect provide a powerful and detailed picture of the prevalence of communicable diseases across New Zealand and in our communities. This work improves public health by reducing the harm and costs of infectious disease.

The dashboard shows trends in all notifiable diseases across New Zealand, and the prevalence of cases by gender, ethnicity, age and location. The information shown in the disease dashboard provides a timely and comprehensive understanding of diseases in New Zealand and helps the Ministry of Health, district health boards, public health units and the wider sector to plan services and respond to emerging issues.

The dashboard also gives health researchers valuable data that can easily be analysed, providing the potential to improve health research outcomes. It draws on our reference laboratory information, the Notifiable Diseases Database and information collected from laboratories.



A separate dashboard has been developed to show trends in sexually transmitted infections in New Zealand. The surveillance data shows a significant increase in the number of syphilis cases in New Zealand. Users can view the data at national and regional levels by age, sex and sexual behaviour. The Ministry of Health will use the information presented in the dashboard to monitor the effectiveness of the newly released national syphilis action plan.

The team at ESR has also been developing visualisation tools to support measles elimination and outbreak investigation work, by allowing for tracking and tracing of measles cases in New Zealand. This visualisation is helping the Ministry and the health sector to investigate ongoing measles outbreaks in New Zealand. It also helps to inform international reporting to confirm that endemic measles remains eliminated in New Zealand.

Providing scientific services that keep our communities healthy

This year ESR and the Ministry of Health committed to a new agreement for the provision of scientific services. In developing the agreement, consideration was given to align these services with the four outcomes that ESR strives to achieve – healthier communities, safer communities, safer food and a cleaner environment.

The agreement with the Ministry supports a large proportion of our work on healthy communities to safeguard the health of New Zealanders through improvements in the management of human biosecurity and threats to public health.

The early detection of public health threats and the implementation of effective interventions are critical to ensure that these threats are managed appropriately. Our work provides early detection and supports the implementation of interventions, therefore reducing the harm and cost of public health threats. ESR's laboratory expertise and extensive health surveillance and intelligence networks allow us to rapidly identify and alert health authorities to public health threats and assess the effectiveness of those interventions.

Using a diverse range of data and information sources, including our reference laboratory, our National Notifiable Diseases Surveillance System, laboratory notifications and outputs from our early warning systems, our scientists and clinicians are able to provide intelligence on significant public health threats such as influenza, antimicrobial resistance, gastroenteritis and vaccine-preventable diseases.

ESR focuses on improving the wellbeing of all New Zealanders by:

- Reducing the burden of infectious diseases and other health threats
- Improving our readiness and response to public health threats
- Improving human biosecurity
- Mitigating risks to human health from radiation
- Improving the safety of medicines
- Improving the understanding of complex and challenging public and environmental health issues.

Our experts provide advice, support and recommendations across the New Zealand health sector including to the Ministry of Health, public health units, district health boards and primary care and international health agencies. Primarily our work is to support national, local and regional public health policies and interventions.

Reducing the spread of meningitis

This year our communities were affected by the highly virulent strain of meningococcal bacteria, Men W.

Seven cases were confirmed in Northland communities in 2018, resulting in the deaths of three children. The high number of cases in Northland signalled a potential community outbreak and alerted health authorities to initiate a public health response. This included the local provision of a vaccine to control the spread of the disease. The actions taken depended on ESR's timely surveillance, characterisation of the Men W strain and provision of intelligence.

ESR monitors all cases of invasive meningococcal disease and has seen the number of Men W cases rise significantly in the past two years. At a health select committee hearing in June 2019 on the outbreak response, Dr Lisa Oakley and Dr Phil Carter spoke on ESR's role in identifying the community outbreak, and described ESR's high-quality and timely work before and during the outbreak. The Chair of the committee complimented ESR on its work.

Monitoring nine measles outbreaks in one year

Measles is a serious and highly infectious disease, requiring close surveillance by ESR on behalf of the health sector (or for health providers). During the first half of 2019, based on data from district health boards across New Zealand, ESR identified nine separate measles outbreaks.

ESR publishes a weekly measles report for New Zealand, which includes epidemiological data on the location, ethnicity,

age group and vaccination status of newly identified measles cases. Our surveillance data showed that in the first half of 2019, 263 cases were reported by 12 different district health boards.

We used the latest genotyping techniques to identify the separate measles outbreaks and trace the spread of infection across communities. Each of these was traced back to a person who had contracted the virus overseas.

In New Zealand, the measles virus spread rapidly to others in the community. Unfortunately our vaccination rates in New Zealand are simply not high enough to stop the spread of this preventable disease.

Genotyping of measles viruses is used to identify separate outbreaks and trace the spread of infection across communities. Public health officials then take action to isolate and quarantine confirmed cases and their susceptible contacts as soon as they are identified.

Our analysis of the ongoing measles outbreaks in New Zealand underscores the critical need for higher vaccination rates across the New Zealand population.

How well prepared is New Zealand for health threats and hazards?

In 2018 New Zealand completed its first World Health Organization Joint External Evaluation (JEE). The evaluation provides an independent external assessment of a country's capability to deliver the core capacities around detecting, planning for, responding to and communicating on health threats and other hazards.

Given our role in the surveillance, detection and investigation of health threats, ESR played a significant role in supporting the JEE in the lead-up to and throughout the evaluation. We provided technical input to several areas, presenting to the external evaluators on surveillance systems, biocontainment, radiation safety and national laboratory systems.

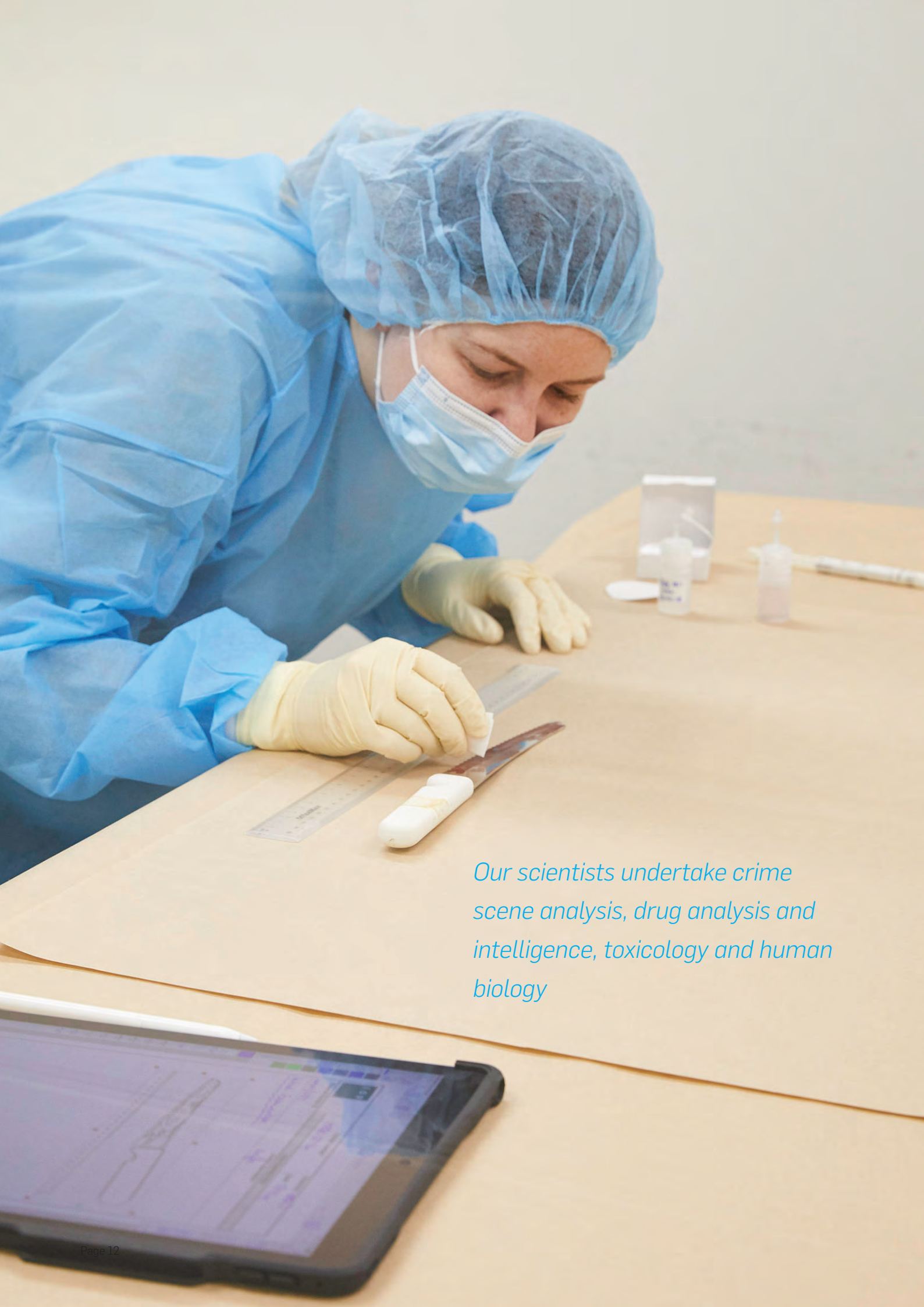
A contamination monitor is used to make sure surfaces, samples and people aren't contaminated when we work with unsealed radioactive sources.

As part of its assessment, the evaluation team visited ESR's National Centre for Biosecurity and Infectious Disease to understand our preparedness to respond to health threats and other hazards.

Although the final evaluation report has not yet been published, the external evaluators agreed with New Zealand's self-assessment that we are prepared for and able to prevent, detect and respond to health threats.

Ensuring radiation equipment is safe at site for its operators and patients in New Zealand

ESR operates a radiation instrument calibration facility that meets international primary radiation standards. These calibrations cover a wide range of instruments, from the radiation survey meters used in industry to check for radiation leakage from baggage X-ray equipment to the large, fixed radiation source gauges on production lines. They include the contamination meters used for checking that work areas haven't become contaminated following the use of radioactive materials through to the electronic personal dosimeters worn by radiation workers to give them immediate warnings if they encounter a high-radiation areas. We also calibrate and monitor the complex kV/dose instrument kits used by medical physicists and X-ray servicemen to ensure that hospital X-ray machines are performing optimally when delivering radiation doses to patients.



Our scientists undertake crime scene analysis, drug analysis and intelligence, toxicology and human biology

Safer communities

We increase the effectiveness of forensic science services applied to safety, security and justice investigations and processes.

ESR has a vital role in providing trusted, independent forensic evidence to inform criminal investigations and court proceedings.

We provide world-class forensic science services and research to our strategic partner New Zealand Police, and other government agencies.

Our expert scientists undertake crime scene analysis, drug analysis and intelligence, toxicology, and human biology in forensic laboratories accredited to the highest international standards.

Our crime scene investigators work with Police and international law enforcement on physical evidence analysis, blood pattern analysis, clandestine laboratories and DNA profiling. We work closely with the New Zealand Customs Service on illicit substance screening and detection.

Our research and development team continually seeks out new ways to use the latest technology to solve crime. We are currently experimenting with machine learning and portable sensors to develop practical solutions that analyse drugs rapidly.

2018/19 forensic statistics

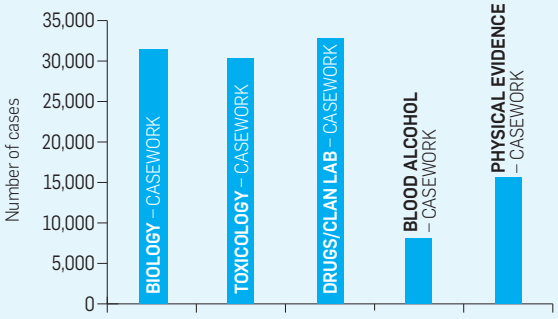
10,904
total cases

50,776
total exhibits

202,140
total DNA profiles held in database

118,337
total samples analysed

71%
crime-to-person link rate against DNA database



67
homicide cases

3,316
blood alcohol cases under the LTA

508
sexual assault cases

1,993
coronial cases

Providing real-time intelligence on the consumption of drugs in our communities

Until recently there has been no clear picture of the actual volume of each illicit drug being consumed in our communities.

Knowing where and when illicit drugs are most commonly used provides Police, the Ministry of Health and other agencies with a better understanding of drug-use patterns in the population, enabling them to develop more effective interventions.

This year Police commissioned a nationwide pilot of 30+ sites, which provided 75% population coverage. This was implemented after pilots in Auckland, Whāngārei and Christchurch in the previous two years. It allows authorities to map drug-use patterns and provides better data than that achieved through self-reporting or drug arrests. Police and the New Zealand Customs Service are able to ascertain the impacts of their interventions.

Wastewater analysis is an emerging science and provides a valuable snapshot of drug flow through cities. Its use in a pilot in 2018/19 was the first time for a government agency in New Zealand.

Seven months of sampling – seven consecutive days per month – produced interesting results in each seven-day period, meaning patterns could be identified both daily and in the longer term.

Chemist Andrew Chappell and the ESR team analysed the wastewater in both cities to determine the amount, type and distribution of illicit drug use. Using a robust sampling protocol and a modified and validated extraction method, Andrew tested for methamphetamine, heroin, cocaine, alpha PVP (bath salts) and ecstasy (MDMA).

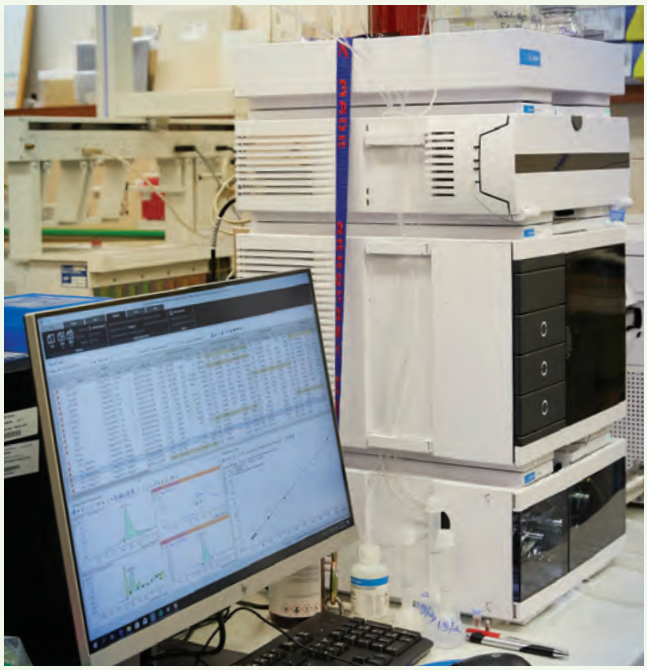
Analysing drugs in wastewater is particularly useful for looking at trends over time. “You can look for correlations between other interventions, education programmes and so on, to establish whether these interventions have been useful,” Andrew says.

“Instead of taking months or years to test thousands of samples of urine and analyse them in any one study, analysing wastewater can provide results about a population in near real time, enabling interventions that could save lives.”

The pilot identified valuable information for Police and other agencies. Methamphetamine use was relatively constant day to day, suggesting habitual use. MDMA showed very distinct usage spikes at the weekends, suggesting recreational use. These patterns were reasonably consistent each month.

Wastewater-based epidemiology is a rapidly emerging scientific field. The approach can be used to access a wide variety of community health data. It can be used to identify the presence of food contaminants, infectious diseases and pesticides. “We can look at human health biomarkers

Andrew Chappell and the team are working to determine drug consumption in New Zealand communities.



like heart disease, for instance, and while it’s a relatively new field, these are things that are starting to be looked at overseas,” says Andrew.

The tragic impacts of synthetic cannabinoids

New psychoactive substances are making their way onto our shores. These dangerous drugs are not only causing significant harm, but leading to an increasing number of fatalities.

ESR's work in this field helps to identify and detect how to treat people who have severe reactions to drugs. We work closely with Police, the New Zealand Customs Service, the Ministry of Health and medical experts to help mitigate and reduce the harm of these substances.

A two-year ESR research project identified new psychoactive substances crossing our border, tracking their real-time use in our population and identifying which substances are causing harm in New Zealand communities.

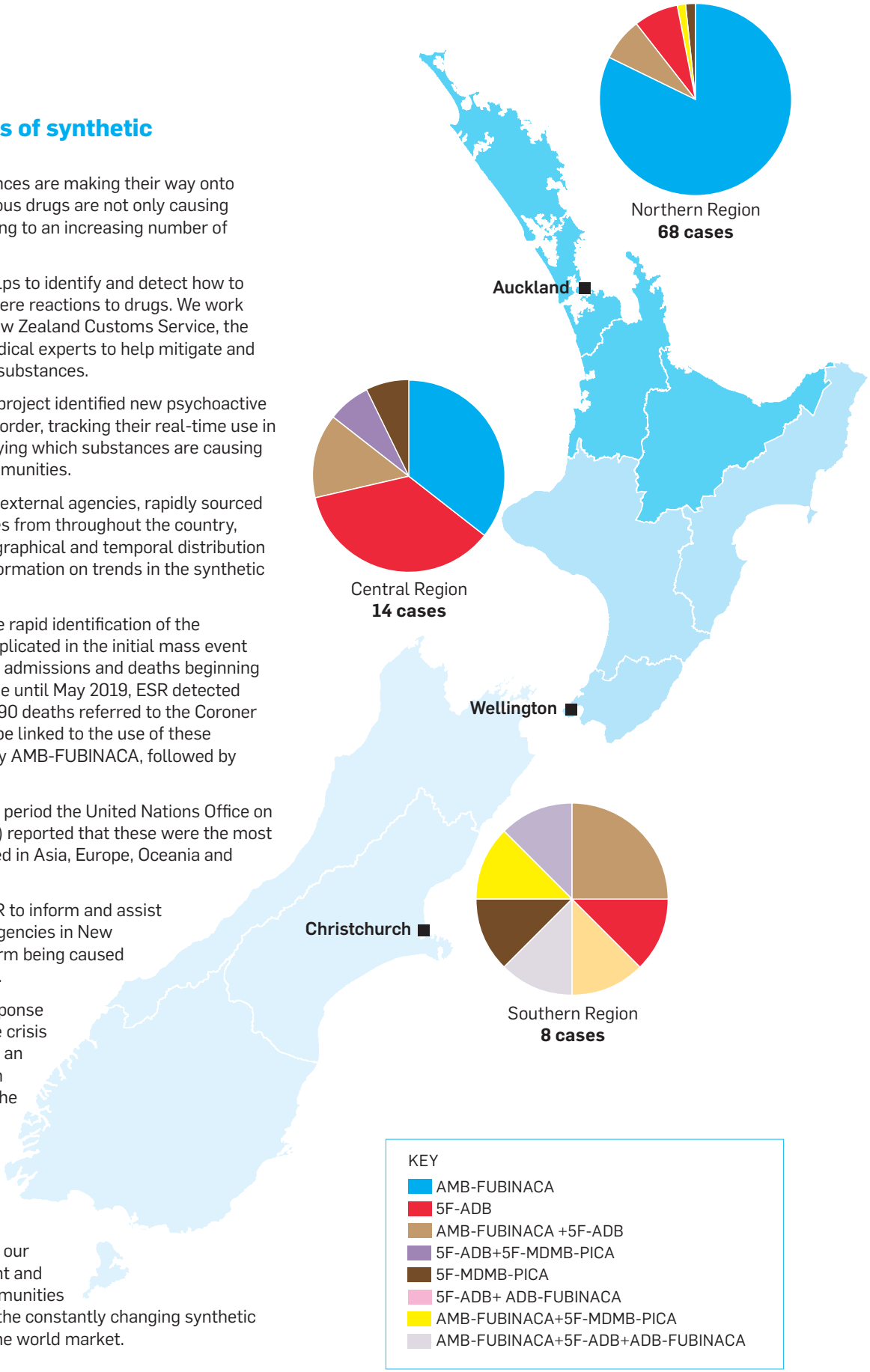
ESR, in collaboration with external agencies, rapidly sourced and analysed drug samples from throughout the country, identifying distinctive geographical and temporal distribution patterns and providing information on trends in the synthetic drugs market.

This project resulted in the rapid identification of the synthetic cannabinoids implicated in the initial mass event of emergency department admissions and deaths beginning in May 2017. From this time until May 2019, ESR detected synthetic cannabinoids in 90 deaths referred to the Coroner in New Zealand that may be linked to the use of these substances, predominantly AMB-FUBINACA, followed by 5F-ADB.

During the same two-year period the United Nations Office on Drugs and Crime (UNODC) reported that these were the most common substances seized in Asia, Europe, Oceania and the Americas.

This data was used by ESR to inform and assist enforcement and health agencies in New Zealand in tackling the harm being caused by these dangerous drugs.

ESR is part of a global response to the synthetic substance crisis and a major contributor to an international collaboration with UNODC to prioritise the most harmful, persistent and prevalent new psychoactive substances for international action. Timely data-sharing within New Zealand and internationally is assisting our partners to predict, prevent and protect New Zealand communities from the harm caused by the constantly changing synthetic substances available on the world market.



Enabling frontline police to identify illicit drugs rapidly

New Zealand Police currently seizes approximately 10,000 suspected drug samples per year. Testing drug samples in a laboratory takes time, and testing all of the samples seized would not be cost effective.

ESR is developing a real-time drug-detection service, enabling frontline police to analyse samples in the field.

The real-time identification of illicit drugs will reduce the amount of Police time spent processing enquiries, improve health and safety, streamline the judicial process, and enable the earlier treatment and rehabilitation of drug users.

ESR is evaluating a handheld near-infrared (NIR) device combined with the power of machine learning to deliver a world-leading service in New Zealand. Suspected drug samples can be screened in the field to identify drugs within seconds. The service we are developing will be able to scan through glass and clear packaging, maintaining the integrity of a sample while also protecting the health and safety of the officer conducting the test.

ESR's extensive drug chemistry expertise is being used to develop comprehensive machine learning models that can accurately determine the presence of illicit drugs, even when diluted or in mixed samples.

For the New Zealand market, the project is being developed in collaboration with New Zealand Police as part of the Evidence-Based Policing Centre. This collaboration identifies opportunities where new developments can support evidence-informed decision-making. A field pilot is planned for later in 2019 and we expect to be able to offer the service to Police within 12 months.

Rapid access to drug detection results will enable Police to reduce the harm caused by drug use, directing users towards health and other services where appropriate.

'Bleeding hearts' MDMA.

Using machine learning to streamline forensic analysis

ESR is developing exciting opportunities to utilise artificial intelligence (AI) in our forensic laboratories. We are exploring the potential for machine learning, a type of AI, to automate part of the workflow used when analysing suspected methamphetamine samples in the laboratory.

Methamphetamine samples are analysed for Police every month at ESR. Most samples are analysed and reported based on the results of infrared analysis, but although this analysis can be completed relatively quickly, a scientist is required to visually compare the results to a traceable standard.

In approximately 25% of samples per month, the presence of methamphetamine cannot be confirmed by infrared analysis due to the presence of other substances such as cutting agents. Further work, including derivatisation and GCMS (gas chromatography–mass spectrometry) analysis, is then required to confirm the presence of methamphetamine in the samples.

ESR partnered with the University of Waikato to develop a prototype application that uses machine learning to interpret and identify methamphetamine. The process is rapid, with results being returned in less than a second.

This process has an accuracy of 99.8% as measured against the currently processed test data. An additional feature of machine learning being explored is the ability to predict the purity of methamphetamine in a sample.

The application was trialled on casework samples and was able to identify methamphetamine rapidly even in the presence of a cutting agent. Streamlining routine cases has the potential to allow our scientists to spend more time analysing and interpreting complex samples.

ESR is now developing a methodology to apply this technology in developing a low-cost service, providing rapid screening of suspected drug samples in the field.

ESR is developing a real-time drug-detection service, enabling frontline police to analyse samples in the field

Using RNA to identify body fluids

Accurately identifying particular types of body fluid present in forensic samples can provide critical information to inform criminal investigations and subsequent court proceedings.

Using RNA (ribonucleic acid), ESR has developed a range of body fluid identification tests to be used in casework to identify the source of a body fluid.

RNA was considered less stable than DNA as it degrades rapidly on cell death, limiting its use for diagnostic purposes. However, ESR scientists discovered that some parts of RNA actually do remain stable in organisms, tissues and fluids over time. Using these stable regions of RNA, new ground-breaking genomics tools have been developed by ESR scientists. These enable the identification of body fluids, tissues and cells using RNA for a much broader range of samples, specifically those that are older or compromised by environmental effects, where it would not have been possible to obtain results in the past.

RNA analysis can be a critical contributor to forensic investigations by identifying the type of body fluid present. When used in combination with DNA analysis, our scientists are now able to say not only whose DNA is present in a sample, but also where the sample came from, supporting decision-making about the type of activity that allegedly occurred. These genomics tools can be used on current and new equipment, including portable devices and sequencing equipment, allowing for a broader use-case.

The genomic tools we've developed provide ESR with intellectual property that is now being used to work with international companies to commercialise the tools.

The RNA body fluid work has diversified into areas outside forensic science. For instance, ESR scientists are working with the University of Auckland to use RNA to identify and diagnose concussion, which is currently difficult, time-consuming and very subjective. This work could also help develop new diagnostic tests and services that will be more sensitive than any currently available.

Other new areas for using RNA are being investigated, including projects that will bring ESR scientists from the Forensic and Environmental and Health Groups together.

Expanding our 3D laser scanning services

Critical elements to any crime scene examination are the initial documentation of the scene and the location of items within it.

Until the turn of this decade, the primary way to capture this documentation was with photographs, hand-drawn images and a tape measure, which was time consuming and limited in its use.

In 2012 ESR investigated using laser scanners to document crime scenes in incredibly high three-dimensional (3D) detail, and seven years on these scanners are still considered a crucial part of ESR's crime scene examinations.

The laser scanners have allowed our scientists to produce a wide range of visualisations for New Zealand Police and the courts, including complex diagrams, flythrough movies, virtual walkthroughs and projectile trajectory analysis.

Fast forward to 2019. With advances in 3D processing software, ESR laser scan experts are now able to utilise this 3D data to create complex interactive applications with embedded information that can provide a far greater context for and understanding of crime scenes than ever before. By presenting a 3D crime scene to a jury, complete with scene notes, photographs, trajectories and labels, the comprehension of the evidence is vastly improved when compared with more traditional methods of evidence presentation.

Utilising specialist software, Veesus' Arena4D, our scientists construct these deliverable 3D applications, each dubbed an 'ESR SmartSite'. The use of ESR SmartSites is not restricted to forensic science. By layering 3D data with various pieces of relevant information, they can have huge impacts on a number of processes in industry, including:

- Site visits by clients
- Health and safety training
- Remote auditing
- Technical training
- Environmental monitoring
- Construction planning.

After capturing the 3D data using a laser scanner or drone, the ESR SmartSite is prepared and sent to the client for navigation on a screen. At the touch of a button, this navigation can also be viewed in virtual-reality headsets to immerse the client in the scanned environment and provide them with an entirely new perspective of the data. The presentation of data in this manner has demonstrated the same advantages as those experienced in forensic science: that information is best received and retained when presented visually and with context. Presentations of this type are also more stimulating to the viewers, which enables greater attention to detail.

ESR has demonstrated the use of SmartSite at a variety of events in the past year and has expanded the use of this type of data capture to a range of new clients. Our laser scan experts see huge potential for SmartSite and its application in virtual reality, and believe the future of 3D data at ESR is looking very bright.

Emerging scientist – Tayla Schaapveld

Using Bayesian networks to provide a better statistical approach to forensic evidence

Tayla Schaapveld will be beginning her PhD this year in the forensic science programme at the University of Auckland, supported by an ESR Vision Scholarship. Tayla holds a Bachelor of Science (statistics), a Bachelor of Health Science (population health), a Postgraduate Diploma in Forensic Science and a Master of Science (MSc) (forensic science) from the University of Auckland. She has been based at ESR's Mt Albert Science Centre for the past 18 months.

Tayla's research investigates how a Bayesian network can be applied to help with the evaluation of biological evidence at ESR. Currently at ESR, it is common for biological evidence to be reported in court at a level that only considers how likely it is that the DNA sample originated from a particular individual or individuals. However, an ability to answer questions that consider the source of this DNA, or the activity that took place, would be more valuable in enabling the court to make better informed decisions. Currently, such questions are typically answered by scientists subjectively, with little or no logical framework to assist them.

Bayesian networks have proven to be beneficial in providing logical reasoning by way of a likelihood ratio to help combine experienced, yet still subjective, opinions of experts with experimental data when answering questions that can be both uncertain and complex.

In her MSc, Tayla specifically designed a Bayesian network to help address the source-level question of how likely it is that saliva is present within a stain. After construction it was used to evaluate evidence for specific casework scenarios. Despite some challenges and limitations, the research found that Bayesian networks have the potential to be a structured and understandable way to evaluate biological evidence.

Tayla's PhD will focus on improving the network used in her MSc and building a more refined model that can be confidently understood by ESR scientists. She is hopeful this will go a long way towards improving the current method of evaluating source- and activity-level questions in court.

The Ian Riebeling Memorial Medal winner – Mickayla Dustin

One of the main types of evidence analysed at ESR's Mt Albert Auckland Forensic Physical Evidence laboratory are intimate swabs from sexual assault complainants for the presence of condom lubricants. The detection of a condom lubricant can provide scientific evidence to collaborate or refute a given scenario. Persistence studies of such lubricants are vital to support the interpretation of this type of evidence.

The majority of published research relating to the forensic analysis of condom and sexual lubricants has focused on evaluating and validating different analytical methods. Very little research has been published relating to the transfer and persistence of such lubricants during a sexual assault. In addition, most of the previous research has focused on investigating the persistence of condom lubricants in the vagina.

In the past few years the Physical Evidence laboratory has carried out research on the persistence of polydimethyl siloxane (PDMS), the most common condom lubricant, found on the penis, in the mouth and on skin. A range of personal care products, including tampons, has also been analysed to determine how widely spread PDMS is in common personal care products, and whether or not condom PDMS can be discriminated from other sources of PDMS. The research has also investigated whether PDMS can be detected on swabs that have previously undergone DNA extraction.

Mickayla Dustin, a senior technician in the Physical Evidence team, presented the results of this research at the Australian and New Zealand Forensic Science Society (ANZFSS) Symposium in Perth in September 2018. Her presentation, 'Further persistence studies of PDMS condom lubricants', was well received. At the awards dinner she was presented with the 2018 Ian Riebeling Memorial Medal and the Best Oral Presentation award for the Chemical Criminalistics stream.

The Ian Riebeling Memorial Medallist is selected from the oral and poster presenters at the biennial ANZFSS International Symposium, who are within their first five years of employment as forensic practitioners. In addition to the medal, Ian's family awarded a monetary prize, so Mickayla can advance her professional skills by attending the next ANZFSS International Symposium, which is in conjunction with the 22nd Triennial Meeting of the International Association of Forensic Sciences, in Sydney in September 2020.

The Physical Evidence Laboratory plans to continue the research on the persistence of condom lubricants on and in the human body to ensure that a wide range of scenarios is investigated. There is a lack of research on the persistence of condom lubricants in the anus and rectum, and the number of vaginal persistence studies is relatively small. It also plans to extend the number of samples pertaining to background levels of PDMS on random people, both in body cavities and on the skin. Research on the persistence of water-soluble condom lubricants, such as glycerol, is also proposed. Transfer and persistence studies are essential for the correct interpretation of any type of trace evidence.

ESR has provided essential epidemiological, public health, clinical and laboratory support to the Ministry of Health, the Ministry for Primary Industries and public health units in response to outbreaks of gastric diseases

Safer food

We work to enhance the protection of New Zealand's food-based economy through the management of food safety risks associated with traded goods and protect New Zealand's reputation as a quality food producer.

ESR's food safety work includes multiple risk-management projects for the Ministry for Primary Industries, collaborative research projects through the New Zealand Food Safety Science and Research Centre (NZFSSRC), and commercial contracts with the food industry.

We provide a range of services to the Ministry for Primary Industries, to avoid, detect, mitigate and respond to foodborne hazards.

Amongst our commercial contracts are food forensic investigations that determine where and when food contamination has occurred, identify the type of contaminant and its source, and identify foreign taints and odours and their sources. We can also verify exactly what ingredients are in food.

Food forensics investigations are undertaken for a number of reasons, including consumer safety, industry liability and reputation, regulatory requirements, public relations and product perceptions.

Protecting New Zealand's reputation as a quality food producer

ESR is involved in several research projects funded through the NZFSSRC. The centre was established in 2016 to harness the best scientific expertise in industry, government and research providers. The aim is to provide an internationally credible science base for decision-making in public health and the food industry.

ESR is one of seven partners in the NZFSSRC, which is addressing industry-initiated food safety research projects. This year we continued to be an active collaborator in a number of developments and projects to focus on better ways of detecting hazards in the food production chain and reducing the risk of foodborne illnesses to consumers. In brief, these projects included:

- Establishing a database and protocols to collate and analyse whole-genome sequence (WGS) data for the bacterium *Listeria monocytogenes*. The database includes data from various sources, including isolates from human cases, so protection of patient privacy, and data security are priorities. The objective is to understand the genetic population structure of this pathogen in New Zealand and improve control measures
- Developing updated Process Hygiene Index Toolbox for the Meat Industry, to improve the validation of chilling meat
- Determining the source(s) of *Campylobacter* for poultry flocks during growth in sheds, which commenced in 2019

- Developing a horizon scanning system to detect emerging risks and opportunities for the New Zealand food industry, drawing on experiences of New Zealand and overseas food safety agencies
- Collaborating with NZFSSRC in a programme investigating the use of aptamers in rapid tests for the detection of foodborne pathogens. Aptamers are short sections of synthesised DNA that can fold into shapes suitable for binding micro-organisms or chemicals.

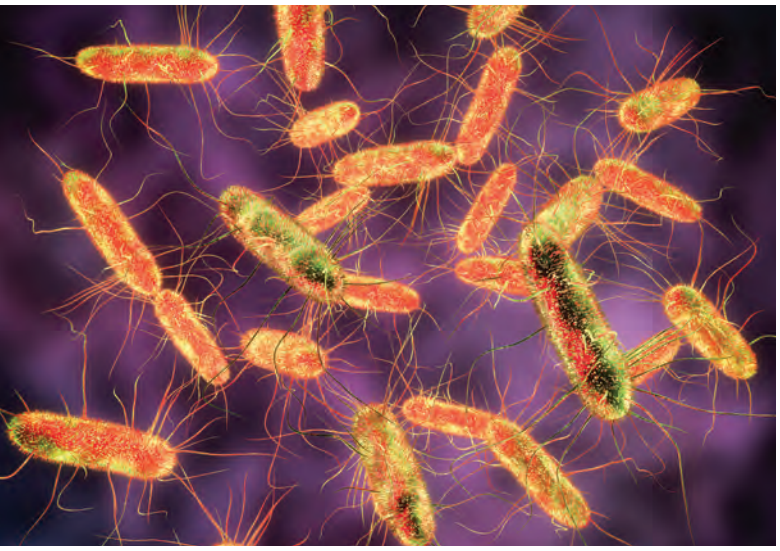
The rate of *Yersinia* infection in New Zealand is concerning as it is much higher than it is in other developed countries. A workshop for local experts to discuss issues related to *Yersinia* was convened to examine the available evidence for food, water and other potential sources of infection, and support the development of further research.

ESR's partnership with the NZFSSRC brings our expertise in and understanding of food safety matters to the centre while offering our scientists opportunities to undertake exciting science with colleagues from other NZFSSRC partners and contribute to advancing food safety in New Zealand.

Responding to foodborne disease outbreaks

Enteric (gastric) illnesses continue to be the most common notifiable diseases in New Zealand, and several are increasingly being reported. This increase is partly due to changes in diagnostic laboratory testing practices, with a shift from culture-based methods to rapid non-culture-based methods that are able to test for several diseases at the same time.

In addition to the changes in diagnostic methods, WGS is rapidly enhancing ESR's ability to characterise pathogens, detect outbreaks of disease, understand the pathways of pathogen transmission and identify the causes of disease.

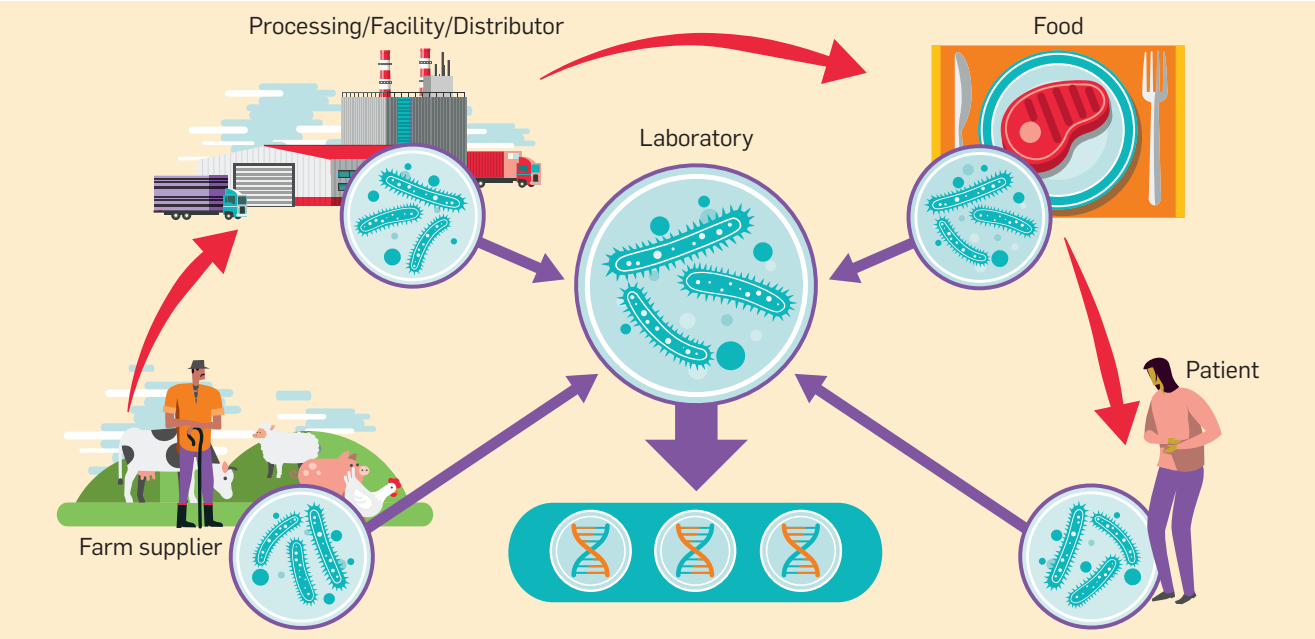


Salmonella pathogen.

The specialist skills and experience of ESR scientists are required to interpret the laboratory and epidemiological data for enteric pathogens. This interpretation is important for protecting the health of New Zealanders as it means we are able to detect outbreaks and inform responses to outbreaks of enteric pathogens.

In the past year ESR has provided essential epidemiological, public health, clinical and laboratory support to the Ministry of Health, the Ministry for Primary Industries and public health units in response to outbreaks of enteric diseases, including *Salmonella typhimurium*, Shiga-toxin-producing *Escherichia coli (E. coli), Vibrio parahaemolyticus* and yersiniosis. For example, early in 2019 ESR identified an outbreak of 70 cases of *Salmonella typhimurium* phage type 108/170. Cases were reported from multiple regions around New Zealand, which suggested that a nationally distributed food source may be implicated. ESR worked with the Ministry of Health, the Ministry for Primary Industries and affected public health units to coordinate the national outbreak investigation to identify a food source and inform appropriate public health action to protect the public health of New Zealanders.

State-of-the-art whole-genome sequencing for food safety



Tracking and isolating a pathogen in the food chain, from farm to fork.

The burden of foodborne disease in New Zealand is significant, with some studies estimating more than 500,000 cases per year, at a total cost of approximately $162 million. The impacts of foodborne disease are many – from public health burdens including socio-economic costs, such as medical care, loss of productivity and the intangible cost of long-term illness and death. Foodborne disease is also costly for the food industry. Ensuring food is safe is a priority of food companies, for the protection of public health as well as international market access. A food contamination outbreak can have devastating affects for those involved with illness and can bring unimaginable economic loss to a food company, an industry and even a country's reputation.

ESR has a key role in improving food safety in New Zealand. Our scientists have developed a commercial service (GenomESR) that uses state-of the-art sequencing technologies to gain the entire DNA make-up, or WGS of a bacterium (pathogen), which in turn can help identify and track it along the food chain. WGS provides a precision far superior to previously used methods.

The benefits of this precision have been demonstrated in the United States and Europe, where outbreaks have been quickly identified and subsequent action has prevented further illness. The transition to WGS at ESR has been occurring for the past four years. International scientific consortia such as PulseNet International are working towards establishing standard practices so data can be readily compared between countries. ESR's Brent Gilpin is the lead of PulseNet Aotearoa, and he and others continue to collaborate with PulseNet International so that ESR is in line with best practices. This is especially important as we face a growing global food chain where outbreaks can span multiple countries.

Today, WGS is becoming routinely used in New Zealand. Advances in the sequencing technology have made this approach more cost effective for tackling some serious food safety issues. The cost benefits are particularly worthwhile if a company is facing chronic contamination issues in its manufacturing processes. An analysis of the WGS of multiple bacterial isolates, obtained through a factory environment, can identify the likely source of contamination, which can then be addressed through cleaning or other mitigation strategies. Also, while WGS can implicate a source of contamination, it can also exonerate a potential source, which can be equally valuable.

WGS is also adding to the databank of knowledge about known pathogens and bacteria from food, health, water and environmental samples. The collation of these large genetic data sets allows ESR scientists to research and add value to the information gained by looking at the genetic make-up of these pathogens more closely. We can determine the population structure of pathogens in New Zealand and put it into an international context. This helps us gain insight into how these pathogens have evolved in New Zealand, and also identify the appearance of new strains and assess their ability to cause disease and other traits such as antimicrobial resistance. The ultimate aim is to improve the ways we can detect and control these pathogens in the food chain.

ESR provides expert advice to the food industry as to the best genome sequencing analyses and further interpretation of the results obtained, making people, and the food they eat safe.

Hugo Strydom developing subtyping for investigating pathogens in Yersinia outbreaks.

Tracking and tackling *Yersinia*

Bacterial pathogens, even though minute in size, have a massive advantage, millions of years of evolution and an impressive rate of evolution. Bacterial cells replicate about every 20 minutes, re-adjusting themselves every time and positioning themselves to sidestep any obstacle humankind could put in their way, irrespective of whether it is refrigeration to store food or antibiotics to treat disease. However, with current technology, this advantage is also a weakness – it is this rate of evolution that allows us to link related bacteria, find the source and plug the holes in our defence.

Some species of the bacteria *Yersinia* cause a foodborne disease called yersiniosis. The symptoms include diarrhoea, vomiting, fever and occasionally abdominal pain in children, but are usually limited to severe abdominal pain in adults. The impressive thing about these bacteria is their ability to grow at very low temperatures. Even in refrigerated food this bacteria will survive and may continue to grow.

Today, mega facilities produce food at scale and distribute it around the world. Because of globalisation, food distribution networks have become very complex. This makes tracing the source of food that carries this disease-causing bacteria challenging. Another issue is that these bacterial cells are usually present in very low numbers in most food products. However, once ingested, the bacteria experience the warm and cosy environment in the human gut and with access to excess amounts of nutrients, proliferates to cause illness in three to seven days.

In an ESR study, the aim was to develop methods that would enable us to use DNA from these disease-causing bacteria to find the source of the food that carried them. To do this we compared the DNA of clinical samples from yersiniosis patients. If DNA sequences are the same or very similar we can argue that the bacteria are related and therefore from the same source.

Data science technologies increasingly allow us to compare massive DNA data sets. This information in turn allows epidemiologists and clinicians to determine what these linked yersiniosis patients have in common, such as what they ate in the weeks prior to the onset of symptoms, what food products they bought from which supermarket, and what restaurant they visited.

Using aptasensors to detect *Listeria*

Listeria is a foodborne pathogen that is a significant risk to be managed for many of New Zealand's food exporters. To ensure that exported food is safe, extensive testing programmes are required to ensure compliance, and product is usually held until clearance. These tests currently take up to three days, from sending samples to the lab to getting results. This means food products, particularly high-value chilled foods such as seafood, lose a significant proportion of their shelf-lives prior to export.

Rapid point-of-use sensing devices have the potential to transform significantly the way traditional laboratory diagnostic services are delivered across multiple sectors, including those of ESR's key impact areas of health, environment, food and forensics. ESR is working with collaborators at Plant and Food Research, the University of Auckland and AuramerBio to develop and trial aptamer-based sensors (aptasensors) for detection of the *Listeria* pathogen in foods. Aptamers are single-stranded RNA or DNA molecules that fold into three-dimensional structures. These structures enable selective binding of target molecules with high affinity. Targets can include cells, viruses, proteins and small molecules such as antibiotics. Aptamers have similar properties to antibodies, but are far more stable, have equal or greater sensitivity, can be synthesised without the use of animals, and are amenable to more target types. These properties make them superior to antibodies for use in diagnostic devices.

The aptasensors we develop will be used by food exporters as screening tools on the factory floor, to increase significantly the speed of detecting food safety pathogen issues. Our aptasensor technology will be deployable on-site, scaleable, rapid and cost effective compared to existing solutions. Increased speed and effectiveness in detecting *Listeria* in foods will save exporters money by significantly lowering holding times for perishable product, so increasing shelf-life and profitability.

Is kai gathered from our environment safe to eat?

Mahinga kai (food gathered from the environment) and recreational fishing are a source of key sustenance for Aotearoa. However, the health of these harvesting sites has been declining due to the impact of people, including pollution from urbanisation and industrial processes. Our research into mahinga kai is looking at how safe it is to eat. This research is a great example of how western and indigenous knowledge can be used together to provide better health outcomes for our communities.

Pollution in areas where kai is gathered has multiple physical and social implications. One area where there is a gap in our knowledge is the safety of kaimoana (seafood) harvested from customary fishing areas. The research underway is already yielding some interesting insights. Several microbiological pathogens that are threats to human health have been identified in customary fishing areas, including *Listeria* and *Norovirus*.

Another finding of our research is that faecal contamination is frequently found in pāua. This is a surprising result, as pāua do not bioaccumulate bacteria, unlike most other shellfish.

Further research on the source of the contamination in pāua is needed. A possible reason that could be researched is that faecal bacteria may be present on the seaweed upon which pāua graze.

Is there radiation in our shellfish?

ESR collaborated with the University of Canterbury and the Ministry for Primary Industries on a research project to better understand the dietary exposure of the New Zealand population to radiation.

In New Zealand, pollution of the environment by radionuclides is often associated with the fallout from nuclear weapon testing in the Pacific and the accident at the Fukushima Daiichi nuclear power plant. However, a recent study has identified that the dietary exposure of the New Zealand population to ionising radiation originates mostly from naturally occurring radionuclides polonium-210, present in the shellfish we consume.

A PhD student has completed the first stage of the project at ESR within the National Centre for Radiation Science (NCRS), for her research aimed at identifying variability ^{210}Po activity concentration in New Zealand shellfish. Shellfish samples from 14 sampling sites across New Zealand were analysed, every two months for 12 months and identified significant spatial variability in ^{210}Po activity concentration.

The student is now undertaking the second step of her project, aiming to identify the origin of spatial variability in ^{210}Po in New Zealand shellfish and quantify shellfish consumption in areas affected with high ^{210}Po in shellfish. The aim is to evaluate accurately the dietary exposure of the New Zealand population to ionising radiation.

ESR provides advice, analysis and support to regional and city councils in the areas of freshwater quality, groundwater and drinking water

Cleaner water and a cleaner environment

We seek to improve the safety of freshwater and groundwater resources for human use and the safe use of biowastes.

ESR specialises in investigating water quality, identifying contamination sources and addressing possible risks to public health. We develop innovative solutions to improve the quality of our rivers, streams and groundwater.

ESR continues to provide advice, analysis and support to regional and city councils in the areas of freshwater quality, groundwater and drinking water. In the past year this included undertaking advanced analysis of sources of faecal pollution for at least 12 councils.

ESR also works with other organisations on the sustainable management of biowaste. We have expertise in treatment options for wastewater, effluent, greywater, biosolids and sewage sludge, with a focus on land application and re-use.

Through community engagement we aim to ensure that the solutions are culturally appropriate, have enduring community support and have a sound scientific base.

We are a key partner in the Pacific region, providing end-to-end engagement with stakeholders. To improve environmentally mediated health outcomes, such as safe water and sanitation, and climate change resilience and adaptation, we work with entities ranging from international and regional donor agencies and national and provincial governments to local communities and individuals.

Why is the health of our groundwater so important?

Our groundwater resource is the water in the pores and cracks in the sands, gravels and rocks beneath our feet. It is out of sight but essential for our environment, communities and agricultural productivity.

Irrigation sourced from groundwater is estimated to contribute $2 billion annually to New Zealand's economy. Maintenance of surface water flows and quality, are more difficult to quantify but are likely to be even more significant. However, surface water is vulnerable to contamination by disease-causing micro-organisms, as well as from nitrates, pesticides and other contaminants.

80%
of New Zealand's annual river flow volume comes from groundwater

40%
of people rely on groundwater for drinking-water supplies, either partially or completely

The health of our surface waters, our irrigation waters and our mahinga kai can be directly linked to the quality of groundwater resources. Yet our groundwater resources, like some of our rivers, are under stress. Contaminants from our urban centres, farming, industry and waste threaten groundwater quality. The pollution is widespread and difficult to treat.

As the Government embarks on huge reforms in the area of water, with the Three Waters Review and the Essential Freshwater programme, it is critical that groundwater is included. This is even more important in the face of new challenges such as climate change and emerging organic contaminants.

Improving the supply of safe drinking water for all

The Government Inquiry into Havelock North Drinking Water was a result of the campylobacter outbreak there in 2016. Up to 5,500 people were ill as a result and four people are thought to have died from associated causes. The outbreak was the biggest ever recorded outbreak of *Campylobacter*.

Running parallel to the latter stages of the Havelock North inquiry, the Three Waters Review began in mid-2017. The Three Waters Review is a cross-agency initiative led by the Minister of Local Government.

The initial findings of the review raised broader questions about the effectiveness of the regulatory regime for the three waters (drinking water, wastewater and stormwater), and the capability and sustainability of water service providers. Most three-waters assets and services are owned and delivered by local councils.

Effective three-waters services are essential for our communities:

- Our health and safety depend on safe drinking water, safe disposal of wastewater and effective stormwater drainage
- Our prosperity depends on an adequate supply of cost-effective three-waters services for housing, businesses and community services
- Our environment depends on the well managed extraction of drinking water, and the careful disposal of wastewater and stormwater.

Two of our senior staff are members of the Ministry of Health Drinking-Water Advisory Committee, which provides the Director-General of Health with advice on health issues relating to drinking-water quality in New Zealand. The advice is used by the Director-General as an input to decisions and actions, and to advise the Government on improving systems for the supply of safe drinking water, including the development of the new regulatory regime for drinking water being progressed as part of the Government's Three Waters Review.

Sharing groundwater knowledge and expertise

ESR is collaborating with GNS Science, Lincoln Agritech and Aqualinc Research to improve the understanding of, information on, tools for and the research capacity of groundwater in New Zealand. Scientists still know relatively little about this important resource, particularly how it is affected by pollution, climate change and the increasing overall demand for water. ESR scientists have identified the need to build up our scientific knowledge in order to protect groundwater now and for future generations.

In 2019 ESR and its collaboration partners held a GroundsWell symposium in Christchurch looking at groundwater science and what needs to be done. The event brought together some of New Zealand's best minds in the groundwater space, including people from central government agencies and territorial local authorities, researchers from other CRIs and universities, health workers and representatives of industry organisations such as Federated Farmers.

The symposium covered four themes:

- He Waiora – Māori insights on groundwater management from Te Mana o Te Wai
- Groundwater under pressure: characterisation, drivers/pressures and stressors by Environment Canterbury
- Managing groundwater at the front line by Manaaki Whenua
- Groundwater prediction and dynamic responses.

The conclusions on the most important issues to come out of the symposium are being used to develop a case for more sustainable funding for groundwater science and research in New Zealand.

Innovative research to reduce nitrate levels in groundwater

ESR is exploring new and exciting ways to naturally reduce the strength and presence of nitrates in groundwater to maintain freshwater quality, particularly in rural locations.

Gravel aquifers contain much of New Zealand's usable groundwater and are particularly vulnerable to nitrogen contamination. Aquifers are bodies of saturated rock or sediment from which groundwater can be extracted in sufficient quantities for use.

Our work is targeted at reducing nitrates in these systems through trialling woodchip denitrification wall technology. A wall of solid, porous, organic woodchip substrate is placed within a nitrate-contaminated aquifer, which stimulates the native microbes in the chip to strip out the nitrates before the groundwater reaches the waterway.

ESR has installed a denitrification wall in an aquifer near Kaiapoi, as part of a field trial testing the use of passive groundwater remediation systems to remove nitrate in shallow gravel aquifer systems effectively.

The monitoring of wells is showing a reduction in groundwater nitrate from seven milligrams per litre upstream to effectively zero downstream of the wall.

"The initial results show that it is doing what we hoped it would do," says ESR scientist Murray Close.

The aim is to study the performance of the denitrification wall for the long-term. Its impact on local groundwater conditions will be intensively monitored for the next two years, although the structure will last a lot longer than that.

This is the first time that a denitrification wall has been trialled in a gravel aquifer setting anywhere in the world. Presenting a number of diverse engineering and science challenges, it encompasses hydrogeology, chemistry, microbiology and social science. Hydro-geophysical methods that have not previously been applied in New Zealand are being used to inform the design and evaluate the hydraulic performance of the denitrification wall. The project also provides an opportunity to examine how changes in the chemical states of shallow groundwater systems affect the groundwater ecology, including stygofauna that inhabit New Zealand's gravel aquifers.

ESR's Mt Albert Science Centre staff planting mānuka at Lake Waikare.

Researching antimicrobial properties of mānuka

ESR has been collaborating with partners in the Centre for Integrated Biowaste Research (CIBR) to discover how mānuka's antimicrobial properties could be used to reduce pathogens and nitrate loads in water.

The team has already made some interesting findings. *E. coli* levels reduce much faster in soil where mānuka is grown compared with the levels present in pasture. E. coli is an indicator of faecal contamination, so its presence in waterways indicates there might be other illness-causing bacteria. The effect that mānuka has on *E. coli* suggests this plant can potentially also reduce the survival of other pathogenic organisms in the soil, reducing their arrival to waterways. Laboratory experiments also demonstrated the antimicrobial properties of mānuka against *Salmonella* sp. and *Campylobacter* sp. This is fundamental for keeping our water clean and safe.

An excessive concentration of nitrate in waterways creates algal blooms, and is one of the main concerns for the health of our waterways, according to the Environment Aotearoa 2019 report from the Ministry for the Environment. There was also 10 times less nitrate leaching where mānuka was grown compared to where pine trees were grown. A high concentration of nitrate in drinking water is also a risk for human health.

There are still many questions we are seeking the answers to, and which we will continue to work on.

Can we use mānuka in the real world to reduce pathogen- and nitrogen-rich farming run-off before it enters waterways?

We have two field trials in the North Island, in Lake Waikare and Lake Wairarapa, testing for this, funded by and in collaboration with the Waikato River Authority, Waikato Regional Council, Greater Wellington Regional Council, Vision Mātauranga and the Strategic Science Investment Fund. We are also collaborating with four iwi groups in both locations – Ngaa Muka, Matahuru Marae, Te Riu o Waikato and Ngāti Kahungunu ki Wairarapa – and many other research organisations (CIBR partners) to answer this question. Our Master of Science student focused on the Wairarapa field trial, to conclude the strong effect of mānuka in nitrate conversion. ESR and the University of Canterbury also have a PhD student and a Master's student working on the plots in Waikare. These projects are tightly linked with mātauranga Māori and ecological restoration in the research areas, and we have demonstrated the extra benefits and values that we can recover, apart from just water quality. Mānuka is just one of multiple New Zealand native species that can thrive in riparian bands, and which are taonga for the iwi who rely on them.

Can we use mānuka to reduce nitrogen leaching from irrigation with treated municipal wastewater?

Similarly to the field trials in Waikare and Wairarapa, the CIBR team has two field trials in Levin, led by Lowe Environmental Impact (LEI) and funded by the Freshwater Improvement Fund (Ministry for the Environment), and Horowhenua District Council. A third is located in Duvauchelle, funded by Christchurch City Council and in collaboration with the rest of the CIBR partners, for testing the use of mānuka and other New Zealand native species to reduce nitrogen leaching from irrigation with municipal wastewater. A PhD student is working on these plots.

Are there other native plants that can do the same?

A greenhouse trial with two other native trees found that other plants may also have potential to reduce *E. coli* in soil.

These results are important for many reasons. CIBR will be able to demonstrate the benefits of mānuka plantings for improving water quality, and also increase the biodiversity of the plantings with other antimicrobial plants. Mānuka is a good incentive for farmers, providing potential incomes from honey and essential oil production.

What are DNA synthetic tracers?

Reductions in the level of contaminants are urgently needed as intensified human activities have significantly polluted New Zealand's fresh water. A major barrier to better contaminant management is the lack of an effective means to provide spatially accurate information for tracking the sources of pollution and contamination pathways.

ESR has developed novel and environmentally friendly DNA tracer technology that can be used to concurrently track multiple water-contamination sources and pathways. These new DNA tracers can be used in their free form or can be microencapsulated.

Free DNA tracers are able to diffuse into the porous media of soils and aquifers, whereas encapsulated DNA tracers are protected from the environmental stresses often encountered in surface water and effluent. We have validated DNA tracers in surface water, groundwater and soil systems and were able to track them in a surface stream up to one kilometre. Compared to the traditional salt or dye tracers used for water tracking, the quantity of DNA tracers required was seven to nine orders of magnitude less.

DNA tracers show great promise for use as tracking tools and we will continue to work with end-users to further validate these new tracers in field conditions. With further up-scaling, the new DNA tracer techniques could be used to track multiple pollution sources and pathways in freshwater environments concurrently. The impact of this research will be the development of better mitigation strategies for the protection of New Zealand's precious freshwater resources.

It is estimated that there are more than 15 trillion pieces of microplastic debris in the world's oceans, of which 80% originate from land-based activities

Researching microplastics contamination in our environment

New Zealand scientists, regulators and Māori have become increasingly concerned about the impacts of microplastics on the country's unique species and ecosystems, tāonga, and human health.

Microplastics, which include beads, fibres and fragments, are a globally significant environmental pollutant, found in a broad range of ecosystems and consumed by a diverse range of animals and fish.

In September 2018, ESR was awarded more than $12.5 million in government funding to invest in the necessary resources to continue research into the impacts of microplastics and their threat to New Zealand's ecosystems, animals and people.

This five-year research project will significantly improve our understanding of the levels, distribution and impacts of microplastics on our unique ecosystems and taonga. It will also help to further the international knowledge and understanding in this area of research.

Initial national data showed that New Zealand's coastal and freshwater environments were contaminated, but there was limited information to assess the risks that microplastics pose.

The project, led by ESR and Northcott Research Consultants, includes scientists from the University of Auckland, the University of Canterbury, Scion and the Cawthron Institute, along with representatives from the primary industry, regional councils, iwi and communities.

Lead ESR scientist Olga Pantos says the project will undertake a rigorous assessment of the extent of microplastics contamination, advance research on the mediation of that threat and add to the long term well-being of New Zealand's environment, people and economy.

ESR scientists have deployed plastics onto a pontoon in Lyttleton Harbour to see what grows on them, what chemical pollutants are taken up and concentrate upon them, and the changes that occur to the plastic itself. The project is called AIM^2 (Aotearoa Impacts and Mitigation of Microplastics).

Two types of plastic are being trialled – nylon and polyethylene – both commonly found in the marine environment, often in the form of fishing gear and food packaging.

It is estimated that there are more than 15 trillion pieces of microplastic debris in the world's oceans, of which 80% originate from land-based activities.

Olga says the problem is similar to climate change due to its global scale and the broad array of potential risks it poses to ecosystem health and resilience, human health and biosecurity.

Scientists are also looking at bacteria and fungi that may be degrading the plastics, and the mechanisms they are using,

with the hope of finding some solutions to the plastic pollution problem. Research programmes in Europe, Australia and North America have confirmed the presence of microplastics in a range of environments, and their long-term impacts on organisms.

"Plastics pose a significant risk to the ecosystem. Fish and other sea life will eat the plastics. Chemicals associated with the plastics may enter their tissues, which potentially could have impacts up through the food chain," says Olga.

"We need to do a lot more testing on a larger scale to see how much plastic is out there, not only in the marine but also in the freshwater and terrestrial ecosystems, and understand the risks they pose to ecosystems, animals and potentially humans."

While there is a lot of evidence of the detrimental effects of large plastic items on animals and ecosystems, knowledge of the amount and distribution of microplastic waste and its impacts on organisms (including species that are food sources for humans) and ecosystems is still lacking.

Microplastic pollution has become invasive and ubiquitous in all environments. The United Nations Environment Programme recently likened the impacts to climate change, due to its global scale and the magnitude of potential risks it poses to ecosystem health and resilience, human health and biosecurity.

The research focuses on two primary case study sites (located in the Auckland and Nelson regions) predominated by urban and rural/agricultural land uses and their respective sources of microplastics.

The project is one of 69 awarded funding through the 2018 round of the Endeavour Fund. This is New Zealand's largest and most prestigious research and science contestable fund.

The success of this project is due to the expertise and reputations of researchers from each organisation, and the wider collaboration.

Our performance

	TARGET	ACTUAL
Healthier communities		
Time-critical turnaround times are met	100%	100%
Ministry of Health's satisfaction with ESR's services	'Good' or better	Good
Ministry of Health's project brief milestones and deliverables consistently met	95%	98%
Ministry of Health's satisfaction with ESR's support for responses	'Good' or better	Good
Disease surveillance information is distributed to all key decision-makers	100%	100%
Forensic		
Fulfilment of contractual obligations under the service level agreement	90%	>90%
Police satisfaction with ESR's timeliness and quality of service	90%	80%
DNA samples linked to a person	70%	71%
Total number of cases where ESR provides Police with analysis of forensic evidence	N/A	10,904
Number of research projects undertaken by ESR with the Evidence-Based Policing Centre	N/A	2
Safer food		
Number of food science projects delivered to the Ministry for Primary Industries and NZFSSRC	N/A	43
Percentage of Ministry for Primary Industries and NZFSSRC projects delivered on time	100%	100%
Clean water and the environment		
Number of territorial local authorities and interest groups to which ESR provides water quality advice	12	15
Number of publications of ESR's water and environment research group	N/A	16
Number of Strategic Science Investment Funded funded water projects delivered	5	6

Generic CRI performance indicators

		TARGET	ACTUAL
End-user collaboration	Revenue from commercial and other sources per full-time equivalent (FTE)	$159,933	$168,300
Research collaboration	Publications with collaborators	65	63
Technology and knowledge transfer	Commercial reports per scientist FTE	0.45	0.38
Science quality	Impact of science publications (measured using Web of Science citations for the preceding financial year)	3.2	3.9
Financial indicators	Revenue per FTE	$204,708	$200,152
	Commercial and other services revenue	$70.7m	$62.8m

Financial performance indicators (year ending June)

	ACTUAL 2019	TARGET 2019	ACTUAL 2018
Revenue	**$79m**	$86m	$76m
Operating margin *Earnings before interest, tax, depreciation and amortisation (EBITDA) as a percentage of revenue*	**9.6%**	12.5%	14.2%
Return on equity *Net profit after taxation as a percentage of equity*	**3.4%**	6.3%	8.2%
Return on assets *Earnings before interest and tax as a percentage of total assets*	**2.4%**	5.7%	7.2%
Profit volatility *The standard deviation of EBITDA as a percentage of average EBITDA over the preceding seven years*	**26%**	–	27%
Acid test ratio *Current assets excluding prepayments and inventory to current liabilities excluding deferred revenue*	**2.6**	2.8	2.8
Equity ratio *Equity as a percentage of total assets*	**70.6%**	73.0%	71.4%
Gearing *Debt (including finance lease liabilities) as a percentage of debt and equity*	**–**	–	0.1%
Operating margin per full-time equivalent (FTE) *Earnings before interest, tax, depreciation and amortisation, per average full time equivalent employee FTE*	**$19,300**	$25,600	$28,300

Working internationally has always been an important facet of the work ESR does

Active on the world stage

We seek to improve the safety of freshwater and groundwater resources for human use and the safer use of biowastes.

ESR's strong international connections enable us to monitor continually the latest developments in science and technology, adapting them to the New Zealand context to solve complex problems.

These active connections enable us to identify up-and-coming issues that may have significant impacts on communities in New Zealand.

On the world stage, attending and presenting at international conferences is important. Our scientists present their latest research across the globe, work collaboratively in an international sphere of learning and knowledge-sharing, and are respected globally.

Relationships and shared knowledge enable ESR to identify opportunities, not just for collaboration but for commercial revenue, ensuring that our business is sustainable and contributes to the health and wellbeing of our New Zealand communities.

Using our international connections to reduce harm from illicit drugs

Forensic toxicologist Diana Kappatos is a founding member of the Toxicology Committee with UNODC, which was mandated to develop the UNODC Early Warning Advisory on New Psychoactive Substances (NPSs). The purpose of this is to prevent and respond to the adverse health consequences and risks associated with NPSs.

NPSs are a broad range of substances that have appeared on the drug market in the past 15 years, and are synthesised from conventional drugs of abuse by slight chemical modifications in order to obtain new products. The products are constantly changing to be ahead of a country's legislation and detection by standard toxicology screening. They include synthetic cannabinoids, cathinones, opioids and benzodiazepines that are designed to mimic the effects of the parent drugs – often with greater potency. Part of the problem lies in the ease of their synthesis, the ease of purchase at a low cost and the lack of knowledge of harm.

The Toxicology Committee (part of UNODC) developed an online UNODC Toxicology Portal to collect toxicology data from countries in all regions of the world. The adverse effects of each NPS found is assessed utilising the data collected on this portal. This enables the UNODC committee to prioritise the most harmful, persistent and prevalent NPSs for international action. As a member of this committee, ESR has access to real-time data of NPSs coming onto the world market. This ensures we are able to identify the substances coming across our border and detect their use in our community. Providing such data quickly to our stakeholders will assist them to predict, prevent and protect New Zealand communities from the harm caused by NPSs.

Dr Diana Kappatos, forensic toxicologist, ESR.

Sharing our expertise in bloodstain pattern analysis

ESR is one of the world's leading experts in the field of forensic bloodstain pattern analysis (BPA). Our deep expertise in this area has been used to solve serious crimes in New Zealand, and is in demand around the world. To share our expertise internationally, ESR has been delivering BPA courses since 2011.

The training looks at the fundamental scientific principles underpinning the formation of the bloodstain patterns observed at crime scenes. The 40-hour workshop teaches the basic principles of fluid dynamics and how they relate to bloodstain pattern formation. By focusing on the connections between the physical mechanisms of blood-letting events and the static bloodstain patterns that result, participants gain greater interpretative skills, leading to more robust forensic evidence.

The courses are delivered by Dr Michael Taylor, Rosalyn Rough and Professor Mark Jermy from the University of Canterbury. Courses have been delivered in Canada, the US, the Netherlands and France.

Much of the course content has arisen from internationally recognised research in the field undertaken by ESR's BPA research group led by Dr Michael Taylor. Our reputation as a world leader in the field of BPA has grown out of this strong research base and fuels the demand for our expertise in the training of analysts around the world. Online courses in BPA are being trialled with international trainees to enable wider access to the quality training ESR offers.

Sharing our forensic skills with South-East Asia

ESR continued to refine and develop training and consultation proposals with South-East Asian agencies in 2018/19, drawing on our forensic capability, particularly with crime scene examination, capturing crime scenes through 3D laser scanning and BPA, and interpreting the weight of evidence.

Our staff were involved in extensive consultation in South-East Asia this year on how to interpret evidence and what data sets were required, and to deliver tools and ways of thinking about how best to accurately, concisely and clearly communicate the weight of the evidence.

This piece of work will lead to further interaction in the coming year through a mentoring role. We anticipate that further opportunities for commercial operations and partnerships will arise as we continue to refine this technology and service.

Our work in the Pacific

ESR's Healthy Pacific Environments programme supports our Pacific island whānau throughout the region. The programme has developed over a number of years, first gaining a foothold through the development of drinking-water safety planning processes, then in developing regionally recognised expertise in water, sanitation and hygiene (WASH) development. The team has subsequently grown to work with our international partners in the development of whole-system environmental health programmes and environmental health intelligence systems, and is gaining recognition for developing capability in climate change, disaster and health adaptation planning.

Our work provides end-to-end engagement with stakeholders ranging from international and regional donor agencies and national and provincial governments ranging to local communities and individuals.

Matt Ashworth implemented a UNICEF WASH programme in a Solomon Islands school.

Improving water, sanitation and hygiene in the Pacific

ESR has acted as the technical adviser for UNICEF for several national-level WASH programmes throughout the region.

Significant work has been delivered this year in both Vanuatu and the Solomon Islands. The Vanuatu WASH in Schools project is a five-year Ministry of Foreign Affairs and Trade Partnership Fund activity led by UNICEF New Zealand, providing sustainable WASH interventions. This project has developed a programme that will be implemented throughout the province of Penama, involving the participation of all primary and secondary schools in the province.

ESR and UNICEF Vanuatu co-delivered a multi-sector WASH in Schools' improvement planning review to agree on roles and responsibilities at national and provincial levels, including the identification of a range of WASH in Schools funding organisations and mechanisms that schools can access. The review also undertook to cement in place the newly developed, consolidated WASH in Schools model for operation within national and provincial governments. These action points had been identified through the ESR-led technical gap analysis of policies, standards and technical guidelines supporting WASH in Schools.

ESR provided technical and scientific support to Vanuatu's Ministry of Education and Training, Department of Water Resources, Ministry of Health and Ministry of Justice and Child Services to address some of the identified priority gaps that will lead to school-level implementation of good WASH practice. Most recently, UNICEF Vanuatu and ESR co-delivered the training of trainers, and provincial training to end users of the WASH in Schools materials developed for the project.

This process allows schools to identify their individual WASH requirements and supports them to build the portfolio of evidence that supports applications for project funding.

The gathering of this evidence also provides provincial and national governments and donors with regulatory compliance indicators, and donor agencies with quantitative and replicable monitoring and evaluation indicators of WASH implementation.

Understanding the impact of climate change on health in the Pacific

ESR is developing a health adaptation action plan for the Pacific island nations. The plan will assist these nations to manage health-related adaptation and action independently, including the development of their own tailored resilience and response capabilities. By profiling natural disasters and risks, health impacts these nations will develop and produce their own action plans. ESR's proposed activity delivers sustainable capacity and capability development. A project proposal has been welcomed by our in-country partners in Tonga and is currently with the New Zealand Aid Tonga bilateral team.

Improving environmental health practices in Tonga

ESR is in the third year of a five-year project partnering with the Ministry of Health in Tonga. The Healthy Tonga Environments project is funded through the New Zealand Aid, Partnerships for International Development programme. The project is delivering across four major outputs: policy and strategic development; training and skill development; analytical capability and capacity development; and environmental health surveillance and intelligence for action.

Healthy Tonga Environments has supported the Tonga Ministry of Health to develop policies and strategies supporting the recognition and growth of environmental health practice. These have been augmented with the development of operational instructions and systems of work for day-to-day environmental health activities. The environmental health group is receiving skills and knowledge support and development through operational mentoring from experienced public health officers and enrolment in the Fiji National University environmental health undergraduate course.

Analytical and incident response has been strengthened with the design and imminent provision of an environmental health laboratory facility and technical training and support to the team. This will initially cover water-quality monitoring, vector surveillance and control, and foodborne illness outbreak support. The project is developing an environmental health surveillance and intelligence system to manage routine and emergency incidents, coordinate data collection and curation, and develop mature databases.

Intelligence derived from the system will allow operational and strategic decision-making based on quantitative analysis, where the effectiveness of mitigations can be evaluated against robust baseline data.

Collaborating to keep us safe from radiation

Dr Maxie Christison, ESR NCRS Manager; Dr Lassino Zerbo, Executive Secretary CTBTO; Dr Keith McLea, ESR Chief Executive; and Dr Libby Harrison, ESR General Manager Health and Environment.

ESR collaborates with global nuclear agencies including the International Atomic Energy Agency and the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO).

We operate New Zealand's NCRS, which is the lead agency providing technical, regulatory and operational support, assistance and advice to whole of government in the event of radiation emergencies.

We also contribute to the International Monitoring System (IMS) operated by the CTBTO. The IMS is a network of 321 monitoring stations and 16 radionuclide laboratories that monitor underground, underwater and the atmosphere for any sign of a nuclear explosion. ESR operates a number of monitoring stations. We also operate a National Data Centre (NDC), which monitors the data submitted to the International Data Centre for any potential nuclear activity.

In November 2018, our Christchurch Science Centre hosted a visit from geophysicist Dr Lassina Zerbo, the Executive Secretary of the CTBTO. ESR had the opportunity to profile New Zealand's contribution to the CTBTO as we represent New Zealand to meet this obligation. As a CRI, ESR provides advice and services to the Ministry of Foreign Affairs and Trade on nuclear non-proliferation matters.

In 2018 ESR hosted a workshop with the British NDC, funded by the Ministry of Foreign Affairs and Trade. The British NDC has offered to share its in-house software tools tailored to NDC purposes to streamline data retrieval, facilitate in-depth data analysis and allow for machine-generated alerts. With the experiences gained in the workshop, the New Zealand NDC will be able to act faster in regards to detections and possible treaty violations. ESR recently obtained recertification of the laboratory we operate for CTBTO. The laboratory, which is one of only 16 CTBTO laboratories in the world, was damaged during the Christchurch earthquakes and required significant work to prepare for recertification.

We recently participated in and helped to facilitate a major emergency exercise at Whenuapai air base. The exercise ran for a full week, involving more than 150 military and civilian personnel from the US and New Zealand, along with observers from Australia, Thailand, the US and New Zealand. The exercise scenario involved a major fire on board a ship docked at the port of Auckland, carrying high-risk-category radioactive materials.

The ensuing simulated radiological release resulted in the need to take urgent countermeasures to protect the public (some evacuation and sheltering was in place), the consideration of longer-term measures such as relocation of several hundred thousand Aucklanders, and the imposition of agricultural restrictions as far south as Waikato. The exercise involved a combination of desktop activities and live play.

The live play component involved NCRS staff placing radioactive sources on the airfield, to enable a helicopter carrying a radiation-detection system to fly overhead and map actual radiation readings. In addition NCRS deliberately contaminated a helicopter with short-lived radioactive material to allow US and New Zealand military personnel to practise decontamination of aircraft, and personnel and medical management of contaminated casualties.

ESR's Chief Executive appointed to prestigious international committee

Keith McLea attending the 2019 World Environment Day and annual general meeting of the CCICED.

ESR's Chief Executive Dr Keith McLea has the honour of being an international member of the China Council for International Cooperation on Environment and Development (CCICED).

The CCICED supports the implementation of the Chinese Government's socio-economic and sustainable development strategies. It makes recommendations to the Government on these matters, ultimately promoting their adoption into policy, legislation and operational objectives.

The theme for this year's meeting was 'A New Era – Towards a New World of Green Prosperity'.

The council is made up of 50% Chinese and 50% international members appointed by the Vice President of China. China has made significant progress on improving its environment in a sustainable way within a relatively short time. These changes are driven by the President of China and have created a significant ripple effect throughout both central and local governments.

Transforming ESR

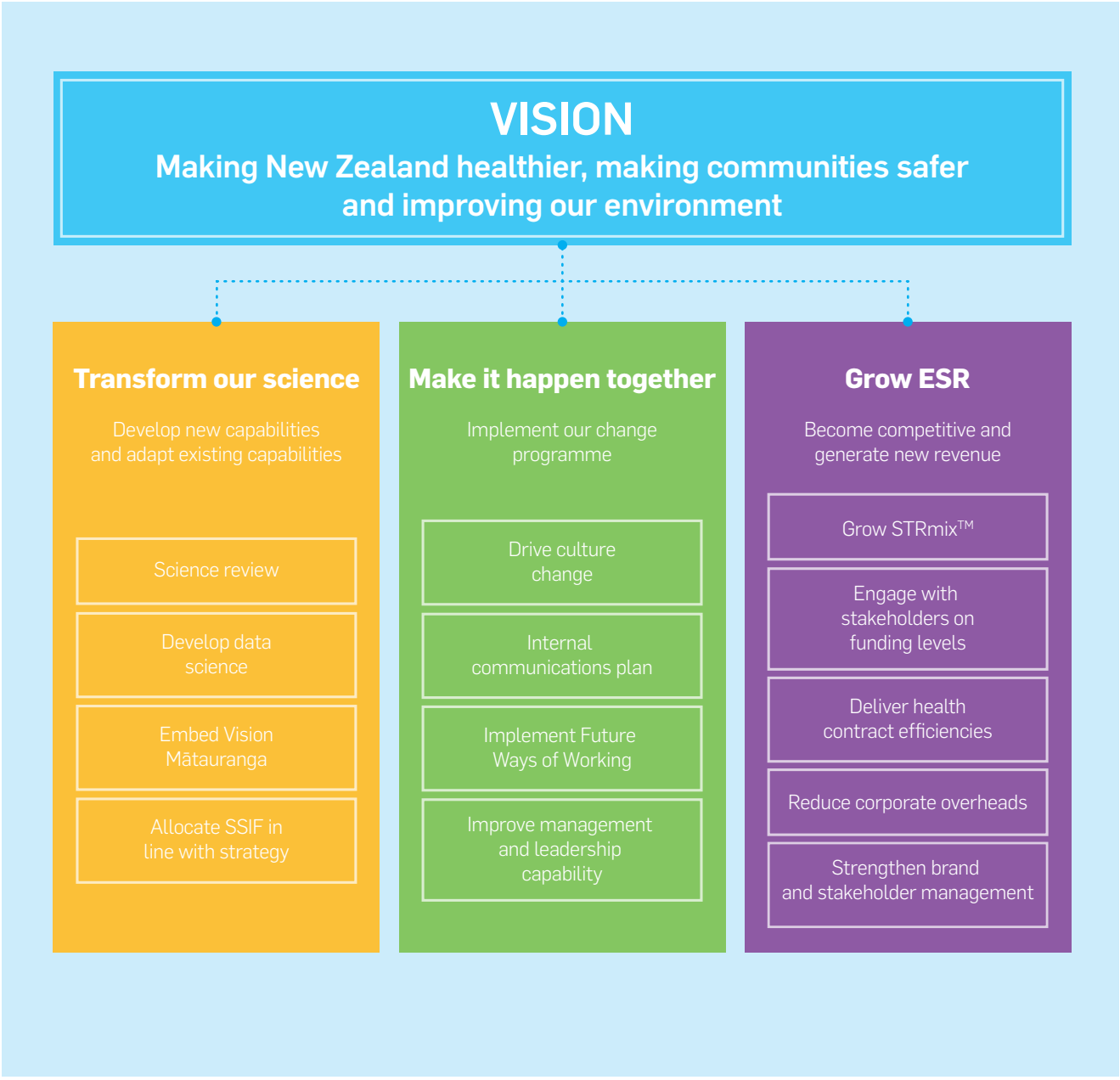
Our aim is to deliver significant improvements in the wellbeing of New Zealanders. We will achieve this by adopting new developments in science and technology, implementing our change programme, and growing ESR to become financially sustainable.

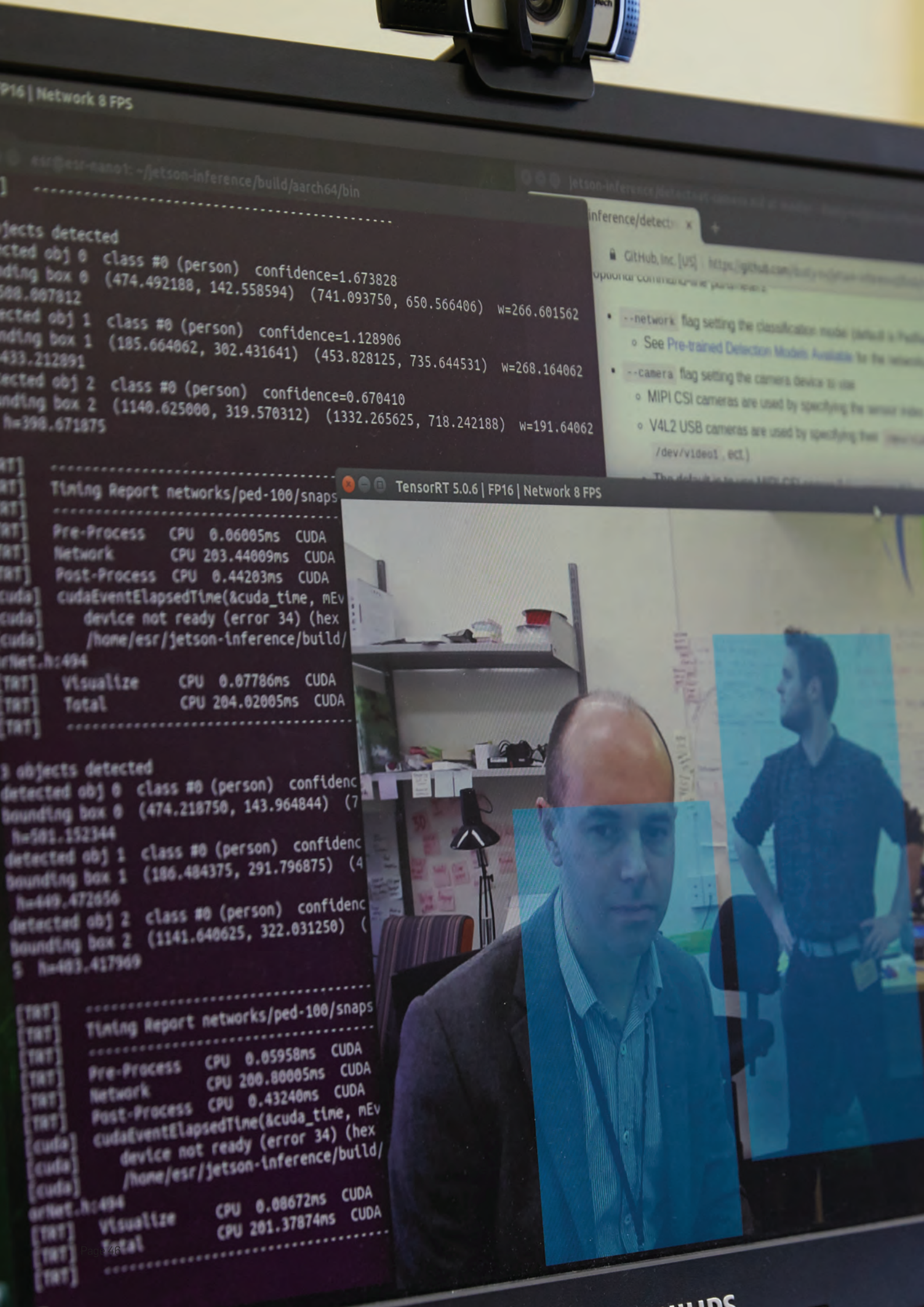
Our *Great Plan for Science*

We are embarking on an ambitious transformation programme to refresh all aspects of our business and position ESR for future success.

All the actions we take will be shaped by our vision: Making New Zealand healthier, making communities safer and improving our environment.

Our goals are to transform our science, work together to make transformation happen, and grow ESR so we can reinvest in our science and continue to improve community wellbeing.

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Transforming our science

Growing our data science capability

Data science has quickly become an essential capability for ESR. We have always been a data-rich organisation but we now collect more data than ever before. ESR's strategic investment in data science capability recognises the changing landscape, enabling us to provide clients with greater insights to inform their decision-making.

This year we invested in new tools and technology, pushed boundaries and proved possibilities through innovative data science projects, and trained more than 100 of our staff – over 25% of ESR's workforce – in data carpentry skills.

The data carpentry course shows people best practices, explains the state of the art and demonstrates quick wins that help to automate the routine. It teaches basic to intermediate use of the statistical programming language R. Our people are shown the 'art of the possible' and the results of trailblazer projects such as our new meningitis explorer dashboard.

In May 2019 ESR hosted data carpentry instructor training in conjunction with New Zealand eScience Infrastructure (NeSI). We trained six ESR staff as instructors and welcomed nine other new instructor-trainees from NeSI, Victoria University of Wellington, NIWA, Genomics Aotearoa and the University of Otago.

Following data carpentry comes the data science accelerator. ESR data scientist Richard Dean encouraged staff at the annual conference to discuss what they do and to pitch ideas at a series of drop-in sessions at our four locations. To be successful, ideas needed to push new data science boundaries, be of high value to the business unit and be achievable within 15 days spread over a three- month period.

Richard says, "The data science accelerator offers enormous potential. We employ incredible domain experts here at ESR. The accelerator helps them get up to speed with the latest tools and technology in a short period of intensive mentoring. It's a win for everyone – business units see it as free consultancy to help them achieve something they needed to do anyway. Our people see it as an investment in their skills, and mentors get to learn about one of ESR's specialist areas."

On the pilot cohort, Richard is mentoring three projects. "I've learned heaps about carbapenamese antimicrobial resistance, helped to streamline how we report invasive pneumococcal disease and been able to transfer some lessons learned on meningitis to a food safety project on listeria."

At our Mt Albert Science Centre, a project being mentored by Janet Stacey and Mark Hareb aims to save three hours a day of manual work by lab technicians by using machine learning techniques to identify DNA alleles.

Richard says, "What's really great about all the data science projects is that they are led by our frontline staff. They can see where inefficiencies lie and together the cohort is stronger than the sum of each individual part." In the past year ESR has invested in new hardware with better data science servers – these include high-powered machines suitable for

Richard Dean and Giles Graham are leading the way in data science.

deep learning and an R studio server that allows anyone with a web browser and an ESR computer to access server-based computing. This forms a natural progression from doing tasks using data and software sitting on an individual laptop and moves ESR towards centralised computing.

Finally, Richard worked on a number of forward-looking research projects, including:

- Our influenza observatory, which took existing data flows, automated the routine and supplemented the data with syndromic surveillance from sources such as Healthline and Google trends
- Developing a meningitis dashboard to combine data from our health systems and WGS, automating manual processes and providing new ways to visualise data more efficiently
- Working with bioinfomaticians to standardise and automate as much of the sequencing pipeline as possible.

Looking to the future, ESR is currently exploring what will make us fit for the future and preparing building work. The work of our labs needs to change, and we need to introduce better ways to capture data to make it suitable for machine learning algorithms.

Richard's next project is to set up a lunchtime code club. "It's going under the working title ERICA – engineering, robotics, innovation, coding and automation," says Richard.

"I'm keen to see our data science initiatives driven by our scientists. We're not some isolated team in a silo. Data science is core to everything we do at ESR. We will work together to solve problems and figure out new ways to work with data."

Embedding Vision Mātauranga at ESR

The meeting point of western and indigenous knowledge provides great opportunities to improve social, economic and environmental outcomes for Māori and all New Zealand. This is an essential capability for ESR and will become part of our cultural DNA.

We have been working to strengthen and improve He Pūtaiao, He Tangata – ESR's Māori economy strategy. The strategy will deliver greater impact and solutions with and for Māori.

ESR is trying to to encourage creative interplay between mātauranga Māori and western science to create new discovery possibilities through He Pūtaiao, He Tangata. This requires a new approach that authentically acknowledges and values mātauranga Māori as a credible knowledge system capable of adding value to our core capabilities. We now have more than 30 partnerships with a range of hapū, iwi and Māori organisations.

We have made good progress in securing external funding to support He Pūtaiao, He Tangata. This includes 11 Māori-led and ESR-supported projects funded by the Ministry of Business, Innovation and Employment's Vision Mātauranga Capability Fund.

To grow our internal capability to engage with Māori, 60 of our people took part in noho marae, gaining a greater appreciation and understanding of Māori culture. Te reo classes at ESR have been particularly popular, with 65 ESR people taking part.

By working collaboratively together – mahi tahi – and using the strengths of Māori and western knowledge and science, we can greatly improve the wellbeing of our communities and our environment.

$2.57m total external funding

11 Māori-led ESR-supported projects

30 partnerships with Māori organisations

60 noho marae experiences

65 staff took part in te reo classes

Weaving together Māori knowledge and western science is an important way that ESR can make a greater difference to wellbeing and the environment

Making it happen together

Collaboration is key to our future success.

Defining the culture we need for future success

In February 2019 we surveyed our staff to understand their experience of ESR's current organisational culture and their desired vision of how our culture might look.

Key stakeholders in different business groups were interviewed to delve further into some of the common themes identified. Following this a culture workshop was attended by our senior leadership team, who identified seven key focus areas that have an impact on people's experiences at ESR:

- Leadership Relations
- Client Relations
- Collaboration
- Change Management
- Performance Management
- Empowerment
- Systems and Processes.

Following this, the senior leadership team has taken responsibility as sponsors for the identified focus areas, and have a team of change champions made up of a cross-section of volunteers from ESR. These change champions, together with our people, are implementing a range of short- and long-term initiatives to enhance our culture in these seven focus areas.

Strategy launched at ESR conference

This year, for the first time, all ESR people from across New Zealand were brought together in one place. The theme of our conference was 'Transform our Science'. The Connections conference was an important opportunity for all staff to understand why ESR needs to change, to understand how other organisations are implementing change, and to share examples of innovation already underway across ESR. Our *Great Plan for Science* was launched at the conference.

The aim was for our people to envisage what science might look like in the future and how they will contribute to the new journey.

Giving our people a Licence to Act

One of the focus areas where we are already making progress is Empowerment. Giving people permission to act or a 'Licence to Act' is an effective lever to shift the culture mind-set at ESR, particularly in terms of organisational structure and how we respond when mistakes happen.

A series of initiatives to improve the sustainability practices in ESR was initiated in early 2019. This is an excellent example of empowering our people with a Licence to Act. A team of volunteers across ESR have committed to making a difference to the way we work and live more sustainably.

Initiatives to reduce the amount of energy we consume, minimise our waste and reduce our carbon footprint have been launched. Our senior leaders agreed to commit to a budget to achieve our future sustainability goals.

ESR is committed to being an environmentally friendly organisation and encourages staff to consider things that we, not only as an organisation but also in our personal lives, can do to act more sustainably.

Keith McLea presents Wendy Popplewell of ESR's sustainability committee with a Licence to Act.

ESR Transformation Award – Mark Hareb

At ESR's Connections 2019 conference, an award was made recognising a staff member who has ESR's future in their vision, and has transformed the way we meet the needs of our clients and all New Zealand. Importantly it was our staff who nominated a peer who exemplified these virtues.

Winner Mark Hareb worked with the University of Waikato to develop his machine learning skills and has built and trained models for both fourier-transform infrared and near-infrared devices. These devices analyse molecular properties, which produce a spectral fingerprint of a material, such as an active pharmaceutical ingredient. Mark has integrated this work with handheld devices, prototyping both hardware and his machine learning models to develop an end-to-end solution for New Zealand Police.

Much of Mark's learning is done in his own time at night, and he is becoming a centre of expertise. He is very proactive, self-training and upskilling. Through his relationship with the University of Waikato he has also facilitated image analysis for sperm identification.

Mark is openly demonstrating and connecting people with his work and is facilitating training workshops for colleagues on this topic. Mark pushes the boundaries and shows great team spirit, helping and coaching colleagues.

To top this off, Mark is a can-do operator with a good blend of science and technical skills.

The ESR team at Mystery Creek Fieldays, part of the award-winning CRI stand 'Science – Growing the Future of New Zealand.

Communicating our science

ESR has continued to build brand awareness by proactively communicating stories that demonstrate how our science assists with important challenges facing New Zealand. We have had a notable increase in media coverage due to an investment in researching and developing stories. In a single week, ESR was featured online in Stuff, New Zealand Herald, multiple newspapers and RNZ's Morning Report, with stories covering designer drugs, the universal influenza vaccine, cleaning up our waterways with native plants and testing our water filtration systems.

In June 2019 ESR went to Mystery Creek in Hamilton for the first time. The purpose was to raise our brand profile, create greater awareness of the work we do and showcase our innovative science.

We were very proud to win the Supreme Site Award at this four-day event. The award was given to ESR, along with Crown Research Institutes Scion, Manaaki Whenua and AgResearch. It recognised how the combined CRI stand, called 'Science – Growing the Future of New Zealand', educated people on how innovative science is helping the rural sector and New Zealand as a whole.

Adopting future ways of working

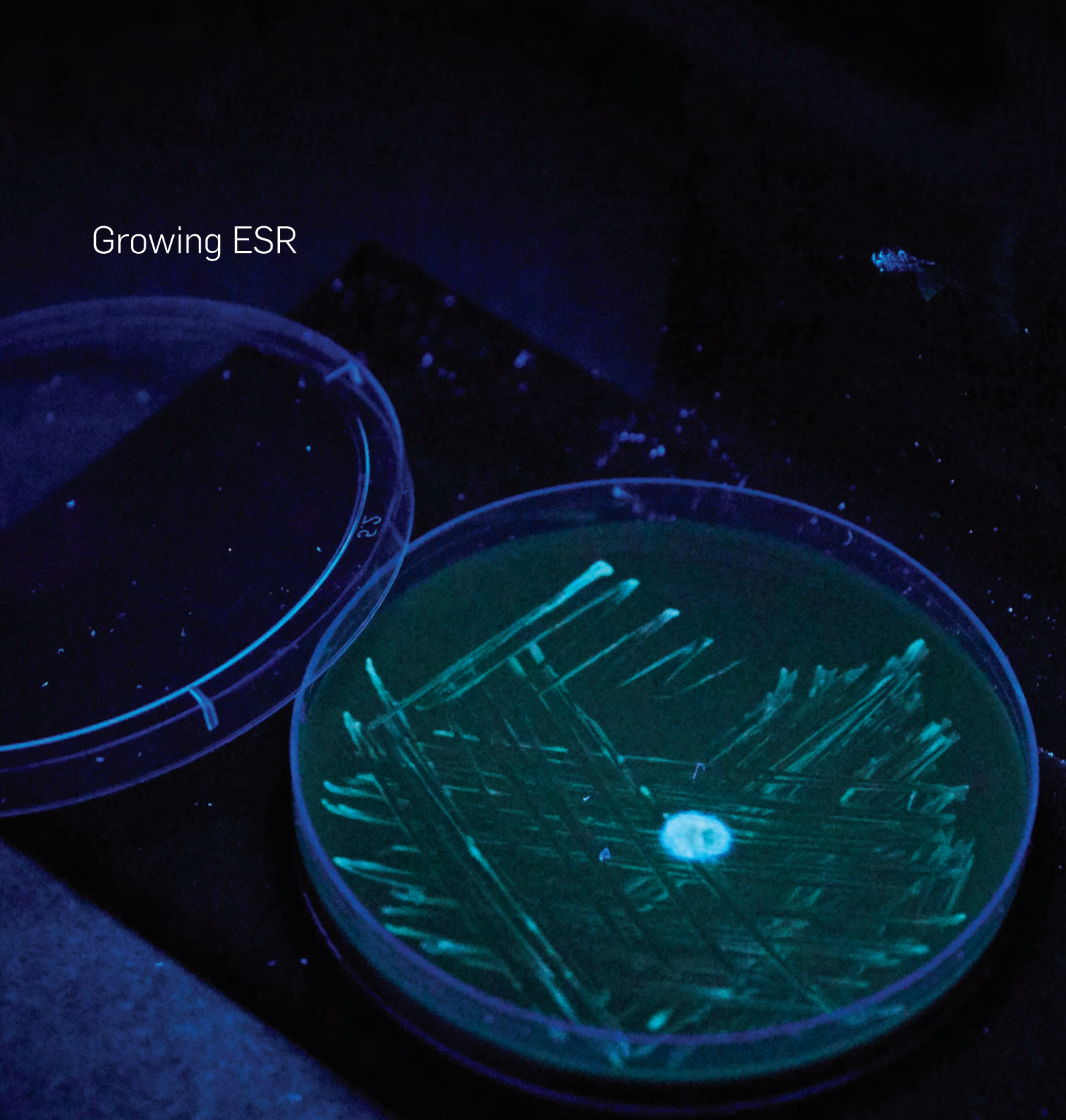
Our Shareholding Ministers were provided with an Indicative Business Base for the replacement of ESR's ageing Kenepuru facilities. Warren and Mahoney Architects was appointed as our lead consultant for the property redesign process, and will be working with a specialist laboratory design firm and workplace strategists.

Input was gathered through a series of staff focus workshops and surveys, which informed the delivery of our new ESR Workplace Strategy. The strategy identifies workspaces that are designed for our future needs, and will enable agile, connected and flexible working environments. The Workplace Strategy was critiqued by our senior leadership team and then socialised with our people. Feedback was very positive and the strategy will now inform our future property needs and initiatives.

The Workplace Strategy presents our vision for the changes required to support our people, processes, technology and place. We have already begun our journey with technology enhancements such as Figshare – an online open-access repository for research, OneDrive for Business – a cloud service for connected files, and Teams – a unified communication platform for collaboration.

This has set the platform for our people to adapt and adopt new, efficient ways of working in the future.

Growing ESR



Growth is essential to fund ongoing investment in our science and keep ESR at the forefront of complex issues facing New Zealand communities.

We are growing international revenue from our commercial products, diversifying our revenue base and generating additional funds for investment. This year we generated $12.4 million in international revenue from our innovative products and services.

We continued to invest an increased amount in research through our Pioneer Fund, providing stage-gated funding for innovative research and developing new products and services.

Increasing the amount of research we do is another area we are focusing on to grow ESR. This year we began researching the impacts of microplastics and the threat to New Zealand's ecosystems, flora, fauna and people. This multi-year, $12.5 million Endeavour Fund project is the largest single research grant received in ESR's history.

We are planning to reduce our overheads and improve our efficiency, so that we are as competitive as possible when bidding for science services and research. We aim to be a commercially focused organisation and free up as much of our money as possible to invest in science.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Our innovative research

Growing our research will lead to more innovative products and services in the future and improve the health and wellbeing of New Zealanders. This is a key part of ESR's business growth strategy.

Collaboration is key

There is hardly an area of our business or science that does not include collaboration.

ESR works collaboratively, both internationally and nationally, with other CRIs, universities, research and science institutions, scientists, teachers, technicians and government ministries. It is this collaboration that enables us to share and learn expert knowledge, that informs some of our world-leading research.

Some of the world's most prestigious health institutions award funding to ESR-led projects. Many of our scientists are world authorities in their chosen fields of expertise, contributing to knowledge of best practices and health outcomes on an international stage, including the United Nations.

This year new collaborations with CRIs and other research organisations included a GNS-led project on groundwater modelling, a University of Canterbury Smart Ideas proposal on using recycled tyres for seismically improved foundations, and a NIWA-led Smart Idea proposal on rivers as dynamic transport vectors of plastic pollution to the ocean. ESR is also part of a New Zealand-wide, collaborative research platform for genomics and bioinformatics, Genomics Aotearoa.

Publishing our innovative research

ESR scientists publish in a range of national and international journals. By having one paper published in a journal with a high impact factor, ESR's key performance indicator for 'potential quality' increased from 3.06 to 3.93. The potential quality indicator is the average impact factor for the set of peer-reviewed papers published in the calendar year prior to reporting. This is a significant increase and reflects the importance of publishing in high-value science journals. A paper on *the molecular surveillance of norovirus*, 2005-16 appeared in *The Lancet Infectious Diseases* journal. It had 32 authors, including Joanne Hewitt, ESR's Enteric, Environmental and Food Virology scientist.

ESR's human genomics group had a previously published paper selected for a special section of the prestigious journal *Obesity*. *Obesity* is the journal of the Obesity Society, the leading professional society focused on obesity science, treatment and prevention.

Editors selected the paper for the Recent Best of Obesity, a section of the journal highlighting "cutting edge research" by top authors.

ESR scientists, along with New Zealand and US collaborators, led the research for the paper on the role of microRNA as biomarkers for insulin resistance and diabetes.

David Wood and Phani Atmakur preparing the Annual Report on Drinking-water Quality for the Ministry of Health.

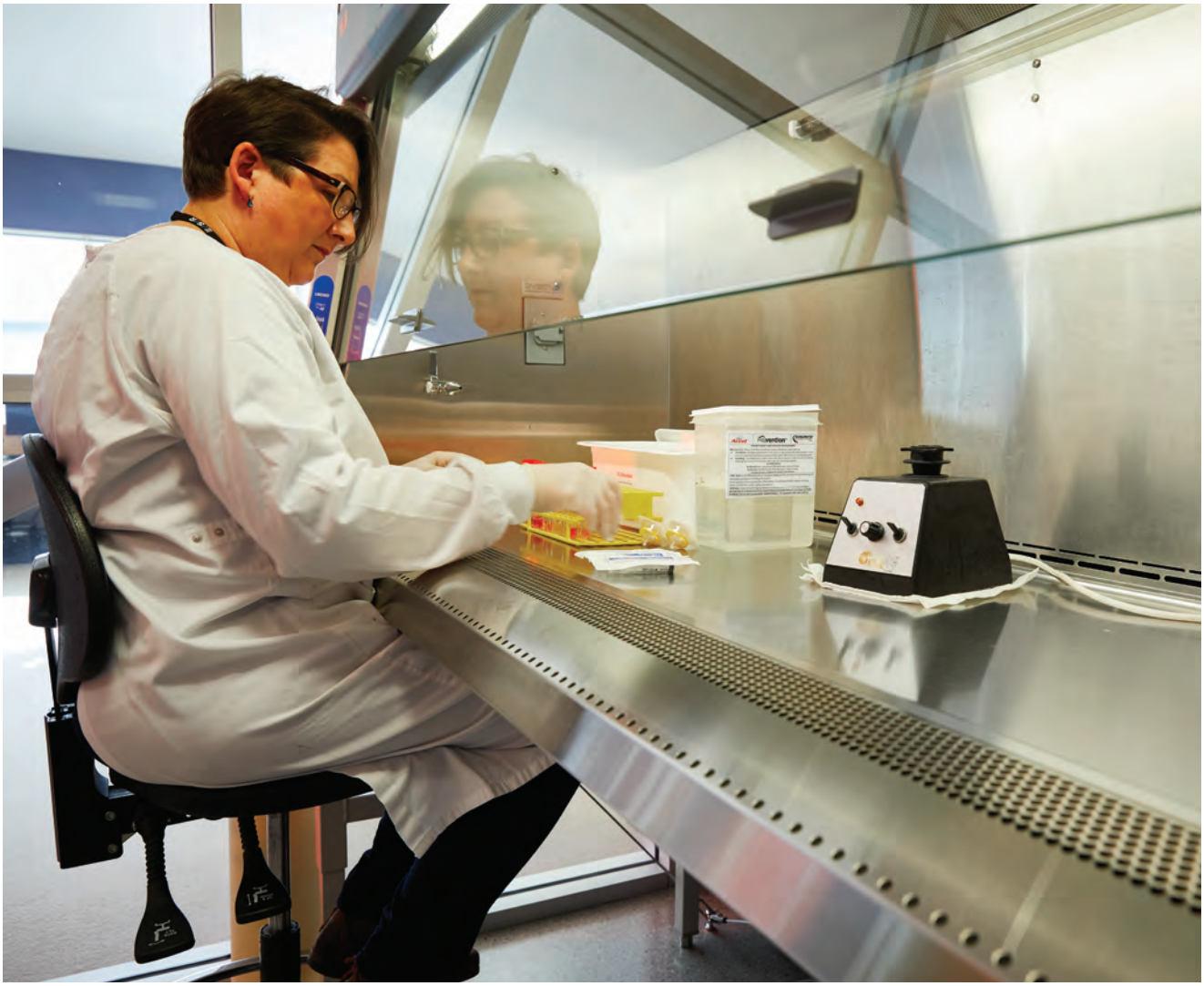
The New Zealand-based research was supported by ESR's core and Pioneer Funding.

Continuing our innovative influenza study

More people die from influenza and influenza-related illnesses than die on our roads. Influenza, unlike a common cold, is a serious illness that affects hundreds of thousands of people globally. In New Zealand, young children and the elderly are particularly vulnerable to its infection.

ESR is working internationally to develop a longer-lasting, more effective, global influenza vaccine, to reduce the burden of health and population mortality.

International collaboration on influenza research, funded by the US National Institutes of Health, aims to improve vaccine effectiveness in New Zealand and globally.



Robyn Madge filter-passing on influenza isolates.

The purpose of the SHIVERS-II study is to better understand the immunity or protection people have against influenza through infection or vaccination.

The SHIVERS-II influenza adult cohort research, funded by the US National Institute of Allergy and Infectious Diseases (NIAID), aims to better understand the immunologic effects of repeated annual vaccinations, to guide future universal influenza vaccine development and policies. SHIVERS-II established a group of prospective adult participants aged 20-69 in Wellington in 2018.

The study followed participants who provided paired pre- and post-influenza season blood samples. The study also followed all participants weekly and collected respiratory specimens from those reporting influenza-like illness (ILI). These specimens were tested for influenza by PCR (polymerase chain reaction), which is a very precise laboratory technique used to make multiple copies of a segment of DNA).

Additionally, study staff collected paired blood from those with influenza-PCR-confirmed ILI, as well as a once-only blood samples from those who had annual influenza vaccinations.

The SHIVERS-II study was highly praised and valued by funder NIAID for its quick turnaround time in study initiation, large cohort size, high-quality information and excellent retention rate of participants (93%, 2,051/2,211). NIAID provided an additional US$1 million in funding to extend the cohort for another year in 2019.

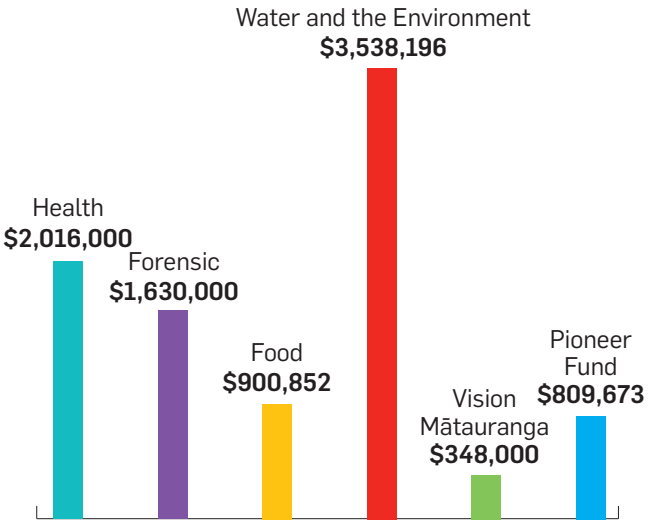
Based on the success of the SHIVERS-II study, a significant funding grant was awarded to ESR in June 2019 for SHIVERS-III. This will continue the study into influenza immunity in infants and babies. The US$3 million, funded by the US National Institutes of Health through St. Jude Children's Research Hospital in Memphis, will be allocated between 2019 and 2026.

Strategic Science Investment Fund research

To support our core research platforms of human and environmental health and forensic science, ESR received $9.2 million from the Strategic Science Investment Fund in the 2018/19 financial year.

This scientific investment fund is to support ESR's core business, investing in long-term research projects that will have significant outcomes for the business, and ultimately our environment, community and population health, safety and wellbeing.

Funds were allocated to ongoing research projects in the genomics and bioinformatics portfolio, National Science Challenge-aligned research, and human health, biowaste, groundwater and environmental health. Newly funded research included the use of machine learning to examine vein patterns and BPA, developing techniques to type bacteria directly from clinical samples and expanding the use of genomics in food safety.



Responding to changes in diagnostic methods

Identifying the micro-organism responsible for an infection is critical to the appropriate treatment being given. This diagnosis is normally carried out by taking a sample from the patient and culturing any organisms present. From this the pathogen responsible for the infection is usually identified and treated accordingly.

Recently, however, new tests have been developed that do not require culture. These are called culture-independent diagnostic tests (CIDTs) and can directly test a sample for the presence of a pathogen. The significant advantage of these tests is that they are simpler and quicker to do, and they are also less expensive. Because of this, they are rapidly replacing culture as the method of choice for the diagnosis of infection.

However, there is a downside to CIDTs – the organisms are not available for further testing that supports public health measures.

The surveillance of infectious disease and the effective management of public health issues are dependent on an understanding of the relationship of the isolate to others of the same type. For example, in a foodborne outbreak it is important to show that an organism isolated from food is the same as the one causing the human infection. If they're not the same then a different source of the organism has to be found. This also helps to identify who is and isn't part of an outbreak. Understanding the relationships of organisms is also important when monitoring cases of vaccine-preventable diseases.

Determinations of relationships between organisms of the same type are usually performed by specialist laboratories like ESR. We receive isolates from diagnostic laboratories and

Yoryea Mantziou running the whole-genome sequencer.

undertake specific tests to show how closely related different isolates are. The loss of isolates through CIDTs means we have to think about how we can obtain this information when there are no isolates. Because of the importance of this information for public health, ESR is working on a Genomics Aotearoa gonorrhoea project and has invested strategic science investment funding in a meningococci project to look at ways of testing samples without the need to culture.

We are targeting DNA from the pathogen present in the sample to get the information. This is not trivial because the sample contains DNA from the host and from micro-organisms that normally occupy the sampling site, or could have contaminated the sample as it was taken.

ESR is using methods that increase the amount of DNA in a sample from a pathogen of interest, which can then be sequenced using a WGS approach to obtain the relevant information. The small amount of DNA present means our laboratory and bioinformatic approach needs to be rigorous to ensure we obtain the correct information from the sample.

Our aim is to have an accurate and reproducible process to deal with changes in the diagnosis of infectious disease and Their impacts on public health surveillance.

DNA-based sensors to detect pathogens

Rapid, point-of-use sensing devices have the potential to transform significantly the way traditional laboratory diagnostic services are delivered across multiple sectors, including those in ESR's key impact areas of health, environment, food and forensics. Through Strategic Science Investment Fund, ESR has funded a project to develop and trial aptamer-based sensors (aptasensors) for the detection of pathogenic micro-organisms. This could also be applied to the development of aptasensors for other chemical and microbial targets.

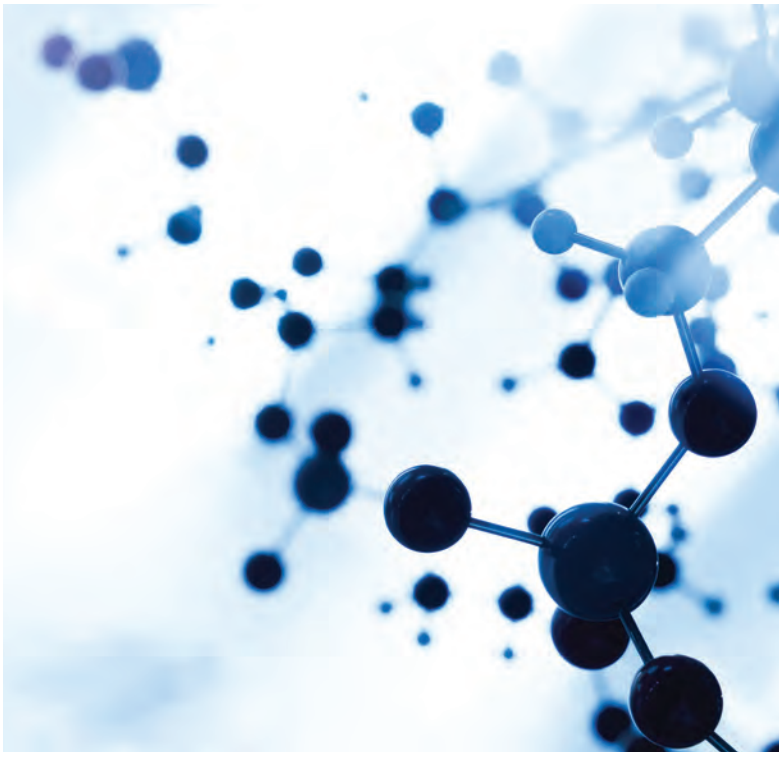
Aptamers are single-stranded RNA or DNA oligonucleotides that fold into three-dimensional structures. They can bind target molecules with high specificity and affinity. Targets can include cells, viruses, proteins and small molecules such as antibiotics. Aptamers have similar properties to antibodies, but are far more stable, have equal or greater sensitivity and can be easily synthesised. These properties make them superior to antibodies for use in diagnostic devices.

Specificity for the target is generated by an in vitro selection and amplification technique known as SELEX (systematic evolution of ligands by exponential enrichment). In SELEX, a DNA or RNA library is incubated with the target molecule. Unbound nucleic acid sequences are separated from target-attached sequences, then the target-bound sequences are released and used as a template for PCR amplification. This cycle is then repeated until highly enriched aptamers are generated. ESR is investigating aptasensors for the detection of *Staphylococcus aureus* and *Yersinia enterocolitica,* two important bacterial pathogens.

Evaluative reporting for forensics

Forensic scientists are often unable to answer the questions that the courts really want to know. We can say with a reasonable degree of certainty that a DNA profile obtained from a bloodstained area may have originated from a particular person. What we are unable to say is that the DNA originated from the blood, because it may have originated from a different source such as skin or saliva. It is also often not possible to associate any blood detected to a crime event because of a lack of scientific studies into the transfer and persistence of blood and/or DNA in different situations. In other words, we cannot say that the DNA profile of a particular person came from the blood in the stain, or how it got there or when; we rely mainly on unstructured and unpublished personal knowledge (experience) to answer these questions.

Evaluative reporting frameworks can be used to obtain a formalised assessment of the relative weight to be attached to scientific findings in relation to an activity that took place or the source of a sample. These frameworks provide a standardised approach based on hypotheses and likelihood ratios. Our research provides new statistical frameworks for forensic science services, underpinning the robust and evidence-based approaches to evidence interpretation. We have developed a software program called 'E-glass' that incorporates new mathematics to overcome the limitations of existing statistical models used to interpret glass evidence. We have also produced a Bayesian network statistical model for the determination of saliva that assists experts in interpreting body fluid evidence in an evidence-based way.



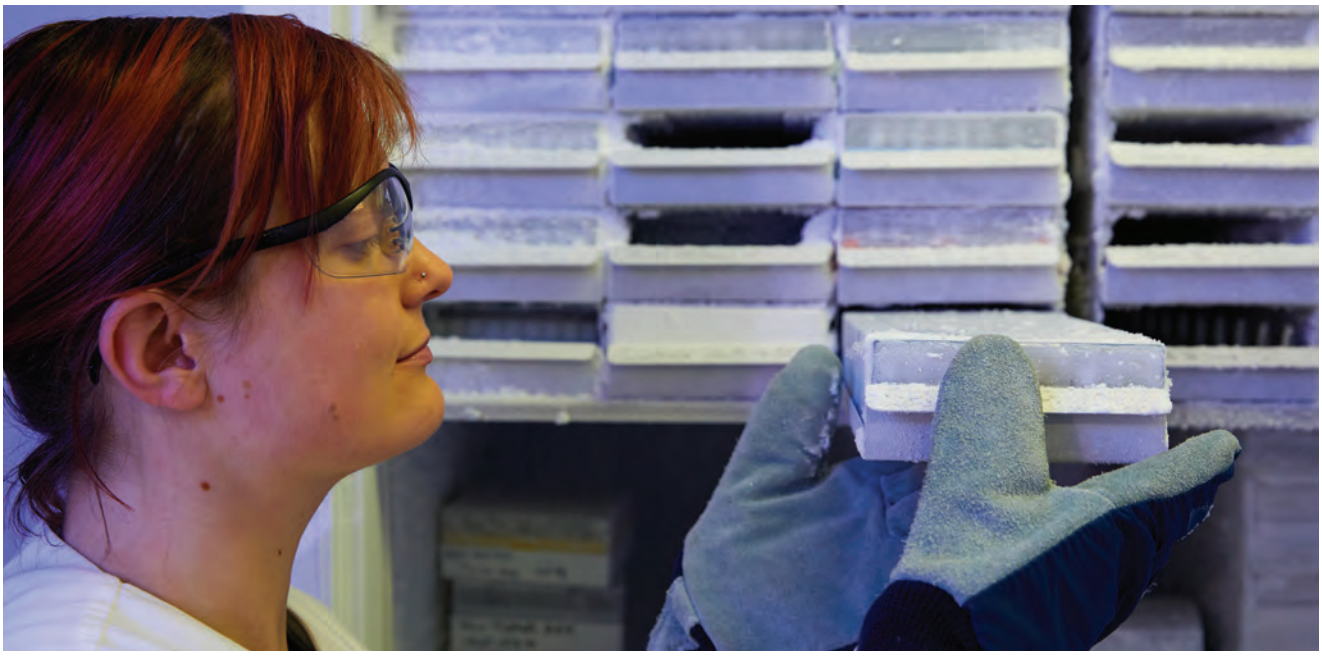
Pioneer research

ESR's Pioneer Funding is designed to kick-start 'fast-win, fast-fail' bright ideas from inception (up to $30,000) through to commercial application (up to $100,000). Projects funded this year include:

PROJECT	PURPOSE
The role of microplastics in antimicrobial resistance in the environment	Measuring the capacity of microplastics to concentrate antibiotic resistance and virulence genes in the environment.
Fourier-transform Infrared Machine Learning Validation and Near-infrared Device Evaluation	Developing a validation framework to test the accuracy, precision, repeatability and robustness of machine learning models used to interpret fourier-transform infrared spectra of controlled substances.
The use of RNA to diagnose sports-related concussion	Proof-of-concept study to evaluate if RNA markers of concussion can be detected in saliva from athletes who have sustained sports-related concussion.
Dark Net Drug Monitoring	To build a prototype real-time collection, storage and analysis process for dark net drug data.
Deep Learning for Groundwater Flow and Transport Modelling	To look at whether deep learning can assist in and provide new insights for the modelling of groundwater flow and transport of contaminants.
Extending drug surveillance – synthetic cannabinoids in wastewater	Feasibility study into the potential to detect and monitor synthetic cannabinoids in wastewater.
Exploring further value in the wastewater stream: a multi-drug analytical approach	Further developing ESR's drugs in wastewater capability by extending the range and types of drugs that can be detected and routinely monitored. The project focuses on prescription drugs, counterfeit and adulterated medicine targets, and other illicit drugs not currently monitored.

Our people

A continued focus on people and culture is critical to our success. To meet the science needs of New Zealand, deliver to our customers and increase our revenue, we work to attract, retain and develop a capable, high-performing workforce.



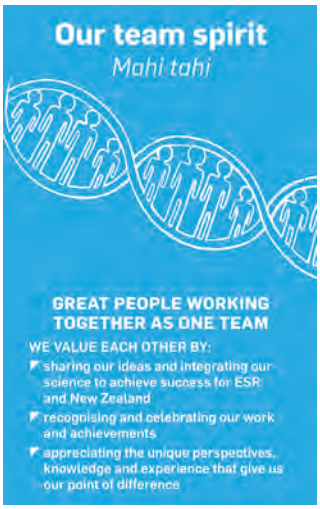
People are our greatest asset and we must invest in them to ensure that ESR continues to deliver world-class science and leading-edge technology, which underpins everything we do.

To retain our people it is important that we have a culture that empowers them to do their jobs. We want them to have a 'Licence to Act' – to make sure they are encouraged to perform to their best and feel safe in their environment and with their colleagues. Culture is about the way we do things, and we are transforming our culture to get the best out of our people and our managers.

Our values

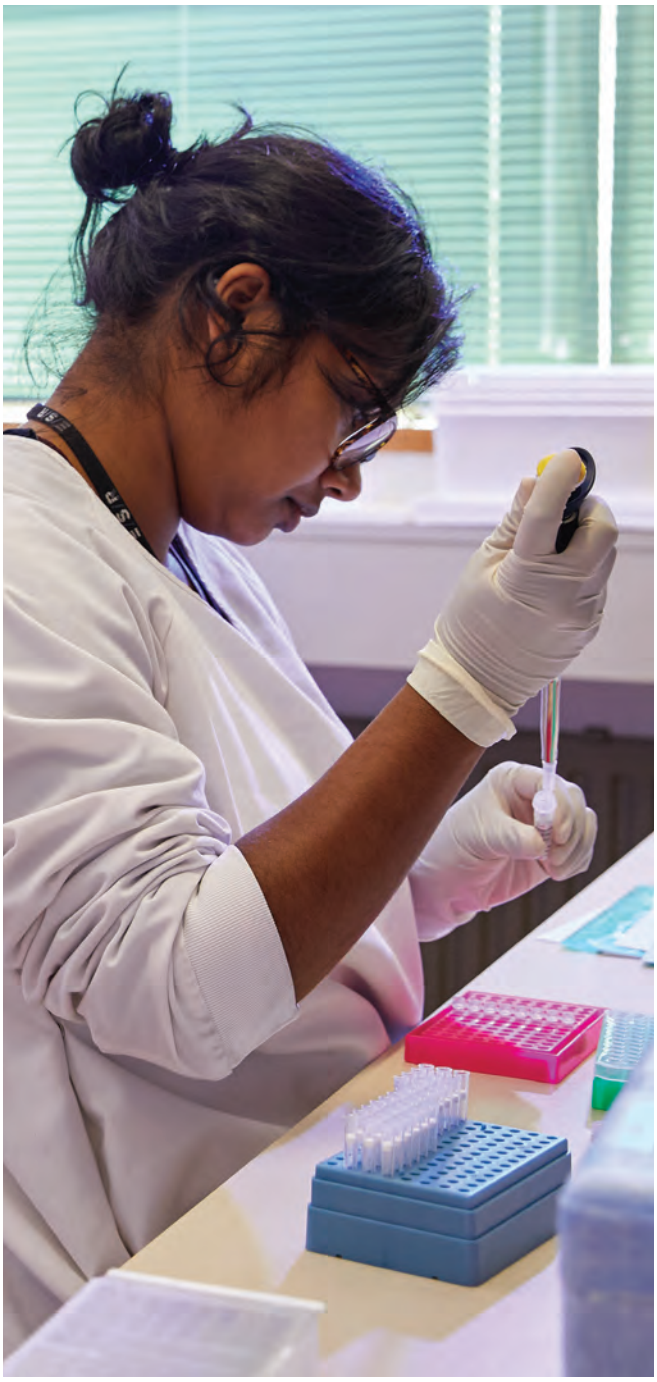
Our values ensure we are trusted advisors, delivering leading-edge science solutions and quality services for the greater good of our organisation and beyond.

Our organisation's values define how we work together and with our clients. Developed by our people, our values are a reflection of what is important to us as we strive to help keep people safe, healthy and prosperous.



Our workforce profile

One of our strengths is the diverse range of people we have working for us. They include New Zealand European/Pākehā, Māori, Pasifika and Asian. The majority of our staff (79%) are employed in science roles. Women make up the majority of our workforce (63%) and are well represented at all levels and in all roles in our organisation. We have a stable workforce with turnover at 8.21% for the year ending 30 June 2019.



2018/19 workforce statistics

Actual as at 30 June 2019	Actual as at 30 June 2018
420 total staff	**408** total staff
346 full-time staff	**330** full-time staff
74 part-time staff	**78** part-time staff
79% staff engaged in science	**81%** staff engaged in science
63% female staff	**65%** female staff
37% male staff	**35%** male staff
36% aged 20-40 years	**36%** aged 20-40 years
53% aged 41-60 years	**54%** aged 41-60 years
11% aged 60+	**10%** aged 60+

	As at 30 June 2019	As at 30 June 2018
New Zealand European/ Pākehā	**246**	230
Pacific peoples	**8**	8
Asian	**56**	63
Māori	**11**	8
Other European	**95**	95
MELAA*	**4**	4
Disability profile	**<1%**	<1%

*Middle Eastern, Latin American and African

Good employer principles

This year we continued to demonstrate our commitment to being a good employer and advocate organisation-wide equal employment opportunity (EEO) practices relating to the recruitment and selection, development, management and retention of all staff.

The table below shows our achievements against the seven key elements of being a good employer, as set out by the New Zealand Human Rights Commission.

GOOD EMPLOYER KEY ELEMENTS	WHAT WE DELIVERED IN 2018/19
Leadership, accountability and culture	• Our leadership team communicated the strategic direction and organisational goals to staff at all levels. • Our Culture Programme initiatives were launched with a focus on leadership relations, collaboration and empowerment. These focus areas are important for building the right culture to support our transformation programme. • ESR strives to ensure that our performance management system and development process builds a high-performance culture with clear accountability, alignment with organisational goals and business plans. Our performance management system is being redeveloped in collaboration with staff to ensure we are meeting the needs of our employees.
Recruitment, selection and induction	• Recruitment and selection processes are in place that foster EEO principles. Recruitment is focused on competencies, values, skills and experience and backed by appropriate assessment and selection tools to ensure the best candidates are selected in a fair and equitable manner. • Our new employees receive a thorough induction that included familiarisation with key policies and processes. • We are using Government Jobs when advertising new roles and we are looking at options to streamline our on-boarding process by digitising the process using our current recruitment tool.
Employee development, promotion and exit	• Our performance management and development system encourages employee development by providing clear and achievable progression through building technical skills and behavioural competencies. Throughout the year we offered on-the-job opportunities, internal secondments and attendance at national and international science conferences. • We are currently reviewing employees' experiences of performance discussions as a focus area of the Culture Programme. • Our annual science promotions process supported career progression for our science staff.

GOOD EMPLOYER KEY ELEMENTS	WHAT WE DELIVERED IN 2018/19
Flexibility and work design	• Flexible working arrangements continued to be high on the priority list for employees. As at 30 June 2019, 18% of our employees worked part-time. • A considerable number of employees used their volunteer days to support activities in the community.
Remuneration, recognition and conditions	• Our terms and conditions of employment are consistent with the good employer philosophy, with a range of benefits valued by our employees. • We reward people fairly and equitably on the basis of contribution, regardless of gender, age and ethnicity. The remuneration review focused on moving towards aligning our median with relevant market data, helping staff feel valued, recognised and appropriately rewarded for their contributions to help nurture a high-performance culture. • We have two annual staff awards that recognise and celebrate individuals and teams for their achievements.
Harassment and bullying prevention	• Our code of conduct and acceptable behaviour policy set out the standards of behaviour expected of all our people, how to deal with unacceptable behaviour including harassment and bullying, and where to access further information and support if required, including the Employee Assistance Programme (EAP). • New employees are introduced to the policy and given training as part of their induction. The policy is reviewed regularly. • We align our approaches with the bullying guidelines produced by WorkSafe to ensure we are following best practice.
Safe and healthy environment	• Our health and safety policies and procedures have been reviewed and we have developed a comprehensive programme of work that is currently being implemented. • We are increasing our emphasis on wellbeing and developing a programme of work. • We are working towards certification to AS/NZS ISO 45001:2018 Occupational Health and Safety Management Systems. • We have implemented improved reporting and an electronic platform for hazardous substances' health and safety management, and we are updating all training systems, guidelines and supervision in relation to the Health and Safety at Work Act 2015. • Our EAP was extended to include a trauma support programme providing tailored support to assist staff in dealing with the physical and psychological symptoms that are associated with exposure to traumatic events, unpleasant information or ongoing traumatic experiences as part of their roles.

Recognising excellence

Our scientists are among the world's best in their respective fields. They are disciplined in their approach to their research and seek to find outcomes that will make a difference. Global health, environmental sustainability and security and justice are what drives our people.

ESR boasts the largest team of forensic, social, radiation, environmental and infectious disease scientists and epidemiologists in New Zealand.

Many of our people are invited to present papers and collaborate on their work at international fora, an accolade in itself. Several of our people were recognised and acknowledged many times this year.

Proof of the calibre of this science excellence can be seen in our people receiving some of the most prestigious international and national awards, and invited to participate in scientific and advisory committees both internationally and nationally.

Notable awards

The Ian Riebeling Memorial Medal was awarded to Mickayla Dustin by The Australian and New Zealand Forensic Science Society.

Rebecca Richards was awarded the ANZFSS Society Symposium Award.

The Shimadzu Prize for Industrial and Applied Chemistry was awarded to Darren Saunders by the New Zealand Institute of Chemistry.

Science New Zealand Early Career Researcher Award

In 2016 Dr Meg Devane completed her PhD in freshwater management, on the development of better water quality indicators for understanding the movement and persistence of faecal bacteria in freshwater systems. She has shown national leadership in the area of naturalised *E. coli*, developing and instigating approaches for investigating environmental sources of *E. coli* and methods for distinguishing these from enteric *E. coli*.

Science New Zealand ESR Individual Lifetime Contribution to Science Award

John Buckleton's caseworking experience covers 34 years and extends across the United Kingdom, the US, Australia, the Netherlands and New Zealand. Currently he is most well known for his work with STRmix™ and mixture deconvolution. However, his research interests have applied probabilistic methods to many other areas of forensic science. In New Zealand John is our most widely cited forensic scientist and internationally our most well known.

Science New Zealand Team Award

The SHIVERS team has contributed new insights into the burden of influenza, vaccine effectiveness, influenza immunology, respiratory syncytial virus, and other respiratory viruses, especially among children and older adults. The study has resulted in more than 17 peer-reviewed publications. The project has had its fair share of awards over the years, being selected by the Ministry of Business, Innovation and Employment in 2016 as one of five case studies of science impact in New Zealand, in terms of its beneficial changes in economic, health, social and cultural outcomes.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Leadership

ESR Board members

Denise Church QSO, CFInstD, *Chair*

Denise Church QSO was appointed as Chair of the ESR Board in July 2015. She is a Director of Leadership Matters Limited, a Wellington-based strategy and leadership practice. She has extensive governance experience including as Chair of Airways New Zealand, the Karori Sanctuary Trust and the Wellington Zoo Trust, and is a Chartered Fellow of the Institute of Directors.

Her other board roles have included of Scouts New Zealand, the National Health IT Board, Ako Aotearoa, Manaaki Whenua – Landcare Research and the Foundation for Research, Science and Technology. Denise was previously Chief Executive of the Ministry for the Environment.

Quentin Hix, *Deputy Chair*

Quentin Hix has many years' experience in governance roles in a broad range of sectors. He is currently a director of Ngāi Tahu Holdings Limited, one of the South Island's larger investment companies. He is also a member of the main governance board for Ngāi Tahu, and is a board member for Presbyterian Support South Canterbury. Previous roles include chairing Westland Holdings Limited and Trust Aoraki Limited and being a director of Hunter Downs Water Limited, as well as holding a ministerial appointment to the South Canterbury District Health Board. Quentin is a lawyer with experience in most areas of the law. He currently practises mostly in the field of criminal law.

Richard Gill

Richard Gill is a technology innovator and serial entrepreneur who has more than 30 years' experience in founding and growing high-tech companies serving a wide range of industries, including broadcasting, manufacturing, finance, education, healthcare and cleantech. He works extensively in technology development, product conceptualisation, early-stage commercialisation and high growth execution. He is the Chief Executive of events workforce technology start-up Blerter.

Dr Helen Darling

Dr Helen Darling graduated with a PhD in public health from the Dunedin School of Medicine, University of Otago and has founded three companies that work in the area of food integrity, including a tech start-up that is using artificial intelligence to address food safety concerns.

Helen continues to work in the area of commercialisation of food integrity services and is particularly interested in the application of technology to enhance global food supply chains. In addition to industry and business knowledge, she has more than 20 years' governance experience; she is currently on the US Pharmacopeial (USP) Convention Food Ingredients Expert Committee and on the USP's Food Adulteration Expert Panel. She is Chair of the People, Performance and Remuneration Committee.

Dr Andy Shenk

Dr Andy Shenk graduated with a PhD in biological sciences from the University of Delaware, and has had a 30-year career spanning academic research, management and governance in biotechnology and nutrition start-up companies, and senior management in a major corporate.

Andy currently works across many fields of research, development and the commercialisation of intellectual property, including early-stage investing in new technologies here in New Zealand and overseas.

Professor Cristin Print

Professor Cristin Print is a medically qualified biomedical scientist who joined the ESR Board in August 2017. He has a 25-year career in academic medical research and biotechnology, including work in Australia, the UK and Japan.

He is a Professor in the University of Auckland's Department of Molecular Medicine and Pathology, where he uses genomic and bioinformatic technologies alongside traditional pathology to better understand human disease.

Cris is currently Chair of the Auckland Regional Tissue Bank's Scientific Advisory Board, a Principal Investigator in the Maurice Wilkins Centre, Director of Auckland's Genomics Into Medicine initiative, on the Science Leadership Team of the Healthier Lives National Science Challenge and Vice President of the Auckland Museum Institute.

Kate Thomson

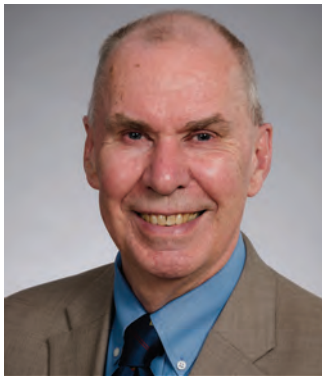
Kate Thomson was appointed to the ESR Board in July 2018. Currently she is Chief Financial Officer of and leads the Strategic Enablers Group for the Australian Road Research Board. She is also a member of the Indigo Shire Council Audit and Risk Committee Independent Board. Kate was Chief Financial Officer at NIWA for six years until 2012, and was a member of the New Zealand Financial Reporting Standards Board from 2009 to 2011. Kate has held a number of senior roles in the commercial sector during her career.

Facing page. ESR Board members left to right: Dr Andy Shenk, Richard Gill, Denise Church (Chair), Dr Helen Darling, Quentin Hix, Kate Thomson and Professor Cris Print.

Strategic Science Advisory Panel

Dr Ian Elsum, Australian National University

Dr Ian Elsum (PhD, BSc Hons) is a Visiting Fellow in the Research School of Management at the Australian National University and an Adjunct Professor in the Centre for Transformative Innovation at Swinburne University of Technology. His research and teaching are focused on the management of innovation. He is a member of Innovation Research Interchange (previously the Industrial Research Institute), where he has co-chaired projects to improve the management of radical/breakthrough innovation and the challenges of business model innovation in established firms. Past positions include 28 years with CSIRO, where he gained extensive experience in the strategic management of applied research and membership of a number of boards and advisory committees in the area of science and technology-based innovation. Before joining CSIRO he carried out fundamental research in chemistry at universities in Australia and the US.



Professor Bruce Weir, University of Washington

Professor Bruce Weir (PhD, BSc Hons) is Professor and former Chair of the Department of Biostatistics and Adjunct Professor, Department of Genome Sciences, University of Washington, Seattle. He is also Director of the Institute of Public Health Genetics and of the Genetic Analysis Center at that university. He has a BSc (Hons) with First Class Honours in mathematics from the University of Canterbury and a PhD in statistics, with a minor in genetics, from North Carolina State University. He is a Fellow of the American Association for the Advancement of Science, the American Academy of Forensic Sciences and the American Statistical Association, and an Honorary Fellow of the Royal Society Te Apārangi. Bruce has held numerous editorial positions with journals in genetics, statistics, biometrics, heredity and epidemiology. He has supervised more than 30 PhD students. His research interests are in statistical genomics, with applications to human disease studies and forensic science. He has published more than 200 peer-reviewed journal articles, which have gathered 66,000 citations. He has an h-index of 86. Bruce was the 2019 recipient of the Elizabeth W Jones Award for Excellence in Education from the Genetics Society of America.

Dr Elizabeth Jazwinska, RMIT University

Dr Liz Jazwinska (PhD, MBA, GAICD, BSc Hons) has more than 30 years' experience in R&D management and business development and has held senior positions in academia, industry and government in Australia and internationally. Liz is currently Director, Business Development in the Enterprise Portfolio at Monash University. In this role she is responsible for building university-wide strategic partnerships with commercial and government-owned organisations and research partners. Prior to joining Monash, Liz held senior leadership positions at RMIT University (Director Research, Innovation and Entrepreneurship), A*STAR in Singapore (Director Industry Engagement), the Ministry of Science and Innovation in New Zealand (Deputy Chief Executive Science Strategy and Investment), the Australian Research Council (Executive Director Biological Sciences and Biotechnology) and Johnson & Johnson Research (Executive Director, Strategic Alliances). She founded the molecular diagnostics company SpeeDx and established and chaired the Governance Board of the Australian Phenomics Network, a National Collaborative Research Infrastructure Strategy-funded infrastructure facility supporting phenomics research for national and international research and industry users. Prior to joining the industry, Liz established a substantial academic portfolio in human molecular genetics and authored more than 62 publications in high-ranking peer-reviewed journals. She holds a BSc (Hons) from the University of Aberdeen, a PhD from the University of Edinburgh and an MBA from the Australian Graduate School of Management. She is also a graduate of the Australian Institute of Company Directors.

Senior Leadership Team members left to right: Trish Bolger, Amber McEwen, Dr Keith McLea (Chief Executive), Dr Libby Harrison, Dr Brett Cowan and John Bone.

Our senior leaders

Dr Keith McLea, *Chief Executive*

Dr Keith McLea became Chief Executive in July 2014. He has worked across a number of government ministries providing strategic and policy advice. Keith has a PhD in human genetics and has trained as a toxicologist. Keith has spent much of his professional career working in the personal injury insurance and injury prevention sectors and has been a Director at Cranleigh Strategic Limited.

Dr Libby Harrison, *General Manager Health & Environment*

Dr Libby Harrison is a biologist specialising in ecology and entomology. Her career in eco-toxicology, field-science management and public service and regulation has always linked to caring for the environment through scientific research, risk assessment, stewardship and policy development.

In 2002 Libby immigrated to New Zealand to help reform our legislation for the regulation of genetically modified organisms. Since then she has worked in organisational leadership and management roles at the Environmental Risk Management Authority, the Ministry for the Environment, the Environmental Protection Authority, Manaaki Whenua – Landcare Research and the Ministry of Business, Innovation and Employment.

Libby holds a PhD from University College, London University on biological control of insect pests; an MSc from Imperial College, London University on insect pest control, and a BA from St Anne's College, Oxford University in Zoology.

She is also a graduate in Public Sector Advanced Leadership from the New Zealand Leadership Development Centre; a member of the Institute of Directors and of the Royal Society – Te Apārangi, and a graduate of the Senior Executive Programme from the Mt Eliza Business School.

Dr Brett Cowan, *Chief Scientist*

Dr Brett Cowan has an eclectic range of qualifications. They include degrees in mechanical engineering and clinical medicine and an MBA, as well as studies in philosophical theology and ancient history. Brett practised emergency medicine for 10 years before starting an academic career at the University of Auckland as foundation Director of the Centre for Advanced MRI and Head of Radiology. This resulted in more than 100 publications on clinical trials, medical imaging, image processing, machine learning and computational modelling and statistics. He was previously the General Manager of Business at Auckland UniServices Limited, and still holds a part-time appointment as Associate Professor at the University of Auckland in the Faculty of Medical and Health Sciences.

Based at ESR's Mt Albert Science Centre, Brett maintains links with the university, working there one day a week.

John Bone, *General Manager Forensic*

John Bone is an executive with 20 years' senior leadership experience in business and technology. He brings solution-based thinking to leadership and management roles. Whilst not a technologist per se, he is quick to comprehend technical concepts and their relevance to business problems of complexity and ambiguity. John is a person who brings energy and tenacity to whatever task or role for which he is responsible. He also simultaneously holds the position of General Manager for STRmix Limited at ESR. This role oversees the operation and service delivery of the STRmix business unit, which is an internationally successful geno-typing software used to solve complex DNA mixtures at crime scenes.

John is a Director of AuramerBio, a biotech sensor company specialising in aptamer-based sensing technologies and chemistry. John holds a Certificate in Company Direction with the Institute of Directors in New Zealand, a Diploma in Business Marketing from the University of Auckland and a BSc in botany/plant biology from Massey University. He has also completed a Leadership Deep Dive course with Case Western Reserve University.

Amber McEwen, *General Manager Business Services*

Amber McEwen joined ESR in June 2019. Amber has more than 20 years' experience in business-to-business service industries with a proven track record in generating revenue and creating brand differentiation through the development, implementation and management of services over networks ranging from telecoms to energy. Recently returned from the UK, Amber held the role of Marketing Director at UK energy company SSE plc. Previously to this she worked for Vodafone where she had responsibility for product, strategy and planning and service delivery.

Her expertise covers the entire customer lifecycle, from brand and proposition development and design to the implementation of global managed services frameworks to ensure customer expectations are met and maintained. Amber says her key strength is the ability to see the big picture, design the appropriate strategy and convert this vision into reality. Amber has a LLB and BCA from Victoria University of Wellington.

Trish Bolger, *General Manager, People, Culture and Communications*

Trish has a broad HR background and brings with her considerable HR management experience. Trish's philosophy is that data and evidence should drive the strategic agenda for the business and its people. Her most recent role was as General Manager, People at the New Zealand Racing Board, and previously her HR management roles included working at Philips Consumer Electronics in the Netherlands, the ANZ Banking Group (New Zealand) and KPMG. She has a Master's in industrial and organisational psychology. Trish manages her own seventeen-hectare olive grove, which has produced award-winning olive oil.

Report from the Chief Financial Officer

2019 result

ESR recorded a net profit after tax (NPAT) of $1.9 million for the financial year.

While down on 2018 and below the *Statement of Corporate Intent* (SCI) target, there were positive aspects to the result, including growth in research revenue, increased investment in our science and positive operating cash flows.

Financial performance

$000	Actual 2019	SCI target	Actual 2018
Revenue	78,584	86,074	76,159
Operating margin	7,579	10,709	10,801
NPAT	1,858	3,536	4,271
Return on equity	3.4%	6.3%	8.2%

Revenue

Revenue grew by $2.4 million year on year, driven by a 38% increase in research revenue and modest growth from core government contracts.

Research revenue was boosted by the award of a multi-year Endeavour Fund project to investigate the impacts of microplastics on our environment. ESR also achieved further success with Ministry of Business, Innovation and Employment Vision Mātauranga research funding applications, continuing to make progress towards our objective of prioritising Vision Mātauranga research to the benefit of Māori and New Zealand.

Despite growing year on year, total revenue was below the SCI target due to lower-than-planned international revenue from science products and services.

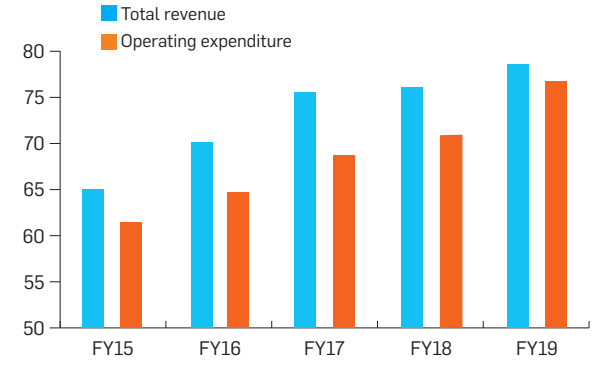
Investing in the future

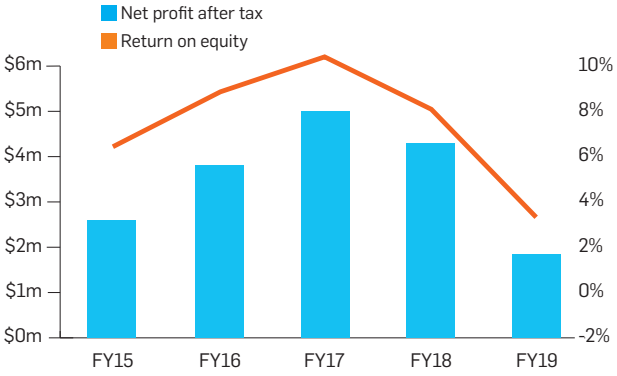
Operating expenses increased 8% to $76.7 million and ESR maintained capital expenditure of $5.0 million, with increased investment in our people and our strategic initiatives.

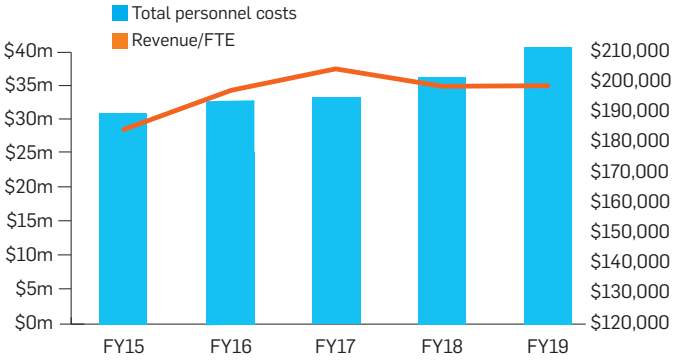
To position ESR for the future we invested in our data science capability and science facilities, adopting new ways of working and increasing our brand awareness. ESR also increased its scientific and technical capability during the year, adding 11 new FTE positions.

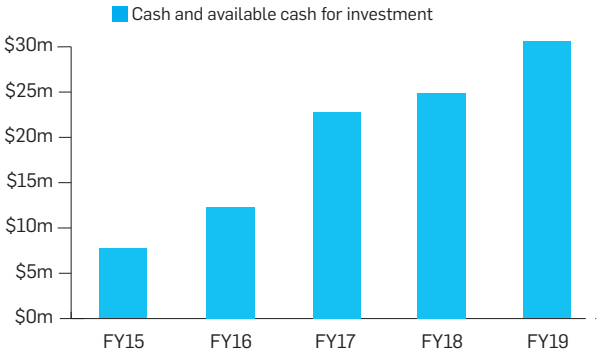
Despite the reduced profit, ESR maintained healthy operating cash flows and continued to build its cash reserves. These reserves will be used to support the *Great Plan for Science* – particularly investment in our working environment and technology infrastructure.

Five-year trends









Five-year trends

	2015	2016	2017	2018	2019
Revenue	$65.0m	$70.1m	$75.5m	$76.2m	$78.6m
Operating margin	13.9%	15.5%	16.3%	14.2%	9.6%
Return on equity[1]	6.5%	8.9%	10.5%	8.2%	3.4%
Return on assets[2]	6.0%	8.6%	10.1%	7.2%	2.4%
Acid test ratio	1.5	1.7	2.7	2.8	2.6
Equity ratio	67.3%	71.3%	70.7%	71.4%	70.6%
Operating margin per FTE	$25,600	$30,500	$33,700	$28,300	$19,300

[1] NPAT to average equity

[2] Earnings before interest and tax to average total assets

Capital investment

	2015	2016	2017	2018	2019
Property, plant and equipment	$2.4m	$4.5m	$2.6m	$4.1m	$3.7m
Intangible assets	$3.9m	$1.3m	$0.5m	$1.5m	$1.0m
Investments	–	–	–	$0.3m	$0.2m
Total capital expenditure	**$6.2m**	**$5.8m**	**$3.1m**	**$5.9m**	**$5.0m**

Capital structure

	2015	2016	2017	2018	2019
Equity	$41.1m	$45.0m	$50.0m	$54.3m	$56.3m
Total assets	$60.8m	$63.1m	$70.7m	$76.0m	$79.7m
Shareholders' funds to total assets	67.3%	71.3%	70.7%	71.4%	70.6%

Financial Statements and Report of Directors

Institute of Environmental Science and Research Limited
For the year ended 30 June 2019

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Financial Statements

- Statement of Profit or Loss and Other Comprehensive Income
- Statement of Changes in Equity
- Statement of Financial Position
- Statement of Cash Flows
- Notes to the Financial Statements

Statement of Responsibility

Report of the Directors

Independent auditor's report

To the readers of the Institute of Environmental Science and Research Limited's Group financial statements for the year ended 30 June 2019.

The Auditor-General is the auditor of the Institute of Environmental Science and Research Limited and its subsidiaries (the Group). The Auditor-General has appointed me, Christopher Ussher, using the staff and resources of PricewaterhouseCoopers, to carry out the audit of the financial statements of the Group on his behalf.

Opinion

We have audited the financial statements of the Group on pages 78 to 105, that comprise the statement of financial position as at 30 June 2019, the statement of profit or loss and other comprehensive income, statement of changes in equity and statement of cash flows for the year ended on that date and the notes to the financial statements that include the statement of significant accounting policies and other explanatory information.

In our opinion, the financial statements of the Group:

- present fairly, in all material respects:
  - its financial position as at 30 June 2019;
  - its financial performance and cash flows for the year then ended; and
- comply with generally accepted accounting practice in New Zealand in accordance with New Zealand equivalents to International Financial Reporting Standards and International Financial Reporting Standards.

Our audit was completed on 23 August 2019. This is the date at which our opinion is expressed.

The basis for our opinion is explained below. In addition, we outline the responsibilities of the Board of Directors and our responsibilities relating to the financial statements, we comment on other information, and we explain our independence.

Basis for our opinion

We carried out our audit in accordance with the Auditor-General's Auditing Standards, which incorporate the Professional and Ethical Standards and the International Standards on Auditing (New Zealand) issued by the New Zealand Auditing and Assurance Standards Board. Our responsibilities under those standards are further described in the Responsibilities of the auditor section of our report.

We have fulfilled our responsibilities in accordance with the Auditor-General's Auditing Standards.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Responsibilities of the Board of Directors for the financial statements

The Board of Directors is responsible on behalf of the Group for preparing financial statements that are fairly presented and that comply with generally accepted accounting practice in New Zealand.

The Board of Directors is responsible for such internal control as it determines is necessary to enable it to prepare financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, the Board of Directors is responsible on behalf of the Group for assessing the Group's ability to continue as a going concern. The Board of Directors is also responsible for disclosing, as applicable, matters related to going concern and using the going concern basis of accounting, unless the Board of Directors has to cease operations, or has no realistic alternative but to do so.

The Board of Directors' responsibilities arise from the Crown Research Institutes Act 1992.

Responsibilities of the auditor for the audit of the financial statements

Our objectives are to obtain reasonable assurance about whether the financial statements, as a whole, are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion.

Reasonable assurance is a high level of assurance, but it is not a guarantee that an audit carried out in accordance with the Auditor-General's Auditing Standards will always detect a material misstatement when it exists. Misstatements are differences or omissions of amounts or disclosures and can arise from fraud or error. Misstatements are considered material if, individually or in the aggregate, they could reasonably be expected to influence the decisions of readers taken on the basis of these financial statements.

For the budget information reported in the financial statements, our procedures were limited to checking that the information agreed to the Group's statement of corporate intent.

We did not evaluate the security and controls over the electronic publication of the financial statements.

As part of an audit in accordance with the Auditor-General's Auditing Standards, we exercise professional judgement and maintain professional scepticism throughout the audit. Also:

- We identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- We obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances but not for the purpose of expressing an opinion on the effectiveness of the Group's internal control.
- We evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the Board of Directors.
- We conclude on the appropriateness of the use of the going concern basis of accounting by the Board of Directors and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Group's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Group to cease to continue as a going concern.
- We evaluate the overall presentation, structure and content of the financial statements, including the disclosures and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.
- We obtain sufficient appropriate audit evidence regarding the financial statements of the entities or business activities within the Group to express an opinion on the consolidated financial statements. We are responsible for the direction, supervision and performance of the Group audit. We remain solely responsible for our audit opinion.

We communicate with the Board of Directors regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

Our responsibilities arise from the Public Audit Act 2001.

Other Information

The Board of Directors is responsible for the other information. The other information comprises the information included on pages 106 to 109, but does not include the financial statements, and our auditor's report thereon.

Our opinion on the financial statements does not cover the other information and we do not express any form of audit opinion or assurance conclusion thereon.

In connection with our audit of the financial statements, our responsibility is to read the other information. In doing so, we consider whether the other information is materially inconsistent with the financial statements or our knowledge obtained in the audit, or otherwise appears to be materially misstated. If, based on our work on the other information that we obtained prior to the date of our auditor's report, we conclude that there is a material misstatement of this other information, we are required to report that fact. We have nothing to report in this regard.

Independence

We are independent of the Group in accordance with the independence requirements of the Auditor-General's Auditing Standards, which incorporate the independence requirements of Professional and Ethical Standard 1 (Revised): Code of Ethics for Assurance Practitioners issued by the New Zealand Auditing and Assurance Standards Board.

In addition to the audit we have carried out engagements in the area of taxation compliance services. Other than the audit and these engagements, we have no relationship with or interests in the Group.

Christopher Ussher

Christopher Ussher

On behalf of the Auditor-General
Wellington, New Zealand

PricewaterhouseCoopers

PricewaterhouseCoopers

Statement of Profit or Loss and Other Comprehensive Income

For the Year Ended 30 June 2019

Group	Note	Group Actual 2019 $'000s	Group Budget 2019 unaudited $'000s	Group Actual 2018 $'000s
Revenue				
Operating revenue	2	69,350	76,840	66,925
Strategic Science Investment Funding		9,234	9,234	9,234
		78,584	**86,074**	**76,159**
Operating expenses				
Scientific materials		5,604	6,244	5,940
Subcontracting, commissions and royalties		8,554	10,658	7,942
Personnel		41,566	41,516	37,065
Depreciation and amortisation	5/6	5,706	6,377	5,538
Other expenses	3	15,281	16,947	14,361
		76,711	**81,742**	**70,846**
Operating profit		**1,873**	**4,332**	**5,313**
Interest income		863	720	766
Finance expense		(10)	–	(10)
Share of net loss of associate accounted for using the equity method	15	(57)	–	(50)
		796	**720**	**706**
Profit before income tax expense		**2,669**	**5,052**	**6,019**
Income tax expense	4	811	1,516	1,748
Profit for the period attributable to the shareholder of the parent		**1,858**	**3,536**	**4,271**
Other comprehensive income		–	–	–
Total profit or loss and other comprehensive income for the period attributable to the shareholder of the parent		**1,858**	**3,536**	**4,271**

The accompanying notes form an integral part of these financial statements.

Statement of Changes in Equity

For the Year Ended 30 June 2019

Group	Note	Share capital $'000s	Retained earnings $'000s	Total equity $'000s
Balance at 30 June 2017		**8,494**	**41,505**	**49,999**
Profit for the period		–	4,271	4,271
Other comprehensive income		–	–	–
Total comprehensive income		**–**	**4,271**	**4,271**
Transactions with owners:				
Dividend		–	–	–
Balance at 30 June 2018		**8,494**	**45,776**	**54,270**
Balance at 30 June 2018		**8,494**	**45,776**	**54,270**
Change in accounting policy	1	–	189	189
Restated total equity at the beginning of the financial year		**8,494**	**45,965**	**54,459**
Profit for the period		–	1,858	1,858
Other comprehensive income		–	–	–
Total comprehensive income		**–**	**1,858**	**1,858**
Transactions with owners:				
Dividend		–	–	–
Balance at 30 June 2019		**8,494**	**47,823**	**56,317**

The accompanying notes form an integral part of these financial statements.

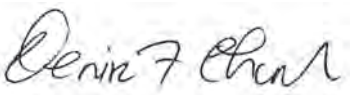
Statement of Financial Position

As at 30 June 2019

Group	Note	Group Actual 2019 $'000s	Group Budget 2019 unaudited $'000s	Group Actual 2018 $'000s
Non-current assets				
Property, plant and equipment	5	29,933	30,790	29,992
Investments accounted for using the equity method	15	442	300	250
Other investments		30	30	30
Investment cash		8,000	–	–
Intangible assets	6	8,485	10,292	9,393
		46,890	**41,412**	**39,665**
Current assets				
Cash and cash equivalents		509	1,239	960
Investment cash		22,000	26,500	24,000
Trade and other receivables	7	8,680	8,100	10,264
Contract assets	2	626	–	–
Inventories – scientific materials and consumables		1,042	1,000	1,079
		32,857	**36,839**	**36,303**
Current liabilities				
Trade and other payables	8	7,653	11,400	12,246
Contract liabilities	2	6,439	–	–
Employee benefits	9	3,778	3,600	3,451
Finance lease liabilities	10	–	–	67
Derivative financial instruments		6	–	11
Income tax payable	11	479	505	903
		18,355	**15,505**	**16,678**
Net current assets		**14,502**	**21,334**	**19,625**
Non-current liabilities				
Employee benefits	9	1,688	1,400	1,367
Deferred taxation	12	3,387	3,885	3,653
		5,075	**5,285**	**5,020**
Net assets		**56,317**	**57,461**	**54,270**
Equity				
Share capital	13	8,494	8,494	8,494
Retained earnings		47,823	48,967	45,776
Total equity		**56,317**	**57,461**	**54,270**

The Board of Directors of the Institute of Environmental Science and Research Limited authorised these financial statements for issue on 21 August 2019.

On behalf of the Board:



Denise Church QSO
Chair

Quentin Hix
Deputy Chair

The accompanying notes form an integral part of these financial statements.

Statement of Cash Flows

For the Year Ended 30 June 2019

Group	Note	Group Actual 2019 $'000s	Group Budget 2019 unaudited $'000s	Group Actual 2018 $'000s
Cash flows from/(used in) operating activities				
Cash was provided from:				
Customers and Strategic Science Investment Funding		81,830	86,047	73,880
Interest received		598	720	592
		82,428	**86,767**	**74,472**
Cash was applied to:				
Suppliers and employees		(70,141)	(75,436)	(65,369)
Interest paid		(9)	–	–
Income tax paid	11	(1,573)	(1,322)	(1,695)
		(71,723)	(76,758)	(67,064)
Net cash inflow from operating activities	14	**10,705**	**10,009**	**7,408**
Cash flows from/(used in) investing activities				
Cash was provided from:				
Proceeds from sale of property, plant and equipment		–	–	2
Term deposit maturities		20,000	11,500	24,000
		20,000	**11,500**	**24,002**
Cash was applied to:				
Purchase of property, plant and equipment		(3,820)	(5,021)	(3,226)
Purchase of intangible assets		(1,028)	(2,791)	(1,470)
Investments		(240)	–	(300)
Investment in term deposits		(26,000)	(15,000)	(32,000)
		(31,088)	**(22,812)**	**(36,996)**
Net cash outflow from investing activities		**(11,088)**	**(11,312)**	**(12,994)**
Cash flows from/(used in) financing activities				
Cash was provided from/applied to):				
Repayment of finance lease liabilities		(68)	–	(227)
Net cash outflow from financing activities		**(68)**	**–**	**(227)**
Net decrease in cash held		**(451)**	**(1,303)**	**(5,813)**
Cash and cash equivalents at the beginning of the period		960	2,542	6,773
Cash and cash equivalents at the end of the period		**509**	**1,239**	**960**

The accompanying notes form an integral part of these financial statements.

Notes to the Financial Statements

1. Statement of significant accounting policies

Reporting entity

These financial statements of the Institute of Environmental Science and Research Limited and its subsidiaries ("ESR" and the "Group") are for the year ended 30 June 2019.

ESR is a Crown entity incorporated and based in New Zealand. Its registered office is 34 Kenepuru Drive, Porirua.

ESR is a Crown Research Institute that provides specialist scientific services and research to the public health, food safety, security and justice systems, and the environmental sector.

Statement of compliance

The financial statements have been prepared in accordance with the requirements of the Crown Entities Act 2004, the Crown Research Institutes Act 1992, the Companies Act 1993 and the Financial Reporting Act 2013.

These financial statements have been prepared in accordance with Generally Accepted Accounting Practice in New Zealand (NZ GAAP). They comply with New Zealand equivalents to International Financial Reporting Standards (NZ IFRS), International Financial Reporting Standards and other New Zealand accounting standards and authoritative notices as appropriate for for-profit entities.

Basis of preparation

The financial statements are prepared on the basis of historical cost, except for financial instruments, certain leased assets and long service leave as identified in the specific accounting policies and accompanying notes.

The financial statements are presented in New Zealand dollars and all values are rounded to the nearest thousand dollars ($'000).

The budget and target figures presented in these financial statements are unaudited.

Changes in accounting policies

Accounting policies have been applied on a basis consistent with the prior year except where they are impacted by the adoption of NZ IFRS 9 and NZ IFRS 15. The nature and effect of the changes resulting from the adoption of these new accounting standards are described below.

NZ IFRS 9 Financial Instruments

NZ IFRS 9 Financial Instruments replaces NZ IAS 39 Financial Instruments: Recognition and Measurement and all previous versions of NZ IFRS 9 and addresses the classification, measurement and recognition of financial assets and liabilities, and introduces new rules for hedge accounting and a new impairment model for financial assets.

Impact of adoption of NZ IFRS 9 Financial Instruments

Given the relatively simple financial instruments held by the Group and low credit risk of most of ESR's debtors, the impacts of adopting this standard are immaterial.

(a) Hedging documentation and effectiveness

The Group does not use hedge accounting; therefore changes in the requirements for hedging documentation and effectiveness on adoption of NZ IFRS 9 will not impact the financial statements.

(b) Measurement of receivables

The Group has used the practical expedient that presumes that a trade receivable does not have a significant financing component if the expected term is less than one year. As such, trade receivables are measured at undiscounted invoice price rather than fair value.

(c) Impairment of receivables

The doubtful debt calculation has been amended to include sources of prospective information as required by the standard. This information is used in conjunction with existing historical information to recognise a day one expected credit loss (ECL) on all trade receivables. The Group's previous policy was to provision against specific trade receivables based on historical information.

The Group has set an ECL rate of 0.15% for current debt, 1% for all debt ageing categories up to 120 days and 10% for all debt aged 121 days and over. The ECL model assumptions acknowledge that there are very limited circumstances under which a debt has no risk (implying a nil provision is not appropriate).

The ECL rates have been set after consideration of the Group's actual history of write offs and the overall stability of the entity. While there have been some trade receivable write offs historically within the ESR business, this has been minimal in relation to total revenue.

Any trade receivable balances aged one year or older are reviewed by management for specific provisioning following discussion with the debtor and consideration of any plan in place to recover the debt.

The impact on the debt provision of applying the above ECL policy is as follows:

- calculated provision – specific item as applied in FY18: $79,000
- calculated provision – applying the ECL rates above: $80,000

The difference between the two methods is immaterial.

NZIFRS 15 Revenue from Contracts with Customers

NZ IFRS 15 addresses recognition of revenue from contracts with customers, replacing the revenue recognition guidance in NZ IAS 18 Revenue and NZ IAS 11 Construction Contracts, and is applicable to all entities with revenue. It sets out a five-step model for revenue recognition to depict the transfer of promised goods or services to customers in an amount that reflects the consideration to which the entity expects to be entitled in exchange for those goods or services. The standard permits either a full retrospective or a modified retrospective approach for adoption.

Impact on the financial statements

The Group has adopted IFRS 15 using the modified retrospective approach with the initial application of 1 July 2018. Under this method, the standard can be applied either to all contracts at the date of initial application or only to contracts that are not completed at this date. The Group elected to apply the standard only to contracts that were not completed as at 1 July 2018.

The Group has recognised the cumulative effect of initially applying this standard as at 1 July 2018 as an adjustment to the opening balance of retained earnings.

The following table shows the adjustments required for each individual line item in the financial statements. These adjustments are explained in (b) below.

	30 June 2018 as originally presented	IFRS 15 adjustments		1 July 2018 restated
		Recognition of contract assets and liabilities	Effect of initial application	
	$'000s	$'000s	$'000s	$'000s
Non-current assets	**39,665**		**–**	**39,665**
Current assets				
Cash and cash equivalents	960	–	–	960
Investment cash	24,000	–	–	24,000
Trade and other receivables	10,264	(844)	–	9,420
Contract assets	–	844	(162)	682
Inventories	1,079	–	–	1,079
	36,303	**–**	**(162)**	**36,141**
Current liabilities				
Trade and other payables	12,246	(4,569)	–	7,677
Contract liabilities	–	4,569	(423)	4,146
Employee benefits	3,451	–	–	3,451
Finance lease liabilities	67	–	–	67
Derivative financial instruments	11	–	–	11
Income tax payable	903	–	72	975
	16,678	**–**	**(351)**	**16,327**
Non-current liabilities	**5,020**		**–**	**5,020**
Net assets	**54,270**		**189**	**54,459**
Equity				
Share capital	8,494		–	8,494
Retained earnings	45,776		189	45,965
Total equity	**54,270**		**189**	**54,459**

Accounting for software sales

The Group's sales of the forensic software product STRmix™ involve separate performance obligations covering the software license, software upgrades, training and the provision of scientific support.

The Group's previous accounting policy was to defer the recognition of software license revenues and the related contract acquisition costs until training had been delivered to the customer.

Under IFRS 15 the performance obligation in relation to the software license is considered to be satisfied at the point in time the customer receives the software. As a result, on 1 July 2018 the Group's deferred revenue and cost balances were, respectively, $423,000 and $162,000 lower than those recognised under the previous accounting policy. Adjusting these balances resulted in a net transfer of $261,000 to retained earnings. This crystallised a current tax liability of $72,000, which was also charged to retained earnings.

	1 July 2018 restated $'000s
Retained earnings as at 30 June 2018	**45,776**
Recognition of revenue from software licence sales	423
Recognition of costs associated with software licence sales	(162)
Increase in current tax liability	(72)
Retained earnings as at 1 July 2018	**45,965**

Critical accounting estimates and judgements

The preparation of financial statements requires judgements, estimates and assumptions that affect the application of policies and reported amounts of assets and liabilities, income and expenses. The estimates and associated assumptions are based on historical experience and various other factors that are believed to be reasonable under the circumstances. Actual results may differ from these estimates. The estimates and assumptions are reviewed on an ongoing basis.

The judgements that have the most significant effect on amounts recognised in the financial statements are applied in the determination of revenue.

Revenue from contracts with customers

Satisfaction of performance obligations

Revenue for contract deliverables is recognised as the related performance obligation is satisfied, either at a point in time or over time.

The Group has determined that the various deliverables included within a contract for the sale of forensic analysis software are capable of being distinct. Revenue from software licenses and training is recognised at a point in time when, respectively, the customer has been provided with access to the software license and training has been delivered. Software upgrades and support revenues are recognised over time. Software upgrade revenue is recognised over time as the Group has a stand ready obligation to provide software upgrade and enhancements as and when they are available. Software support revenue is recognised as the customer utilises the support purchased with the software license.

For the majority of other contract deliverables, the Group has concluded that the satisfaction of performance obligations occurs over time. In these circumstances the Group has determined that an input method is most appropriate in measuring progress on a contract as there is a direct relationship between the Group's effort (i.e. labour hours and other costs incurred) and the transfer of services to the customer. In these circumstances the Group recognises revenue on the basis of labour hours expended and other costs incurred, relative to the total expected cost to complete the service.

Revenue from the balance of commercial and research activities is recognised at a point in time. This is the point at which the Group has determined it has transferred control of the related good or service to the customer.

Determination of transaction prices

The transaction price for bundled deliverables associated with software license sales is allocated to each performance obligation based on the stand alone selling price or estimated based on industry benchmarks.

Principal versus agent considerations

The Group has concluded that it is the principal in its revenue arrangements as it controls the goods or services before they are transferred to the customer.

Variable consideration

Where the consideration in a contract includes a variable amount arising from a value-based rebate, the Group estimates the amount of consideration to which it will be entitled in exchange for transferring the goods or services to the customer. The Group applies the most likely amount method to determine the amount of consideration to which it will ultimately be entitled.

Financing components

The Group does not have any contracts where the period between the transfer of the promised goods or services to the customer and payment by the customer exceeds one year. As a consequence, the Group does not adjust any of the transaction prices for the time value of money.

Principles of consolidation

Subsidiaries

The consolidated financial statements incorporate the assets and liabilities of all subsidiaries of ESR as at 30 June 2019 and the results of the operations of all subsidiaries for the year then ended.

Subsidiaries are those entities controlled, directly or indirectly, by the Parent. Subsidiaries are consolidated from the date on which control is transferred to ESR. They are de-consolidated from the date that control ceases.

The acquisition method of accounting is used to account for the acquisition of businesses by the Group. The cost of an acquisition is measured as the fair value of the assets given, equity instruments issued and liabilities incurred or assumed at the date of exchange. Identifiable assets acquired and liabilities and contingent liabilities assumed in a business combination are measured initially at their fair values at the acquisition date, irrespective of the extent of any non-controlling interest. The excess of the cost over the fair value of the Group's share of the identifiable net assets acquired is recorded as goodwill. If the cost of acquisition is less than the Group's share of the fair value of the identifiable net assets of the subsidiary acquired, the difference is recognised directly in the profit or loss.

Associates

An associate is an entity over which the Group has significant influence. Significant influence is the power to participate in the financial and operating policy decisions of the investee, but is not control or joint control over those policies.

The Group's investments in its associates are accounted for using the equity method. Under the equity method, the investment in an associate is initially recognised at cost and subsequently adjusted to recognise the Group's share of changes in net assets of the associate since the acquisition date. Goodwill relating to the associate is included in the carrying amount of the investment and is not tested for impairment separately.

In applying the equity method of accounting, the Group's share of the post-acquisition profits or losses of its associated companies is recognised in profit or loss and its share of post-acquisition other comprehensive income is recognised in other comprehensive income. These post-acquisition movements and distributions received from the associated companies are adjusted against the carrying amount of the investment.

Unrealised gains on transactions between the Group and its associated companies are eliminated to the extent of the Group's interest in the associated companies. Unrealised losses are also eliminated unless the transaction provides evidence of an impairment of the asset transferred.

After application of the equity method, the Group determines whether it is necessary to recognise an impairment loss on its investment in its associates. At each reporting date, the Group determines whether there is objective evidence that the investment in the associate or joint venture is impaired. If there is such evidence, the Group calculates the amount of impairment as the difference between the recoverable amount of the associate and its carrying value, and then recognises the loss within the statement of profit or loss.

When the Group's share of losses in an associated company equals or exceeds its interest in the associated company, including any other unsecured non-current receivables, the Group does not recognise further losses, unless it has obligations or has made payments on behalf of the associated company.

Property, plant and equipment

Items of property, plant and equipment are initially recorded at cost and subsequently at cost less accumulated depreciation and impairment. The cost of property, plant and equipment includes the value of consideration given to acquire the assets and the value of other directly attributable costs that have been incurred in bringing the assets to the location and condition necessary for their intended use.

The carrying amounts of property, plant and equipment are reviewed at least annually to determine if there is any indication of impairment. Where an asset's recoverable amount is less than its carrying amount, it will be reported at its recoverable amount and an impairment loss will be recognised.

Losses resulting from impairment are reported in the statement of profit or loss and other comprehensive income.

Realised gains and losses arising from the disposal of property, plant and equipment are recognised in the profit or loss and other comprehensive income in the periods in which the transactions occur.

Depreciation is charged on a straight-line basis at rates calculated to allocate the cost of an item of property, plant and equipment, less any estimated residual value, over its estimated useful life, as follows:

Type of asset	Estimated useful life
Land	Not depreciated
Freehold buildings and building fit out	10 – 50 years
Leasehold improvements	10 years
Plant, equipment and vehicles	3 – 10 years
IT equipment and software	3 – 12 years

Intangible assets

Computer software

Items of computer software that do not comprise an integral part of the related hardware are treated as intangible assets with finite lives. Intangible assets with finite lives are recorded at cost, and subsequently recorded at cost less any accumulated amortisation and impairment losses. Amortisation is charged to the statement of profit or loss on a straight-line basis over the useful life of the asset (between 3 and 12 years).

Customer contracts

The intangible asset customer contracts represents the fair value of future revenue streams from customer contracts acquired under business combinations. Initial recognition of the intangible asset is stated at fair value. Subsequent to initial recognition, acquired intangible assets are stated at initially recognised amounts less accumulated amortisation and any impairment. Amortisation of acquired intangible assets is made according to the straight-line method over their estimated useful life, not exceeding 10 years.

Research and development costs – internally generated intangible assets

Expenditure on research is expensed when it is incurred.

Development expenditure incurred on an individual project is capitalised if the process is technically and commercially feasible, future economic benefits are probable and ESR intends to, and has sufficient resources to, complete development and to use or sell the asset.

Any expenditure capitalised is amortised over three years from the point the asset is ready for use, which is the period of expected future sales from the related project.

Impairment of non-financial assets

Intangible assets that have an indefinite useful life or intangible assets not yet ready to use are not subject to amortisation and are tested annually for impairment.

Assets that are subject to depreciation and amortisation are reviewed for impairment whenever events or changes in circumstances indicate that the carrying amount may not be recoverable. An impairment loss is recognised for the amount by which the asset's carrying amount exceeds its recoverable amount. The recoverable amount is the higher of an asset's fair value less costs to sell and value in use. For the purposes of assessing impairment, assets are grouped at the lowest levels for which there are separately identifiable cash flows (cash-generating units).

Taxation

Current tax

Current tax is calculated with reference to the current period's taxable profit or loss calculated using tax rates and tax laws that have been enacted or substantially enacted by reporting date. Current tax for the current and prior periods is recognised as a liability (or asset) to the extent that it is unpaid (or refundable).

Deferred tax

Deferred tax is calculated using the comprehensive balance sheet liability method in respect of temporary differences arising from differences between the carrying amount of assets and liabilities in the financial statements and the tax base for those items.

Deferred tax assets and liabilities are not recognised if the temporary differences giving rise to them from the initial recognition of assets and liabilities (other than as a result of a business combination) affects neither taxable income nor accounting profit.

Deferred tax assets are recognised for deductible temporary differences and unused tax losses only if it is probable that future taxable amounts will be available against which deductible temporary differences or unused tax losses and tax offsets can be utilised.

Deferred tax assets and liabilities are measured at the tax rates expected to apply when the assets are recovered or liabilities settled using tax rates and tax laws that have been enacted or substantially enacted by the reporting date.

Cash and cash equivalents

Cash means cash on hand, demand deposits and other highly liquid investments in which ESR has invested as part of its day-to-day cash management. The following definitions are used in the statement of cash flows:

- Investing activities are those activities relating to the acquisition, holding and disposal of fixed assets and investments.
- Financing activities are those activities that result in changes in the size and composition of the capital structure of ESR and this includes both equity and debt not falling within the definition of cash. Dividends paid in relation to the capital structure are included in financing activities.
- Operating activities are the principal revenue-producing activities and other activities that are not investing or financing activities.

Investment cash

Investment cash represents cash held in bank deposits with original maturities of between 3 and 12 months. Investment cash movements are included in investing activities in the statement of cash flows.

Trade and other receivables

Trade receivables are recognised initially at fair value and subsequently measured at amortised cost using the effective interest method, less any provision for impairment.

Collectability of receivables is reviewed on an ongoing basis. A provision for doubtful debts is established from day one in the acknowledgement that the expected credit losses model assumes that there are very limited circumstances under which a debt has no risk (implying a nil provision is not appropriate). Bad debts are written off in the period in which they are identified.

Inventories

Stocks of consumables and work in progress are stated at the lower of cost and net realisable value. Cost is determined on a first in, first out basis.

Trade and other payables

Trade payables are obligations to pay for goods or services that have been acquired in the ordinary course of business from suppliers. Accounts payable are classified as current liabilities if payment is due within one year or less. If not, they are presented as non-current liabilities. Trade payables are recognised initially at fair value and subsequently at amortised cost using the effective interest method.

Employee benefits

Wages, salaries and annual leave

Liabilities for wages and salaries including annual leave that are expected to be settled within 12 months of the reporting date are recognised in respect of employees' services up to the reporting date and are measured at the amounts expected to be paid when the liabilities are settled.

Obligations for contributions to defined contribution retirement plans are recognised as an expense in the statement of profit or loss and other comprehensive income as they fall due.

Long service leave and retirement leave

Liabilities for long service and retirement leave are recognised as employee benefit liabilities and measured as the present value of expected future payments to be made in respect of services provided by employees up to the reporting date. Consideration is given to the expected future salary levels, experience of employee departures and periods of service. Expected future payments are discounted using market yields at the reporting date for government bonds with terms to maturity and currency that match, as closely as possible, the estimated future cash outflows.

Leases

Finance leases transfer to ESR, as lessee, substantially all the risks and rewards incidental to ownership of a leased asset. Initial recognition of a finance lease results in an asset and liability being recognised at amounts equal to the lower of the fair value of the leased asset or the present value of the minimum lease payments. Each lease payment is allocated between the liability and finance charges so as to achieve a constant rate of finance charge over the term of the lease. Property, plant and equipment acquired under a finance lease are depreciated over the shorter of the useful life and lease term of the asset.

Leases in which a significant portion of the risks and rewards of ownership are retained by the lessor are classified as operating leases. Payments made under operating leases (net of any incentives received from the lessor) are charged to the statement of profit or loss and other comprehensive income on a straight-line basis over the period of the lease.

Share capital

Ordinary shares are classified as equity. Incremental costs directly attributable to the issue of new shares or options are shown as appropriate in equity as a deduction, net of tax, from the proceeds.

Revenue

Revenue from contracts with customers

Revenue from contracts with customers is recognised when control of the goods or services is transferred to the customer at an amount that reflects the consideration to which the Group expects to be entitled in exchange for those goods or services.

For some contracts, revenue is recognised based on the actual service provided to the end of the reporting period as a proportion of the total services to be provided, as the customer receives and uses the benefits simultaneously or the Group has an enforceable right to payment for performance completed to date. The revenue recognised is typically determined based on actual labour hours and other costs incurred.

Estimates of revenues, costs or extent of progress toward completion are revised if circumstances change. Any resulting increases or decreases in estimated revenues or costs are reflected in profit or loss in the period in which the circumstances that give rise to the revision become known by management.

In case of fixed-price contracts, the customer pays the fixed amount based on a payment schedule. If the services rendered by the Group exceed the payment schedule, a contract asset is recognised. If the payments exceed the services rendered, a contract liability is recognised.

Sale of software

The Group sells expert forensic analysis software. Contracts for the sale of this software comprise several deliverables: software license, software upgrades, training and support.

Revenue for each deliverable is recognised as the related performance obligation is satisfied, either at a point in time or over time. Revenue from software licenses and training is recognised at a point in time when, respectively, the customer has been provided with access to the software license and training has been delivered. Software upgrades and support revenues are recognised over time. Software upgrade revenue is recognised over time as the Group has a stand ready obligation to provide software upgrades and enhancements as and when they are available. Software support revenue is recognised as the customer utilises the support purchased with the software license.

Invoicing or payment for software upgrades and support is generally made in advance of the satisfaction of these performance obligations. A contract liability is recognised to the extent payment received or due exceeds the services rendered by the Group.

The transaction price is allocated to each performance obligation based on the stand alone selling price or estimated based on industry benchmarks.

Strategic science investment funding

ESR receives strategic science investment funding from the Government in order to perform scientific research activities. Strategic science investment funding is treated as a government grant and recognised at fair value in the statement of profit or loss and other comprehensive income when the requirements under the funding agreement have been met.

Interest income

Interest income is recognised in the statement of profit or loss and other comprehensive income on a time proportion basis, using the effective interest rate method.

Foreign currency

Items included in the financial statements of each of the Group's entities are measured using the currency of the primary economic environment in which the entity operates. The Group financial statements are presented in New Zealand dollars, which is ESR's functional currency.

Foreign currency transactions are recorded at the foreign exchange rates in effect at the dates of the transactions. Monetary assets and monetary liabilities denominated in foreign currencies are translated at the rates of exchange ruling at the end of each reporting period.

Goods and Services Tax

Items in the statement of profit or loss and other comprehensive income and statement of cash flows are disclosed net of Goods and Services Tax (GST). All items in the statement of financial position are stated net of GST with the exception of receivables and payables, which include GST invoiced.

Dividends

A provision is made for the amount of any dividend declared on or before the end of the financial year but not distributed at balance date.

Financial instruments

The designation of financial assets and financial liabilities by ESR into instrument categories is determined by the business purposes of the financial instruments, policies and practices of management, the relationship with other instruments and the reporting costs and benefits associated with each designation.

Financial assets

The Group classifies its financial assets as loans and receivables and at fair value through profit and loss. Management determines the classification of its financial assets at initial recognition.

Loans and receivables are non-derivative financial assets with fixed or determinable payments that are not quoted in an active market. They are included in current assets, except for maturities greater than 12 months after the reporting date, which are classified as non-current assets. ESR's loans and receivables comprise trade and other receivables, investment cash, and cash and cash equivalents in the statement of financial position.

Regular purchases and sales of financial assets are recognised on the trade-date – the date on which the Group commits to purchase or sell the asset. Financial assets are derecognised when the rights to receive cash flows from the investments have expired or have been transferred and the Group has transferred substantially all risks and rewards of ownership. Loans and receivables are carried at amortised cost using the effective interest method.

The Group recognises an allowance for expected credit losses (ECLs) for all financial assets not held at fair value through profit or loss. ECLs are based on the difference between the contractual cash flows due in accordance with the contract and all the cash flows that the Group expects to receive, discounted at an approximation of the original effective interest rate.

Financial liabilities

Financial liabilities held by ESR include trade and other payables, employee benefits and finance lease liabilities.

Such financial liabilities are recognised initially at fair value less transaction costs and subsequently measured at amortised cost using the effective interest rate method.

Derivatives

Derivative financial instruments are recognised both initially and subsequently at fair value. They are reported as either assets or liabilities depending on whether the derivative is in a net gain or net loss position. ESR does not use hedge accounting and as such derivatives are classified as held-for-trading financial instruments with fair value gains or losses recognised in the statement of profit or loss and other comprehensive income. Such derivatives are entered into for risk management purposes.

Adoption status of relevant new financial reporting standards and interpretations

The Group has elected not to early adopt any other new standards and amendments to existing standards which have been issued as at 30 June 2019 but that are not yet effective. It is anticipated that these standards will not significantly affect the financial statements of the Group once adopted.

NZ IFRS 16 Leases (effective for annual periods beginning on or after 1 January 2019)

NZ IFRS 16 Leases introduces a single lessee accounting model and requires a lessee to recognise right-of-use assets and liabilities for all leases with a term of more than 12 months, unless the underlying asset is of low value. The Group has yet to assess the full impact of NZ IFRS 16. The Group will apply this standard from 1 July 2019.

2. Operating revenue

a) Total operating revenue

Group	2019 $'000s	2018 $'000s
Revenue from contracts with customers	68,850	–
Revenue from rendering of services	–	66,925
Other revenue	500	–
	69,350	**66,925**

b) Revenue from contracts with customers

i) Disaggregated revenue information

Group – year ended 30 June 2019	Domestic $'000s	International $'000s	Total $'000s
Core government contracts	47,068	–	47,068
Research	4,430	1,630	6,060
Commercial products and services	4,981	10,741	15,722
	56,479	**12,371**	**68,850**

Note that the overall research output of the Group includes activity funded by $9,234,000 of Strategic Science Investment Funding. This funding is accounted for as a government grant and not included in the table above.

ii) Remaining performance obligations

The transaction price allocated to the remaining performance obligations (unsatisfied or partially unsatisfied) as at 30 June 2019 is $20,095,000, split between current and non-current as below:

	Total $'000s
Current	9,175
Non-current	10,920
	20,095

The remaining performance obligations expected to be recognised in more than one year relate to multi-year research projects to be completed over the next five years, and prepaid software upgrades. All other remaining performance obligations are expected to be recognised within one year.

The balance of current remaining performance obligations does not include obligations under contracts for periods of one year or less.

iii) Contract balances

Group	2019 $'000s	1 July 2018 restated $'000s
Trade receivables	7,630	7,869
Contract assets	626	679
Contract liabilities	6,439	4,146

Trade receivables are non-interest bearing and generally on terms of 30 to 90 days.

Contract assets comprise revenue due from customers and capitalised costs of obtaining contracts for software sales:

- Revenue due from customers are balances recognised for services rendered where receipt of consideration is dependent on the completion of a project milestone and acceptance by the customer. Amounts initially recognised as contract assets are reclassified as trade receivables as milestones are completed and invoicing agreed with the customer.

- Incremental costs of obtaining contracts for software sales are $405,000 as at 30 June 2019. These costs are initially capitalised and then amortised systematically as the related performance obligation is satisfied. Amortisation recognised in 2019 was $1,807,000.

Contract liabilities represent amounts relating to research projects and software sales and support where the payment received or due under the contract exceeds the satisfaction of performance obligations by the Group. Contract liabilities are recognised as revenue when these performance obligations are satisfied.

The significant increase in contract liabilities in 2019 was due to the early stage of completion of several large domestic research projects awarded in 2019, and the timing of software sales in 2019 compared with 2018.

The Group recognised revenue of $4,058,000 during the period that was included in contract liabilities at the beginning of the period. No revenue was recognised in the period from performance obligations partially or fully satisfied in prior periods.

3. Other expenses

Group	Note	2019 $'000s	2018 $'000s
Fees paid to PricewaterhouseCoopers for:			
– the audit of the statutory financial statements		146	113
– the SHIVERS Project Uniform Guidance audit		–	29
Total audit-related fees paid to the auditors		146	142
– taxation compliance and advice		24	40
– cyber security training		–	36
Total fees paid to auditors		**170**	**218**
Directors' fees	17	198	193
Directors' expenses		41	30
Bad debts written off		7	8
Communication costs (including network charges)		559	600
IT systems maintenance and licence costs		1,764	1,606
Legal and consultancy fees		2,563	2,496
Impairment of receivables (loans and advances)		(29)	11
Fair value loss/(gain) on forward exchange contract		(15)	79
Office and administration		1,499	1,421
Occupancy and insurance		3,004	2,711
Rental and operating lease costs		759	665
Travel		2,310	2,066
Restructuring expense		178	154
Outsourced costs		1,791	1,885
Other operating costs		482	218
Other expenses		**15,281**	**14,361**

Given the nature of ESR's principal business activities, research comprises part of ESR's everyday business operations. As such, expenses relating to research are not separately identified. The cost of research to ESR is distributed between the relevant expense items, for example employee benefits and scientific materials used.

4. Taxation

Group	Note	2019 $'000s	2018 $'000s
The taxation charge has been calculated as follows:			
Profit/(loss) before income tax expense		**2,669**	**6,019**
Prima facie taxation at 28%		747	1,685
Plus taxation effect of:			
Net prior years under/(over) estimation		–	(1)
Non-deductible/(assessable) items		64	64
Tax/(credit) expense for the year		**811**	**1,748**
The tax expense for the year is represented by:			
Current taxation	11	1,142	1,992
Deferred taxation	12	(331)	(244)
		811	**1,748**

5. Property, plant and equipment

Group	Freehold land	Buildings and leasehold improvements	IT equipment	Plant, equipment and vehicles	Assets under construction	Total
	$'000s	$'000s	$'000s	$'000s	$'000s	$'000s
At 1 July 2017						
Cost	476	31,499	7,583	34,533	40	74,131
Accumulated depreciation	–	(9,608)	(6,260)	(28,719)	–	(44,587)
Net book value at the beginning of the year	**476**	**21,891**	**1,323**	**5,814**	**40**	**29,544**
Year ended 30 June 2018						
Net book value at the beginning of the year	476	21,891	1,323	5,814	40	29,544
Additions	–	317	1,260	2,194	350	4,121
Transfers from assets under construction	–	39	–	–	(39)	–
Disposals	–	–	(2)	(10)	–	(12)
Depreciation for the year	–	(1,020)	(977)	(1,664)	–	(3,661)
Net book value at the end of the year	**476**	**21,227**	**1,604**	**6,334**	**351**	**29,992**
At 30 June 2018						
Cost	476	31,855	8,015	35,139	351	75,836
Accumulated depreciation	–	(10,628)	(6,411)	(28,805)	–	(45,844)
Net book value at the end of the year	**476**	**21,227**	**1,604**	**6,334**	**351**	**29,992**
Year ended 30 June 2019						
Net book value at the beginning of the year	476	21,227	1,604	6,334	351	29,992
Additions	–	355	884	2,079	398	3,716
Transfers from assets under construction	–	–	353	–	(353)	–
Disposals	–	–	–	(5)	–	(5)
Depreciation for the year	–	(1,036)	(1,043)	(1,691)	–	(3,770)
Net book value at the end of the year	**476**	**20,546**	**1,798**	**6,717**	**396**	**29,933**
At 30 June 2019						
Cost	476	32,210	8,772	36,564	396	78,418
Accumulated depreciation	–	(11,664)	(6,974)	(29,847)	–	(48,485)
Net book value at the end of the year	**476**	**20,546**	**1,798**	**6,717**	**396**	**29,933**

IT equipment recognised under finance leases (where ESR is a lessee) included in the above table has the following values:

Group	2019 $'000s	2018 $'000s
Cost – capitalised finance lease assets	–	456
Accumulated depreciation	–	(402)
Net book value at the end of the year	**–**	**54**

ESR does not have any property, plant and equipment used as security for liabilities.

Restriction on title

In relation to the transfer of land owned by ESR, shareholding ministers shall have regard to the principles of the Treaty of Waitangi in accordance with section 10 of the Crown Research Institutes Act 1992.

Properties owned by ESR in Christchurch, Wellington and Auckland have caveats on the land as required by section 31 of the Crown Research Institutes Act 1992, which maintains the general provisions of the Public Works Act 1981. ESR complies with section 31 of the Crown Research Institutes Act 1992.

6. Intangible assets

Group	Computer software – externally purchased	Computer software – internally generated	Customer contracts	Assets under construction	Total
	$'000s	$'000s	$'000s	$'000s	$'000s
At 1 July 2017					
Cost	8,503	13,836	1,338	454	24,131
Accumulated amortisation and impairment losses	(7,288)	(5,798)	(1,245)	–	(14,331)
Net book value at the end of the year	**1,215**	**8,038**	**93**	**454**	**9,800**
Year ended 30 June 2018					
Net book value at the beginning of the year	1,215	8,038	93	454	9,800
Additions	568	15	–	887	1,470
Transfers from assets under construction	17	383	–	(400)	–
Amortisation for the year	(508)	(1,276)	(93)	–	(1,877)
Net book value at the end of the year	**1,292**	**7,160**	**–**	**941**	**9,393**
At 30 June 2018					
Cost	9,078	14,234	1,338	941	25,591
Accumulated amortisation and impairment losses	(7,786)	(7,074)	(1,338)	–	(16,198)
Net book value at the end of the year	**1,292**	**7,160**	**–**	**941**	**9,393**
Year ended 30 June 2019					
Net book value at the beginning of the year	1,292	7,160	–	941	9,393
Additions	347	19	–	662	1,028
Transfers from assets under construction	–	538	–	(538)	–
Disposals	–	–	–	–	–
Amortisation for the year	(519)	(1,417)	–	–	(1,936)
Net book value at the end of the year	**1,120**	**6,300**	**–**	**1,065**	**8,485**
At 30 June 2019					
Cost	9,419	14,791	1,338	1,065	26,613
Accumulated amortisation and impairment losses	(8,299)	(8,491)	(1,338)	–	(18,128)
Net book value at the end of the year	**1,120**	**6,300**	**–**	**1,065**	**8,485**

ESR does not have any intangible assets whose title is restricted or used as security for liabilities.

Intangible assets include ESR's laboratory operating system with a net book value of $5,656,000 (2018: $6,784,000). The laboratory operating system has an estimated remaining useful life of five years.

7. Trade and other receivables

Group	2019 $'000s	2018 $'000s
Trade debtors	7,680	8,792
Allowance for expected credit losses	(50)	(79)
	7,630	8,713
Prepayments	1,050	1,551
	8,680	10,264

As at 30 June 2019, trade receivables of $1,482,000 (2018: $1,218,000) were past due but not impaired. These relate to a number of customers for whom there is no recent history of default. The ageing analysis of these trade receivables is as follows:

Group	2019 $'000s	2018 $'000s
Past due 1 – 30 days	992	781
Past due 31 – 60 days	296	102
Past due >61 days	194	335
	1,482	**1,218**

8. Trade and other payables

Group	2019 $'000s	2018 $'000s
Accrued expenses	1,977	2,133
GST payable	16	311
Trade payables	5,660	5,203
Revenue in advance	–	4,599
	7,653	**12,246**

9. Employee benefits

Group	2019 $'000s	2018 $'000s
Annual leave accrual	3,469	3,160
Service leave accrual	294	274
Other	15	17
Current liabilities	**3,778**	**3,451**
Service leave accrual	1,599	1,290
Retirement leave accrual	89	77
Non-current liabilities	**1,688**	**1,367**

10. Finance lease liabilities

Future minimum lease payments are as follows:

Group	2019 $'000s	2018 $'000s
Not later than one year	–	70
Later than one year and not later than five years	–	–
Total minimum lease payments	**–**	**70**
Future finance charges on finance leases	–	(3)
Present value of finance lease liabilities	**–**	**67**

The finance leases related to IT equipment. Upon termination of the initial lease period, ESR could either choose to extend the term further, or return the leased assets to the lessor. There was no option to purchase the leased assets upon termination. As at balance date all leases had been terminated and the assets had been returned to the lessor.

The present value of finance lease liabilities is as follows:

	2019 $'000s	2018 $'000s
Not later than one year	–	67
Later than one year and not later than five years	–	–
	–	**67**

11. Income tax payable

Group	2019 $'000s	2018 $'000s
Balance at the beginning of the year	903	620
Current year charge	1,142	1,992
IFRS transition adjustment	72	–
Prior period adjustment	(65)	(14)
Provisional taxation payments	(1,573)	(1,695)
Balance at the end of the year	**479**	**903**

12. Deferred taxation

Deferred tax liabilities/(assets) are attributed to the following:

Group	2019 $'000s	2018 $'000s
Balance at the beginning of the year	3,653	3,885
Prior period adjustment	65	12
Charge to statement of profit or loss and other comprehensive income	(331)	(244)
Balance at the end of the year	**3,387**	**3,653**

	Accelerated tax depreciation $'000s	Employee benefits $'000s	Provisions and other items $'000s	Total $'000s
Year ended 30 June 2018				
Balance at the beginning of the year	5,276	(1,315)	(76)	3,885
Over provision in prior years	–	12	–	12
Current year charge/(credit) to statement of profit or loss and other comprehensive income	(167)	(133)	56	(244)
Balance at the end of the year	**5,109**	**(1,436)**	**(20)**	**3,653**
Year ended 30 June 2019				
Balance at the beginning of the year	5,109	(1,436)	(20)	3,653
Over provision in prior years	–	65	–	65
Current year charge/(credit) to statement of profit or loss and other comprehensive income	(262)	(115)	46	(331)
Balance at the end of the year	**4,847**	**(1,486)**	**26**	**3,387**

There are no unrecognised deferred tax assets or liabilities.

13. Equity

Share capital Group	2019 $'000s	2018 $'000s
8,494,000 ordinary $1 shares (issued and fully paid)	**8,494**	**8,494**

All ordinary shares rank equally with one vote attached to each fully paid ordinary share.

No dividends were proposed or declared for the 30 June 2019 year (2018: nil).

14. Reconciliation of profit/(loss) after taxation to cash flows from operating activities

Group	Note	2019 $'000s	2018 $'000s
Profit for the year after taxation		**1,858**	**4,271**
Non-cash items:			
Depreciation and amortisation expense	5/6	5,706	5,538
Equity accounted earnings from associate company investment		57	50
Transition to IFRS 15	1	189	0
Bad debts written off	3	7	8
Increase/(decrease) in allowance for expected credit losses	7	(36)	11
(Decrease)/increase in deferred tax liability	12	(266)	(232)
Fair value loss/(gain) on derivative financial instruments		(5)	79
Other non-cash items		(9)	0
		5,643	**5,454**
Changes in working capital:			
(Increase)/decrease in trade and other receivables and contract assets		987	(2,625)
(Increase)/decrease in inventories		37	(210)
Increase in trade and other payables and contract liabilities		1,846	806
Increase/(decrease) in income tax payable		(424)	283
Increase in employment benefits		648	304
		3,094	**(1,442)**
Items classified as investing and financing activities:			
(Profit)/loss on disposal of property, plant and equipment		5	11
(Increase)/decrease in trade payables related to property, plant and equipment		104	(896)
Finance charge on leases		1	10
		110	**(875)**
Net cash inflow from operating activities		**10,705**	**7,408**

15. Investments

Subsidiary companies

ESR has two wholly owned subsidiary companies:

Name	Balance Ddate	Country of incorporation
ESR Limited	30 June	New Zealand
STRMIX Limited	30 June	New Zealand

ESR's financial statements include the financial statements of ESR and entities controlled by ESR. All intra-group transactions,balances, income and expenses are eliminated in full on consolidation.

No stake in any subsidiary was acquired or disposed of during the year.

Investments

ESR holds 18 shares in Kiwi Innovation Network Limited and the investment has a carrying value of $30,000 (2018: $30,000)

Auramer Bio Limited, a start-up company focused on the development of DNA aptamer sensors, is classified as an associate, with ESR holding 19.5% of the shares of the company.

As at 30 June 2019, Auramer Bio Limited has total assets of $1,574,000 and net assets of $996,000. The carrying amount of this equity accounted investments has changed over the reporting period as below:

	2019 $'000s	2018 $'000s
Beginning of the period	250	–
Additions	249	300
Profit/(loss) for the period	(57)	(50)
Dividends paid	–	–
End of the period	**442**	**250**

16. Commitments

Capital commitments

Group	2019 $'000s	2018 $'000s
Property, plant and equipment	653	417
Intangible assets – software	258	–
Total capital commitments	**911**	**417**

Operating lease commitments

The future aggregate minimum lease payments under non-cancellable operating leases are as follows:

Group	2019 $'000s	2018 $'000s
Not later than one year	208	22
Later than one year and not later than five years	246	69
Total operating lease commitments	**454**	**91**

ESR leases land, buildings, equipment and vehicles. There are renewal options in respect of the land and building leases. There are no renewal options or options to purchase in respect of vehicles held under operating leases.

ESR has a number of standard operational agreements for the purchase of materials and consumables that have both fixed and variable components, some of which extend beyond one year.

17. Related party transactions and key management personnel

Related party transactions

ESR is a wholly owned entity of the Crown. ESR receives Strategic Science Investment Funding from the Government and enters into transactions with other Crown entities on a commercial basis. In the year ended 30 June 2019 revenue from commercial transactions with Crown entities amounted to 75% of operating revenue (30 June 2018: 61%).

Related parties include the entities disclosed in note 15.

The following transactions were carried out with related parties:

- Personnel and equipment were supplied to STRMIX Limited to the value of $7,604,553. As at balance date STRMIX Limited owed ESR $2,862,247. (30 June 2018: nil)
- Professional services were supplied to Auramer Bio Limited to the value of $8,970 (30 June 2018: nil). There was no debt owing by Auramer Bio Limited as at balance date (30 June 2018: nil)
- Fees paid to directors during the year were $198,264 (30 June 2018: $192,691). There were no directors' fees payable at balance date (30 June 2018: nil).

No provision has been required, nor any expense recognised, for impairment of receivables from related parties.

Key management personnel compensation

Key management personnel comprise the Chief Executive Officer, members of the Senior Leadership Team and the directors. Key management personnel compensation is disclosed below.

Group	2019 $'000s	2018 $'000s
Salaries and other short-term employee benefits	2,246	2,180
Termination benefits	99	36
Other long-term employee benefits	2	2
Directors' fees	198	193
Total key management personnel compensation	**2,545**	**2,411**

18. Financial instruments by category

Group	Financial assets at amortised cost	Financial assets at fair value through profit or loss	Total
	$'000s	$'000s	$'000s
30 June 2018			
Assets as per balance sheet:			
Trade and other receivables excluding prepayments	8,713	–	8,713
Cash and cash equivalents	960	–	960
Investment cash	24,000		24,000
Total	**33,673**	**–**	**33,673**

	Financial liabilities at amortised cost	Financial liabilities at fair value through profit or loss	Total
	$'000s	$'000s	$'000s
Liabilities as per balance sheet:			
Finance lease liabilities	67	–	67
Derivative financial instruments	–	11	11
Employee benefits	4,818	–	4,818
Trade payables and accrued expenses	7,336	–	7,336
Total	**12,221**	**11**	**12,232**

Group	Note	Financial assets at amortised cost	Financial assets at fair value through profit or loss	Total
		$'000s	$'000s	$'000s
30 June 2019				
Assets as per balance sheet:				
Trade and other receivables excluding prepayments	7	7,630	–	7,630
Contract assets	2	626	–	626
Cash and cash equivalents		509	–	509
Investment cash		30,000	–	30,000
Total		38,765	–	38,765

	Note	Financial liabilities at amortised cost	Financial liabilities at fair value through profit or loss	Total
		$'000s	$'000s	$'000s
Liabilities as per balance sheet:				
Employee benefits		5,466	–	5,466
Derivative financial instruments		–	6	6
Trade payables and accrued expenses	8	7,637	–	7,637
Contract liabilities	2	6,439	–	6,439
Total		**19,542**	**6**	**19,548**

19. Financial risk management

ESR's activities are exposed to a variety of financial risks: market risk (including cash flow and fair value interest rate risk), credit risk and liquidity risk. ESR's overall risk management programme focuses on the unpredictability of financial markets and seeks to minimise potential adverse effects on ESR's financial performance. The policies approved and financial instruments being utilised at balance date are outlined below.

a) Market risk

In accordance with its Treasury Management Policy, ESR uses derivative financial instruments to economically hedge its exposure to foreign exchange risks from its operational, financing and investment activities. These derivatives are classified at fair value through profit or loss, and gains and losses are recognised in profit or loss in the statement of profit or loss and other comprehensive income.

i) Foreign exchange risk

Foreign exchange risk occurs as a result of transactions denominated in a currency other than ESR's functional currency of New Zealand dollars. Currencies commonly transacted in, and giving rise to, foreign exchange risk include the United States dollar, Australian dollar, euro and the pound sterling. ESR is subject to foreign currency risk through its trade receivables and trade payables balances.

ESR is required by its Treasury Management Policy to hedge net foreign currency exposures equivalent to greater than NZD $100,000 using approved treasury instruments.

ESR held two forward exchange contracts with notional principal amounts totalling US$187,522 at 30 June 2019 (30 June 2018: three contracts totalling US$1,000,000).

The carrying amounts of the Group's trade and other receivables denominated in foreign currencies are:

	2019 $'000s	2018 $'000s
US dollar	3,001	1,886
Australian dollar	32	13
Pound sterling	–	4
Euro	57	–

The carrying amounts of the Group's trade and other payables denominated in foreign currencies are:

	2019 $'000s	2018 $'000s
Australian dollar	62	328
US dollar	544	21
Euro	2	7
Pound sterling	5	5

ii) Interest rate risk

As at reporting date, ESR is subject to interest rate risk through the holding of cash and cash equivalents and investment cash. ESR uses a mixture of call and short-term deposit investment accounts to hold excess funds. Available interest rates are monitored to ensure the best return on cash.

iii) Market risk sensitivity analysis

ESR is exposed to market risk through the holding of the following financial instruments: cash, trade receivables and trade payables. ESR management has analysed the sensitivities in market risk factors over a 12-month period below:

- proportional foreign exchange rate movement of -10% (depreciation of New Zealand dollar) and +10% (appreciation of New Zealand dollar) against foreign currencies
- a parallel shift of +1%/-1% in market interest rates in New Zealand.

If these movements were to occur (all other variables held constant), the impact on ESR's reported net profit after tax for the year ended 30 June 2019 would be:

- foreign currency $243,000 (30 June 2018: $528,000)
- interest rates $194,000 (30 June 2018: $144,000).

b) Credit risk

Credit risk refers to the risk that a counterparty will default on its contractual obligations, resulting in financial loss to ESR. The financial instruments which expose ESR to credit risk are, principally, cash and cash equivalents, investment cash and trade receivables.

Bank balances and short-term investments (comprising cash and cash equivalents and investment cash) are held with New Zealand registered banks in accordance with ESR's Treasury Management Policy.

The majority of high-value trade receivables comprise government entities and therefore the potential risk of default is low. ESR has a Contract Management Policy which requires assessment of the credit worthiness of potential clients, where the value of the contract is material as defined in the policy.

A provision for doubtful debts is maintained in respect of trade receivables and this is reassessed on a regular basis. No collateral is held by ESR in respect of cash and cash equivalents, investment cash and trade receivables as at 30 June 2019 (30 June 2018: nil).

The carrying amount of financial assets recognised in the statement of financial position best represents ESR's maximum exposure to credit risk at the reporting date.

As at 30 June 2019, the trade receivables balance included $2,976,000 (30 June 2018: $4,962,000) owed by entities within, or owned by, the New Zealand Government. It is not believed that there is any material risk of loss with these receivables.

c) Liquidity risk

Prudent liquidity risk management implies the availability of funding through adequate levels of committed credit facilities. Liquidity risk is monitored through the forecasting of cash flows, and ensuring that the committed credit lines in place remain adequate for requirements.

The contractual undiscounted maturity analysis of financial liabilities is presented below:

Group	2019					2018				
	Carrying value $'000s	Less than 1 year $'000s	1-2 years $'000s	2-5 years $'000s	Greater than 5 years $'000s	Carrying value $'000s	Less than 1 year $'000s	1-2 years $'000s	2-5 years $'000s	Greater than 5 years $'000s
Trade payables	7,637	7,637	–	–	–	7,336	7,336	–	–	–
Employee benefits	5,466	3,778	130	42	1,516	4,818	3,451	91	39	1,237
Finance lease liabilities	–	–	–	–	67	67	–	–	–	
	13,103	**11,415**	**130**	**42**	**1,516**	**12,221**	**10,854**	**91**	**39**	**1,237**

d) Fair values

The carrying value of financial assets and liabilities recorded in the financial statements approximate their fair values.

Fair value is generally based on the contracted amount payable/receivable of financial assets and financial liabilities, being the amount for which the financial instrument is to be exchanged. Fair value includes the impact of any assessed impairment of the financial instruments – refer to the statement of significant accounting policies for details of each financial instrument and their recognition criteria.

e) Capital risk management

ESR's objectives when managing capital are to maintain financial stability, achieve sustainable growth, and realise its strategic goals and targets, all within the risk appetite of its shareholder and management.

In line with Government requirements, ESR monitors its capital structure through the return on equity and gearing ratios. Government provides ESR with guidelines with the expectation that an appropriate average return is achieved over time, rather than requiring that ESR meet the specified targets annually.

Each year ESR internally sets return on equity and gearing ratio targets, bearing in mind the overall results expected by Government. The ratios are reported in the Statement of Corporate Intent.

The return on equity and gearing ratios as at 30 June 2019 and 30 June 2018 were as follows, along with the relevant annual targets set by ESR.

Group Return on equity ratio	2019 $'000s	2018 $'000s
Profit/(loss) for the year	1,858	4,271
Average equity	55,294	52,135
Actual ratio	**3.4%**	**8.2%**
Target ratio	**6.3%**	**7.7%**
Gearing ratio		
Net debt		
Finance lease liabilities – current	–	67
Finance lease liabilities – non current	–	–
	–	**67**
Equity	**56,317**	**54,270**
Actual ratio	**0.0%**	**0.1%**
Target ratio	**0.0%**	**0.0%**

20. Contingent liabilities

ESR is subject to a legal claim in the United States of America which alleges patent infringement related to aspects of the Group's commercial operations in that country. The Group is defending the action. The impact of these proceedings cannot be reliably quantified due to uncertainty around the outcome.

The directors are satisfied that there are no other claims outstanding that would have a material impact on ESR's financial position as at 30 June 2019 (30 June 2018: nil)

21. Subsequent events

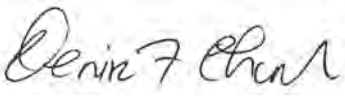
There were no events subsequent to reporting date that require disclosure in the financial statements.

Statement of Responsibility

We certify that the Company has operated in accordance with the principles of the Crown Research Institutes Act 1992 and Companies Act 1993. The Company has also complied with all statutory environmental regulations. We acknowledge responsibility for the preparation of these financial statements and for the judgements used therein.

Internal control procedures are considered to be sufficient to provide reasonable assurance as to the integrity and reliability of the financial reports.

In our opinion these financial statements fairly reflect the financial position and operations of the Institute of Environmental Science and Research Limited (ESR) for the year ended 30 June 2019.



Denise Church QSO
Chair

Quentin Hix
Deputy Chair

Report of the Directors

The directors present the Annual Report and audited financial statements of the Institute of Environmental Science and Research for the year ended 30 June 2019.

The Auditor-General is the statutory auditor pursuant to section 21 of the Crown Research Institutes Act 1992. The Auditor-General has appointed Christopher Ussher, using the staff and resources of PricewaterhouseCoopers, to audit the financial statements and to express an opinion on them.

Principal activity

ESR is a Crown Research Institute that provides specialist scientific services and research, particularly to the health and justice sectors. Its purpose is to deliver enhanced scientific and research services to the public health, food safety, security and justice systems, and the environmental sector to improve the safety and contribute to the economic, environmental and social wellbeing of people and communities in New Zealand.

Dividends

No dividends have been declared or paid in respect of the 2019 financial year.

Directors' indemnity

ESR has arranged for directors' and officers' insurance for any act or omission in their capacity as a director of the Company.

Directors' use of information

No member of the Board of ESR, or any subsidiary, issued a notice requesting to use information received in their capacity as directors that would not otherwise have been available to them.

Donations

Koha and donations totalling $1,339 were made during the year.

Remuneration of directors

The directors who held office in the period of this report and their total remuneration and other benefits were:

Denise Church (Chair)	$48,064
Quentin Hix (Deputy Chair)	$30,040
Kate Thomson (Audit and Risk Chair – appointed July 2018)	$24,032
Dr Helen Darling	$24,032
Richard Gill	$24,032
Cristin Print	$24,032
Andrew Shenk	$24,032
	$ 198,264

Disclosure of interests by directors

As at 30 June 2019, the following directors had made the following general disclosures:

Denise Church (Chair)

Trustee, Scout Youth Foundation
Director and Shareholder, Leadership Matters Limited
Member, National Board, Scouts New Zealand
Director, Predator Free Wellington Limited
Chair, Airways NZ

Quentin Hix

Director, Ngāi Tahu Holdings Corporation Limited
Trustee, Hunter Downs Irrigation Trust
Director and Shareholder, Quentin Hix Legal Limited
Trustee, Q C S & K L Hix Family Trust
Trustee, The T A A H R K Hix Family Trust
Opus approved RMA Commissioner and Chair
Board Member, Presbyterian Support South Canterbury

Director, One to One Corporate Trustees Limited
Director, One to One Corporate Trustees 2011 Limited
Director, Dunedin City Holdings Limited
Director, Dunedin City Treasury Limited
Director and Shareholder, Aoraki Trust Management Limited
Director and Shareholder, Aoraki Investments Limited
Director and Shareholder, Aoraki Management Services Limited
Director and Shareholder, Property Planit Limited
Director, Dunedin Stadium Property Limited (07/07/18)
Director, Presbyterian Support South Canterbury Limited
Director, Ngāi Tahu Capital Limited

Dr Helen Darling
Director and Shareholder, Cherry Futures Limited
Director and Shareholder, Asia Pacific Centre for Food Integrity
Expert Committee, United States Pharmacopeial Convention, Food Ingredients
Expert Panel, United States Pharmacopeial Convention, Food Adulteration
Director and Shareholder, Sumfood Limited

Richard Gill
Director, Shareholder and CEO, Cloud M Limited
Director and Shareholder, Richard Gill Limited
Director, Richard Gill Trustees Limited
Director and Shareholder, Sumfood Limited
Director and President, Blerter Inc.

Cristin Print
Member of the Science Leadership Team of Genomics Aotearoa
Professor, Dept of Molecular Medicine and Pathology, University of Auckland, and lead of the University of Auckland Genomics Into Medicine programme
Standing member of the Assessment Committee of the Cancer Research Trust NZ
Principal Investigator, Maurice Wilkins Centre
Member of the New Zealand eScience Infrastructure Research Reference Group
Chair of the Auckland Regional Tissue Bank Scientific Advisory Board
Member of the Science Leadership Team of the 'Healthier Lives' National Science Challenge
Vice President of the Auckland Branch of the Royal Society
Research collaboration with LabPlus clinical laboratories in the Auckland District Health Board research involving microbiological collections for N. gonorrhoeae, Tuberculosis sp. and Acinetobacter sp.
Co-leader of MBIE/Genomics Aotearoa Precision Medicine Pathfinder Project (includes planned collaboration with ESR staff)

Andrew Shenk
CEO, Auckland UniServices Limited
Director, The Icehouse Limited
Advisor, Zino Ventures Limited
Advisor, Matū Fund Limited
Advisor, 88Kiwis Limited
Director, Hop Revolution Limited
Director, Hop Garden Services Limited
Director, Hop Revolution Trading Company Limited

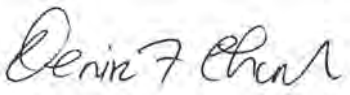
Kate Thomson
Shareholder, Dandaloo Farming Company Limited
Director, Indian Road Survey and Management Pvt. Limited
Independent Member, Indigo Shire Audit and Risk Committee
Chief Financial Officer, Australian Road Research Board Group Limited (ARRB Group Limited)

Directors' interests
No director held any interest in the shares of ESR. ESR has funding contracts with the Marsden Fund and the Ministry of Business, Innovation and Employment, which are negotiated at arm's length with appropriate directors' interests being declared. Except for these contracts no material contracts involving directors' interests were entered into during, or subsequent to, the period covered by this report.

Remuneration
Total remuneration in respect of employees paid above $100,000 was as follows:

Remuneration range	No. of staff
$100,000 – $109,999	34
$110,000 – $119,999	19
$120,000 – $129,999	16
$130,000 – $139,999	6
$140,000 – $149,999	11
$150,000 – $159,999	3
$160,000 – $169,999	4
$170,000 – $179,999	3
$180,000 – $189,999	2
$190,000 – $199,999	2
$200,000 – $209,999	1
$210,000 – $219,999	1
$220,000 – $229,999	2
$230,000 – $239,999	2
$240,000 – $249,999	2
$310,000 – $319,999	1
$470,000 – $479,999	1

Events subsequent to balance date
The directors are not aware of any matter or circumstance since the end of the financial year that has significantly affected, or may significantly affect, the operation of ESR.



Denise Church QSO
Chair

Quentin Hix
Deputy Chair

Our stakeholders

MINISTRY OF HEALTH
MANATŪ HAUORA

New Zealand POLICE
Nga Pirihimana O Aotearoa

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Plastics monitoring structure at Lyttelton Port – part of the ESR-led AIM² (Aotearoa Impacts and Mitigation of Microplastics) project, a part of a five-year MBIE-funded project investigating the impacts of microplastics and the threat to New Zealand's ecosystems, animals and people.

ESR SCIENCE CENTRES

KENEPURU SCIENCE CENTRE

34 Kenepuru Drive
Porirua 5022
PO Box 50348
Porirua 5240
New Zealand

Tel: +64 4 914 0700

CHRISTCHURCH SCIENCE CENTRE

27 Creyke Road
Ilam
Christchurch 8041
PO Box 29181
Fendalton
Christchurch 8540
New Zealand

Tel: +64 3 351 6019

NATIONAL CENTRE FOR BIOSECURITY AND INFECTIOUS DISEASE (NCBID) – WALLACEVILLE

66 Ward Street
Wallaceville
Upper Hutt 5018
PO Box 40158
Upper Hutt 5140
New Zealand

Tel: +64 4 529 0600

MT ALBERT SCIENCE CENTRE

120 Mount Albert Road
Mount Albert
Auckland 1025
Private Bag 92021
Victoria Street
West Auckland, 1142
New Zealand

Tel: +64 9 815 3670

REGISTERED OFFICE

Kenepuru Science Centre
34 Kenepuru Drive
Porirua 5022
PO Box 50348
Porirua 5240
New Zealand

Tel: +64 4 914 0700
Email: info@esr.cri.nz
www.esr.cri.nz

AUDITOR

Christopher Ussher of PricewaterhouseCoopers on behalf of the Auditor-General

BANKER

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