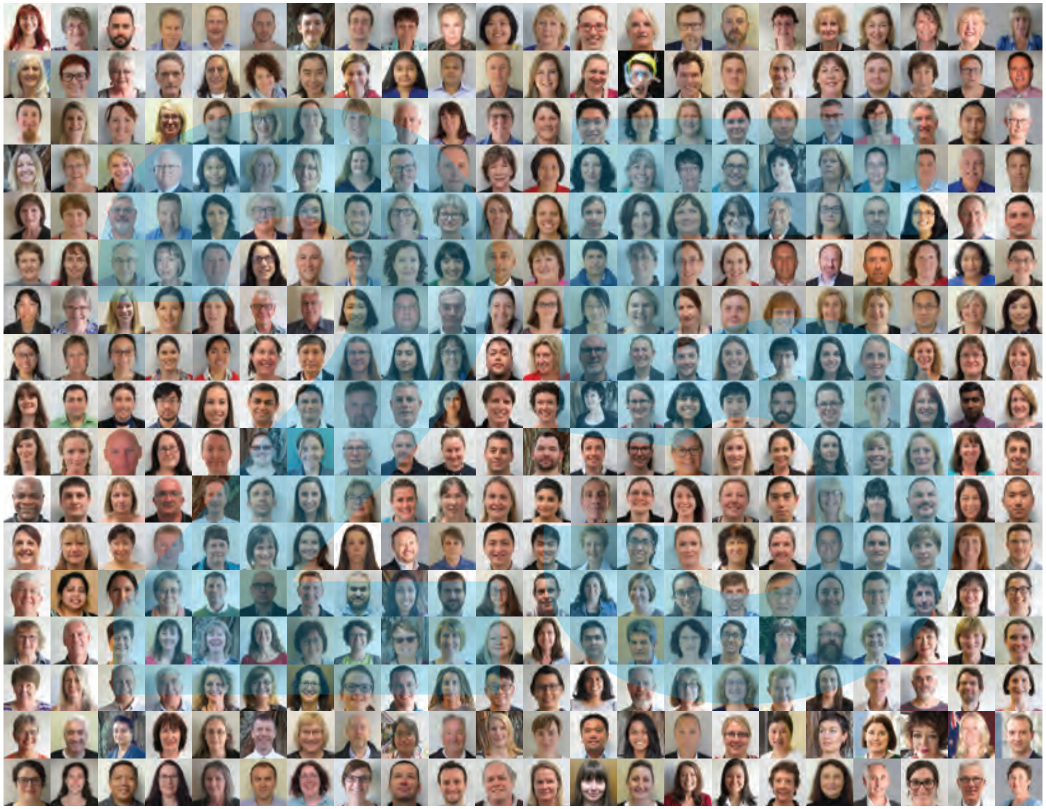

25 YEARS OF ESR 1992–2017

ESR

CELEBRATING 25 YEARS

E/S/R
Science for Communities

25 YEARS OF ESR

Delivering science services for New Zealanders

1992–2017

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MINISTER'S FOREWORD

Twenty-five years ago, the government embarked on an ambitious reform of the New Zealand science system, creating 10 Crown Research Institutes whose core purpose was to deliver science and research for the benefit of New Zealanders. Today, there are seven remaining.

It is my opinion that ESR has achieved that purpose admirably in the last quarter century. ESR started life as the smallest of the CRIs. Unlike its big sisters, it is unique in that it conducts research to solve complex problems that affect New Zealanders and people around the world and also delivers high-end scientific services to protect the wellbeing of our people.

Four hundred scientists and support staff use their world-class knowledge, research skills and laboratory services to safeguard people's health, protect food-based economies, improve the safety of freshwater and groundwater resources and contribute expert forensic science to the justice system. All of these seemingly disparate areas of work are bound together across disciplines as they work together for people and communities.

If New Zealand is to be successful in the 21st century, we must continually innovate, respond and adapt to any new challenges. Countless times over the last 25 years, the people of ESR have risen to these challenges, developing innovative science that provides new and better ways of protecting the health of New Zealanders, keeping them safe so they can build prosperous lives.

ESR works well with government's vision of increasing opportunities to build a better New Zealand for all New Zealanders. As we look into the past 25 years and analyse and celebrate its achievements, we also see that ESR is embracing the future to be cutting edge, forward looking and fast moving to make New Zealand and the world a better place to be.

Hon Dr Megan Woods
Minister of Research, Science and Innovation
June 2018

25 YEARS OF ESR

2017 was a significant year for the Institute of Environmental Science and Research (ESR), marking 25 years of operation since its establishment in 1992. Employing around 400 people, ESR has pushed the boundaries of scientific research to solve some of the most pressing issues facing New Zealand, and through its forensic, health and environmental science services and research, it has worked to keep New Zealanders safe, healthy and prosperous for a quarter of a century.

New Zealand's scientific heritage

New Zealand has a fine scientific heritage. It began with Māori culture and practices that use techniques consistent with scientific methods – including observation and experiment – to generate knowledge. It continued with colonial expeditions including Charles Darwin's nine-day stopover on HMS *Beagle* in 1835. From 1865, New Zealand's national science organisations were established by Dr James Hector including the New Zealand Geological Survey and Colonial Museum and Laboratory, Colonial Observatory, Meteorological Service, Colonial Botanic Gardens and the New Zealand Institute.

However, it was in 1926, after calls for the New Zealand Government to support education and research, that Ernest Marsden founded New Zealand's Department of Scientific and Industrial Research (DSIR). DSIR was the pre-eminent science organisation in New Zealand and was responsible at that time for a large proportion of government science and research efforts.

From DSIR to a new model of science delivery

In the late 1980s, New Zealand commenced the reform of its publicly funded science system. The policy advice, funding and science provision functions were split up. In 1989, the Ministry of Research, Science and Technology was created to be responsible for policy advice, and the Foundation for Research, Science and Technology was set up to administer funding. The huge conglomerate that was DSIR was dismantled and, along with small government scientific research agencies, rearranged into 10 semi-independent Crown Research Institutes (CRIs), each with its own expertise and alignment to specific sectors.

The core purpose of these organisations, set out in the Crown Research Institutes Act 1992, was scientific research for the benefit of New Zealand, with an added rider that they operate along commercial lines and become financially viable. They opened for business on 1 July 1992.

ESR's first senior management team: Standing, left to right: Dr Margaret Lawton, Forensic; Dr Bill Swallow, Health (Food and Water); Dr Judith Collins, Environmental (Consulting). Seated, left to right: Wayne Chisnall, Public Health; Liz Koh, Environmental (Analytical); Mark Templeton, Chief Executive.

DSIR

INSTITUTE OF ENVIRONMENTAL HEALTH & FORENSIC SCIENCES

Providers of Research, Analytical & Consultancy Services

ESR's first logo after DSIR was dismantled.

ESR directors 1992 (from left) Christopher Mace (Chair), Professor Ralph Cooney, Dr Linda Holloway and Sir Robin Irvine (Absent: John Haigh QC).

The technical definition of financial viability changed from time to time, but it focused on a return on equity. The State did not expect CRIs to maximise profit, but simply to cover the costs of capital, to be financially self-sustainable and to make an adequate rate of return that could be reinvested in the science. The aim of this formula was to ensure that the new entities operated commercially and provided technology transfer to the wider New Zealand economy while fulfilling scientific purposes.

Over the last 25 years, the 10 Crown Research Institutes have become seven: AgResearch (NZ Pastoral Agriculture Research Institute Limited), ESR, GNS Science (Institute of Geological and Nuclear Science), Landcare Research (Manaaki Whenua), National Institute of Water and Atmospheric Research (NIWA), Plant & Food Research (formerly NZ Institute for Crop & Food Research, which merged with HortResearch in 2008) and Scion (formerly NZ Forest Research Institute). The New Zealand Institute of Social Research and Development was disestablished in 1995. The New Zealand Institute for Industrial Research and Development merged into a new Crown entity, Callaghan Innovation, in 2013.

Collectively, the CRIs now employ 3,400 staff across 50 sites around New Zealand. They play a unique and important role supporting their sectors to innovate and grow and address New Zealand's most challenging issues. Their aim is to help New Zealand achieve economic growth by improving sectors' productivity and the sustainable use of natural resources. Two-thirds of New Zealand's publicly funded science researchers – outside health and information and communication technology – work for the CRIs, and New Zealand businesses turn to them for over 75% of their external research and development work.

Early 1990s at ESR

ESR began life on 1 July 1992 as the Institute of Environmental Health and Forensic Science. By 1993, it was renamed the Institute of Environmental Science and Research Limited as it was thought this conveyed a more professional approach. The early years were difficult as the organisation sought to make sense of what the Chair of the day, Christopher Mace, called "a disparate set of scientific services that were little more than bits and pieces left over from the formation of the other Crown Research Institutes". This included the DSIR Chemistry division, the Area Health Boards' Public Health Laboratories and the New Zealand Communicable Disease Centre. ESR was different from all the other CRIs. It was not just a research institute but a science services delivery business, with the majority of its funding coming not from the Public Good Science Fund but from three major clients – New Zealand Police, the Ministry of Health and the Public Health Commission (which was reabsorbed back into the Ministry of Health in 1996). According to a case study on ESR published by Victoria University in 1999, government officials privately acknowledged to senior management that they did not think the organisation would survive.

The first Board of ESR included an impressive line-up of directors, with the Chair being highly successful Auckland businessman Christopher Mace. Among other things, Christopher went on to become a founding member of the Sir Peter Blake Trust, a trustee of the Antarctica Heritage Trust and Chair of NIWA. He was knighted for his services to science and education in 2016. Other members of the foundation Board included Professor Linda Holloway, Malcolm Don, John Haigh QC and Professor Ralph Cooney.

Foundation Chief Executive Mark Templeton was still in his mid-30s when he was appointed. An outsider, he had an MBA backed by a science degree, a background in the oil industry and a determination to make the organisation succeed. But he had his work cut out for him, guiding the organisation from the old science system to the new. It was a challenging time for many ESR staff. High-quality scientists in their own right, they were apprehensive and somewhat dispirited after several years of reforms in the science and health sectors. The directive to operate in a competitive environment was unsettling for many who were used to the research environment being funded solely by government.

Mark led the staff through a whole-of-organisation strategic planning process, developing the first mission statement that ESR would become 'an international leader in scientific services for the protection of people and their environment'. This direction stayed relatively constant for more than 10 years. The organisation was initially structured into five nationally organised business units: Public Health, Food and Water, Environmental Consulting, Environmental Analysis and Forensic Science. Senior management had intentionally clumped what was described as up to 50 different businesses into these business units so that compatible skill sets and similar markets worked together. These groups were located across New Zealand with a corporate office in Wellington and laboratories inherited from DSIR and the Area Health Boards in Kenepuru, Gracefield, Mount Eden, Mount Albert, Christchurch and Dunedin. Three brands were created to market ESR services – ESR Forensics, ESR Health and ESR Environmental.

In the early years, ESR's major clients were the Ministry of Health, the regional health authorities, the Public Health Commission, Police, the Marine Biotoxin Management Board and the New Zealand Racing Codes, as well as regional and city councils and some private sector clients. There were also some international clients in Australia and Malaysia. In the first two years, pre-existing levels of bulk funding from Police and Health were continued to enable the new organisation to establish itself commercially.

Uncertainty of funding was a major theme in ESR's early years with many contracts formed on a year-to-year basis. ESR navigated several changes from government such as the Ministry of Health's role of purchasing national public health scientific services in its own right. Output-based funding arrangements for forensic services to Police were also put in place as part of these changes. Police, used to bulk funding of services, now had to adjust to paying for services, causing ESR further funding uncertainty as a result of unpredictable changes in demand for forensic services. Science research received a boost in 1995, with the Foundation for Research, Science and Technology (dissolved in 2011) providing funding for groundwater, marine biotoxin and organic and heavy metal contamination research.

Despite such a shaky beginning, ESR survived and prospered. Projects of the day included smog in Christchurch, dioxins and heavy metals in soil and waterways, a shellfish toxin that crippled the shellfish industry and

Kenepuru Science Centre, Porirua, early 1980s.

DNA profiling to identify and eliminate suspects of crime, including using the polymerase chain reaction technique (PCR), enabling microscopic amounts of DNA to be analysed. Other services included providing a rapid turnaround for cannabis identification, assessing factory air quality emissions and a new workplace drug-testing programme. Research included a project to identify the levels of lead poisoning in children, alcohol breath-testing device effectiveness and research into group A *Streptococcus* bacteria, which caused throat infections with life-threatening complications of rheumatic fever and necrotising fasciitis (the 'flesh-eating bug'). Rheumatic fever was a big problem in the early 1990s, and ESR worked on a school-based prevention programme to combat it. The organisation also stepped up its surveillance programme to take into account the rise of tuberculosis in 1995.

A mid-winter day in Christchurch. Scientists from ESR identified domestic fires as the major cause of smog in the city. ESR's research helped Canterbury Regional Council to reduce pollution.

Virginia Haynes from the Communicable Disease Centre catalogues shellfish samples for analysis during New Zealand's first outbreak of toxic shellfish poisoning.

Mid-1990s at ESR

The mid-1990s were difficult for ESR. The transition from a protected government agency to a competitive commercial enterprise was not easy. Falling revenue and uncertain funding arrangements continued to put pressure on the bottom line. Facing a loss, Chief Executive Mark Templeton had a huge job ahead of him. Restructuring had a significant effect on operational performance in the 1996/97 year. The impact of these actions resulted in depressed revenues. To alleviate the pressure threatening ongoing viability, a programme was put in place to cut discretionary costs and accelerate the transition to lower staffing levels and operating costs. The final result was a tax loss of $637,000 – a low point for ESR.

The following year saw a return to profitability and an increase in revenue. But while the benefits of restructuring and productivity improvements were clearly shown, ESR's major government clients, faced with more reform and policy shifts, were required to further reduce expenditure, making it difficult for ESR to operate a viable organisation. This came on the back of further significant government restructuring in the health sector, which continued to create uncertainty around future purchasing of public health scientific services. Extreme pressures on Police for operational savings also threatened the viability of ESR's forensic services.

The need to develop a productive client/provider relationship was ever more important at this time. Both the client and ESR had to change their understanding from the old way of operating to one that was on a new commercial footing. Contracts had to become tightly specified because the client, especially in the health area, as one manager recounted "would choose all services offered without having the budget to pay for it".

An independent consultancy, BERL, was commissioned to improve the understanding of how ESR and the Ministry of Health worked together. The BERL report recommended that the roles of risk assessment and risk management be clearly defined. Surveillance and the development of tests for unknown and developing risks were not to be contestable, with ESR recognised as the Centre of Excellence, and an agreed funding arrangement was set for this core capacity. Routine testing would become contestable and open to all laboratories.

In the same way, the contract with Police also needed work. BERL was once again called in to improve the situation. The issue was that ESR did not have a viable contract with Police that would enable forensic services to be maintained at the level Police required. The BERL report helped both sides understand the other's issues with recommendations including making pricing and cost recovery more transparent and for each side to work more closely together at all levels of the organisation. (ESR Forensics and operational Police officers, working in the field together, had an excellent relationship.)

The lack of adequate research funding hampered the development of ESR's science research plan with only 7% of ESR's revenues coming from externally funded research. As Chair Christopher Mace put it, "The problem was not a lack of research issues of importance to the country but the gap in science funding in the areas where human health and environmental issues overlap."

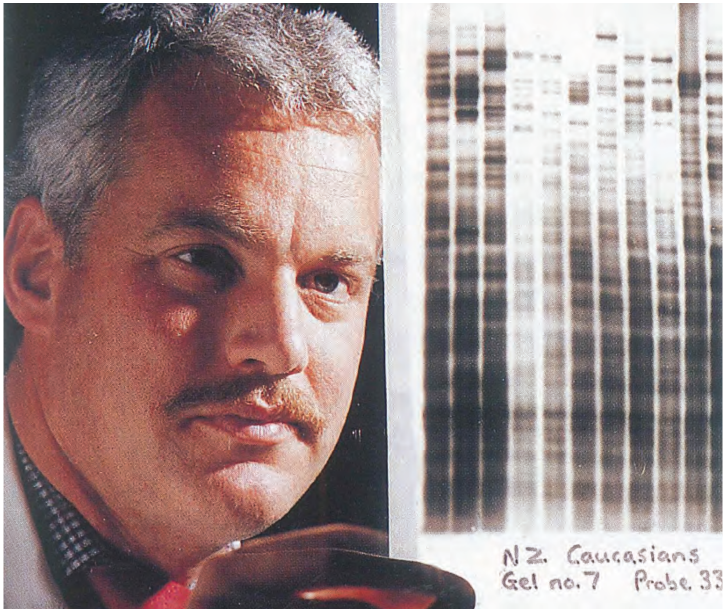
Despite these setbacks, ESR continued to develop its strategy to build the organisation. A major investment was undertaken to upgrade key aspects including the forensics unit, public health laboratories and support services. New facilities were built at Mount Albert to accommodate a new Forensic Service Centre and administrative services. This enabled the existing building at Mount Albert to be better utilised as a laboratory space and for the expanded National Forensic Laboratory and the integrated Food Microbiology and Chemistry Services.

The investment in facilities was recognised when ESR received its first formal accreditation by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) in 1998 for the three forensic laboratory sites in Auckland, Gracefield and Christchurch. Further investment included establishing the DNA Profile Databank in support of Police investigative capability. ESR also began to refine its purpose, and two non-core aspects of the business were sold – the asbestos-testing business as well as the deuterated drugs business.

By 1998, the expensive restructuring process was over, and ESR had developed a flexible organisational structure that was able to cope with continually changing client needs. A more effective integration of Wellington's operation saw the relocation of the corporate office and much of Gracefield to the Kenepuru Science Centre, near Porirua. The DNA Profile Databank moved from Wellington to Auckland to achieve full integration with forensic biology casework. Three Forensic Service Centres had been established in Auckland, Wellington and Christchurch for client liaison and attendance at crime scenes. The DNA Profile Databank had started to demonstrate its value with the first matches between crime-scene DNA profiles and criminal profiles.

ESR had inherited a very narrow research base and was determined to build up its science capability. It differed from other CRIs because it dealt with the convergence of environmental and health concerns – using science to protect people. At the time, this work was seen as outside the

New Forensic Service Centre at Mount Albert Science Centre, Auckland.



New Zealand Police made increasing use of DNA testing to identify and eliminate suspects, particularly in violent crimes. Dr Stephen Cordiner, of the Forensic Services Group, examines a DNA test.

realm of the Public Good Science Fund, which was a source for research funding. However, a gradual recognition of the need for environmental health research began with sector strategies developed through the Ministry of Research, Science and Technology's Foresight programme.

Despite the downturn in finances, ESR continued to provide scientific research, consulting and analytical services related to public health, environmental science and forensic science to both the public and private sector. Revenue jumped from $26.8 million in June 1997 to $29.1 million the year later, and profits just skidded over the line at $197,000. New business included a two-year contract with the Department of Corrections for drug testing in prisons and a renewed marketing effort in Australia following the purchase of a high-resolution mass spectrometer.

Further restructuring saw the consolidation of ESR's analytical services at Wellington as well as the withdrawal from the occupational health consultancy service. The three ESR occupational health consultants took over the business and started trading as Paragon Limited in 1998. The air quality business was also split off, and it formed its own autonomous consultancy.


ESR's Water Group works closely with supply authorities to further improve drinking-water quality for all New Zealanders.

By 1999, ESR began to coalesce as a business. Cross-fertilisation of the business groups started to happen such as taking forensic services to environmental markets, transferring molecular techniques to the food and environmental businesses and selling a broad range of services together. An internal electronic poll asked senior operational and corporate leaders the question: 'Is ESR more than the sum of its parts?' It found that most participants supported this proposition.

Science protecting people in the mid to late 1990s included tackling an outbreak of *Cryptosporidium* in public swimming pools, identifying and fighting a measles epidemic, investigating incidents of foreign material in food, continuing to play a key role in researching the high rate of rheumatic fever in New Zealand and improving ESR's surveillance system EpiSurv.

The surveillance system included the ever-important surveillance of the influenza virus each year. New techniques were also developed to better identify New Zealand strains of viruses that cause human disease.

ESR's environmental science work played a significant role in managing New Zealand water supplies. The team produced the annual report on water quality in New Zealand, maintained the register of drinking-water supplies and developed the Water Information New Zealand (WINZ) database.

Research into environmental oestrogens was also conducted with the aim of developing environmental standards for the management of dioxins and pesticides in air, water and soil. Air pollution effects on ecosystems were also studied, along with the assessment of benzene exposure levels from vehicles, measurement of methane gas output from ruminants and the development of core national environmental indicators. New methods of identifying *Campylobacter* in river water, using DNA analysis, enabled faster, more accurate results of contamination. Groundwater research looked at how pesticides leached from the ground into aquifers and the transport and fate of contaminants in groundwater supplies.

Mark Templeton resigned from the company in late 1999. While a relatively young man, he had led the company, with the guidance of Chris Mace and his Board, through its most difficult time, transforming a public service organisation with a 120-year history in which services were supplied to other government departments into an unashamedly commercial one that dealt in contracts, clients and customer service.

Early 2000s at ESR

The turn of the century saw Malcolm Don appointed to chair the Board and a new Chief Executive, John Hay. John had previously been General Manager of sister CRI AgResearch and before that at DSIR's Grassland Division. As the new team took over from the old, there was significant recognition of the work ESR had done through a challenging time as it tried to mould a disparate set of services into a viable business. The organisation began to post improved profits. These were boosted by sales of assets including the environmental analytical business to State-Owned Enterprise AgriQuality in 2000. This was done to allow ESR to focus on its core research and science services business. The proceeds for land sold at Gracefield and Mount Eden and the sale of the Air Quality Group to Watercare Services were also complete. The sale of the Mount Eden site was controversial at the time as the land had been contaminated by the previous owner, resulting in the necessity of removing hundreds of thousands of tonnes of soil at a significant cost to ESR and remediating the site before it could be sold. The five science centres were rationalised down to three locations at Mount Albert in Auckland, Kenepuru and Christchurch. This helped refine ESR's service offering and put the organisation on a more sustainable footing.

The Kenepuru Science Centre was refurbished in 2000 and now accommodated all Wellington region staff. The refurbishment included purpose-built forensic and toxicology laboratories as well as a new seminar room and staff cafeteria. At the opening, Minister of Research, Science and Technology Peter Hodgson said that ESR was the smallest Crown Research Institute in New Zealand. "It receives little money from FRST [the Foundation for Research, Science and Technology] yet its clientele is the New Zealand public. ESR secures its future by providing the highest-quality public sector science that it can. It is a public good and a remarkably valuable institution."

A new Chair, Ian Wilson, took over from Malcolm Don in 2002. Revenue continued to increase, and in the 2002/03 financial year, a $1.1 million profit was recorded. In 2003/04, this profit rose to $1.789 million – a long way from the days when ESR was a loss-making organisation.

A review of ESR Forensics DNA operations by the Ministry of Justice sought to provide independent reassurance of the integrity of ESR's forensic DNA technology and protocols. This was spurred by unexplained DNA findings in two Wellington homicides, as well as questions raised by retrospective DNA testing using newer technology in a rape case that had earlier resulted in an acquittal. Findings showed ESR's forensic operating systems and procedures were on a par with leading international forensics

Dr John Hay, Chief Executive 2000–2011.

Ian Wilson, Chair 2002–2010.

The DNA Profile Databank was established after the Criminal Investigations (Bodily Samples) Act was passed into law in 1995. The second National DNA Profile Databank in the world after the UK uses the six-locus SGM multiplex and the ABI PRISM® 377 Genetic Analyzer.

DNA profiling technology contributed to the conviction of Teresa Cormack's murderer.


Teresa Cormack.

ESR calibrated and supplied breathalysers.

laboratories. As a result of these reviews, a decision was made to construct a $3 million, purpose-built Forensics DNA facility at Mount Albert that superseded the existing DNA laboratories originally built for chemistry. This opened in 2002. The Forensic Laboratories also received crime scene accreditation in 2002. At the time, there were only four organisations in the world to have achieved this – three in the United States and ESR.

ESR's work with alcohol breath testing was also challenged in 2001 in relation to the evidential breath-testing devices ESR serviced and calibrated on behalf of Police. Court challenges to the accuracy of these devices resulted in a major backlog in the prosecution of drink-driving cases while legal arguments were presented on the disclosure of the commercially sensitive nature of service manuals held by ESR. A full Court of Appeal judgment by five judges ruled unanimously in ESR's favour. A consequential amendment to the Land Transport Act 1998 in December 2001 negated the potential for further challenges, and the backlog was cleared.

ESR continued to process an increasing number of cases using DNA profiling technology. The hit rate of matching crimes to potential offenders on the National DNA Profile Databank increased. In 2003, the upgraded DNA profiling technology led to the long-awaited conviction of the murderer of Teresa Cormack, a six-year-old girl who had been killed in 1987.

The contract for ESR's food programme was transferred from the Ministry of Health to the newly formed New Zealand Food Safety Authority in 2002. A significant contract for $3 million was negotiated with this new body to provide a risk-based food safety programme that included microbiological and chemical surveillance. Food export certification work also included wine export certification, which ESR carried out for the Wine Institute as well as a number of small wineries. The second New Zealand Total Diet Survey, which was carried out by ESR in 1998, was released in 2000. It had previously been done by DSIR. One outcome of the survey was that lead was found in baby food that contained cornflour imported from China. The cornflour was contaminated by the vessel that had previously transported lead concentrate to Australia. ESR is still involved in this valuable survey to this day.

ESR was part of the national response to the severe acute respiratory syndrome (SARS) crisis that hit the world in 2003. Dr Fiona Thomson Carter, ESR's Communicable Disease Centre's Programme Leader, said at the time that, such was the worldwide response to this infectious disease, 111 years of science was telescoped into nine weeks. Three ESR staff members were appointed to the Ministry of Health's technical advisory group during the SARS crisis. ESR had the only virology lab in New Zealand with the training to perform tests that required PC3+ facilities. Although there were very few suspected cases in New Zealand, they were managed efficiently and effectively.

A three-year study on the risk factors of meningococcal disease had been released by ESR in 2000. It found, among other things, that meningococcal disease was associated with overcrowded housing. In 2001, the study won the Royal Australasian College of Physicians Rue Wright Memorial Award for best presentation, which was the only time up until then that this award had been presented outside of Australia.

In 2004, after 13 years of hard work and extensive international collaboration, the MeNZB™ vaccine to fight New Zealand's meningococcal epidemic was rolled out by Dr Diana Martin and her team. The Ministry of Health said that ESR played an instrumental role in the collaborative efforts to bring New Zealand's meningococcal disease epidemic to an end.

ESR occupies a unique niche in New Zealand by being able to collate data on a particular pathogen as part of national reference laboratory activity and, with its public health surveillance work, provide a meaningful platform for other national data. This was further confirmed when the organisation was charged with establishing the national New Zealand Microbial Typing Database in 2003. This collection enabled the harmonisation of sub-typing methods to distinguish isolates of bacteria. One benefit of the new collection was to be able to effectively detect linkages between human isolates and those from food, environmental or other sources.

ESR continued to establish new strategic partnerships and relationships. A strategic alliance was formed with Austhos Pty Limited, a not-for-profit organisation, to help market ESR's forensic DNA Profile Databank system into Asia. This resulted in the sale of a new forensic database system in Malaysia.

In early 2004, Thailand purchased the DNA information management and databank system from ESR, further confirming New Zealand's proven track record and expertise in DNA matching to solve crime. ESR also worked towards the establishment of a New Zealand Forensic Science Research Centre in partnership with international forensic agencies, New Zealand universities, other CRIs and end users such as Police, the Ministry of Justice and Courts.

Significant work also went into increasing ESR's research capability. Funds were freed up to recruit scientists to bolster capability. In 2004, a number of long-term scientific research contracts and prestigious international grants came to fruition.

ESR's virology laboratory during the SARS crisis.

Dr Diana Martin working on the MeNZB™ study.

Clan lab in Fiji.

Virus hunters.

The growth of methamphetamine or P labs came to a head in 2004. ESR had already put major efforts into investigating hundreds of new labs in the preceding years. New funding allowed ESR to expand its methamphetamine clandestine laboratory work meaning that the backlog of cases at the end of the 2004/05 year could be cleared. P was also a big issue in the Pacific, with the largest methamphetamine factory in the southern hemisphere at the time found in Fiji. ESR helped to shut down and dismantle the lab and undertook further analysis in preparation for the associated court case.

As both a provider and user of science and biotechnology products and services, ESR was ideally placed to get involved in commercialising new products, software and processes. The development of 'glowing' bacterial biosensors, brought over from the United Kingdom, to detect toxic chemicals in forensics cases was one such product. New molecular methods were developed for detecting disease-causing viruses and modifying *Rhizobium* soil bacteria with a lux gene from marine bacteria that glows when it comes into contact with heavy metals. The biosensor can be used to find out whether contaminants from sewage sludge affect the biological health of soil.

The years 2004 and 2005 were bad years for the flu. ESR's virology laboratory was part of the World Health Organization's national influenza reference laboratory and collated, analysed and reported year-round virological surveillance. This assisted with early detection of influenza outbreaks and helped identify the predominant strains in the community so plans could be made for an effective influenza vaccine for the subsequent year. The Wellington flu and two B strains, particularly the B/Hong Kong flu, swept the country in 2005 causing a significantly increased workload.

ESR used its forensics and health science expertise to assist Thailand following the Boxing Day tsunami in late December 2004. ESR's existing relationship with Thailand before this tragic event, including setting up their national DNA laboratory and criminal databank system, meant that Thailand turned to ESR for help. The company developed a disaster-victim preparedness software package and trained local staff to use it. ESR forensic scientists also worked for several months in Bangkok to help process difficult samples (tissue and bone) and assist with DNA profile data for kinship matching and reporting.

In March 2005, British scientist Dr Jeannette Adu-Bobie – an expert on meningococcal vaccines – had been in New Zealand only 20 days and at ESR about seven working days when she contracted meningococcal septicaemia. She spent several months in hospital and had both legs, her left arm and the digits of her right hand amputated. After several investigations, it was concluded that Dr Adu-Bobie more than likely contracted the disease through her laboratory work. The report also found that the exact cause of the infection remained unknown. Like previous investigators, the final report had been unable to find any faults with ESR's safety systems. This situation caused considerable media attention and considerable distress to staff at the time.

ESR's partnership with communities saw it working with Hauora Hokianga on the development of Māori solutions to tackle health problems from sewage treatment and disposal in rural areas of Northland. Other work with Māori included a collaborative study with Ngāpuhi iwi on shellfish health in historically important beds around Waitangi.

Mid-2000s at ESR

Revenue continued to grow throughout the mid-2000s with a 70% increase in revenue from $27 million in 2001 to $45.5 million in 2006. Although the organisation continued to post record profits, a tension remained in balancing shareholding ministers' expectations relating to the return on investment and capital structure while striving to enhance the services provided for the public good.

A growing emphasis on national and international research partnerships and collaborations led to new research areas including, most notably in 2005, envirogenomics. This aimed to understand the interaction between unique genetic make-up, environmental agents such as drugs, toxins and microbes and disease to unravel the mysteries of a range of common health issues. This area emerged in the wake of the sequencing of the human genome and the development of cutting-edge biotechnologies. The nicotine metabolic rates in different New Zealand ethnic populations was an early piece of research. Another area was using the genome chip to identify genetic markers in diseases such as stomach cancer, alcoholism and diabetes, especially in indigenous populations. Research projects included gene expression analysis of obesity and diabetes traits, pharmacogenomics of nicotine replacement therapy, folate supplementation, genotype and risk of migraine/stroke, neurogenomics of drug exposure and genetic determinants of gout in Polynesians.

An alliance with the Ministry of Agriculture and Forestry, Agriquality and AgResearch saw the development of a National Centre for Biosecurity and Infectious Disease (NCBID). This new centre provided the scientific infrastructure to respond effectively to biosecurity threats, emerging diseases and chemical, biological and radiological events. With government providing $5 million, it represented the largest investment ESR had made at the time and took five years to develop. Built at Wallaceville, near Upper

Cardiff Takumanawa Carlton (Ngāpuhi, Te Whānau-ā-Apanui) at Te Kaiwaha Marae, Waiwhatawhata.

National Centre for Biosecurity and Infectious Disease (NCBID) laboratory built in 2008.

Infectious disease outbreak testing.

ESR's national health surveillance system.

Treating drinking water to improve water quality in the Pacific region.

Hutt, it came to fruition in 2008. Chair Ian Wilson said it "was an investment vital not only for the future of ESR but to ensure the safety and security of New Zealanders".

The ESR strategy of driving growth continued in the mid-2000s with investment in low copy number (LCN) DNA, providing the forensic team with a new crime-fighting tool. This required further refurbishment of the Wellington and Christchurch Science Centres. Considerable investment was also made to automate the DNA laboratory.

In the environmental health area, in 2006, $1 million was allocated to develop SurvINZ – an integrated national surveillance system to provide early warning of disease outbreaks and vital intelligence for disease, biosecurity and bioterrorism threats. The new technology platform assisted public health users and national crisis managers to quickly model how an outbreak might spread. Applications such as Water Information New Zealand and the national notifiable disease database EpiSurv could now be accessed through the SurvINZ platform.

ESR was now managing a wide range of databases and collections on behalf of the Ministry of Health and Police. These included the Chemical Injury Surveillance System, the DNA Profile Databank, EpiSurv, SurvINZ, PulseNet, the bacteria and fungi Reference Culture Collection, the STI (sexually transmitted infection) Database, Water Information New Zealand and, of course, the national Medical Reference Collection.

In 2006, ESR helped design and implement drinking-water safety workshops in Tonga, Cook Islands, Vanuatu, Palau and Samoa. ESR drew on its own expertise gained in developing and implementing New Zealand's drinking-water management programme to do this. ESR had been supporting the Pacific since the early 2000s and showed it was well placed to use its science and knowledge to assist Pacific communities to achieve healthy, safe and resilient communities.

A major area of difficulty at this time was that government funding for research did not directly accommodate both forensic and environmental health research. The investment portfolios of the agencies that provided government research funds, the Foundation for Research, Science and Technology and the Health Research Council, did not provide research funding for these areas. ESR contended that it should be funded as part of a non-contestable nationally significant science backbone.

The Pharmaceuticals Group, which develops and ensures the safety of medicines and medical devices, gained OECD Good Laboratory Practice accreditation in 2006. New stability rooms enabling drugs to be tested in precisely controlled environments were also installed at this time.

ESR had by now gained an excellent reputation in water quality research. The first-ever Marsden Fund grant received by the organisation came in 2006 to study the mechanism of how viruses hitch a ride on mobile colloids, facilitating rapid transport to drinking-water wells. As groundwater supplied about 40% of New Zealand's drinking water at the time, viral contamination was a significant issue. This work complemented other work, which determined what waterborne pathogens were important for assessing water quality.

ESR's Health team had long provided advice on vaccines to the Ministry of Health. In the mid 2000s, it was also contracted to manage the National Vaccine Store, which purchased, stored and distributed vaccines for the national immunisation programme. This included managing the cold chain system where vaccines are stored and transported at a recommended temperature. This service was provided until mid-2017, when this work was considered not part of core business.

ESR's strategic direction in 2007 was quite ambitious with the goal of 60 in 4, which aimed at reaching $60 million in revenue by 2011. However, the global financial crisis that hit in 2008 meant this target was not reached until 2013.

Funding for research continued to be an issue, with Chief Executive John Hay expressing concern at the proliferation of science research conducted within a number of policy ministries. ESR saw this being in conflict with the CRI model. John said that the strength of the CRI model was that it provided integrated scientific services for New Zealand. For ESR, it clustered some of the country's best minds together to provide science and research services for the health and justice systems. He believed a scattered and fragmented science capability over a number of policy areas would not deliver the optimum results.

The success of the CRI model was illustrated in 2007 with the first royalty cheque received for forensicGEM™. This product was developed in collaboration with biotech firm ZyGEM and enabled the extraction of human DNA from crime scenes. ESR's involvement included developing a DNA extraction prototype kit for forensic laboratories around the world. The forensicGEM™ formulation was based on an enzyme extracted from bacteria discovered in Antarctica by ESR scientists.

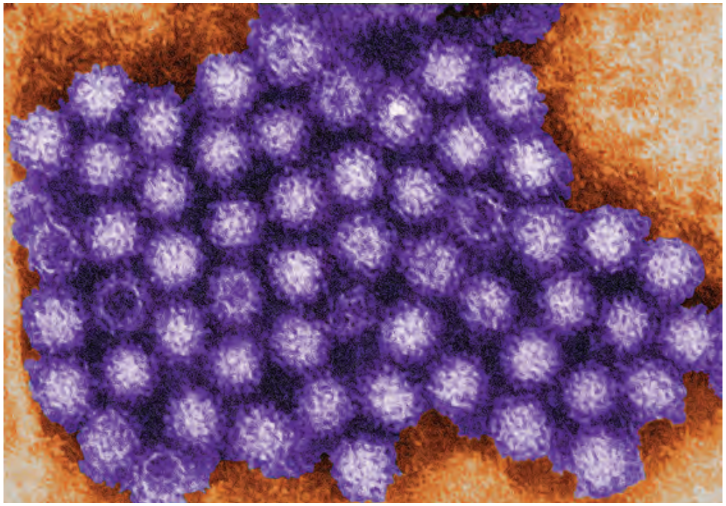
Work in the food safety area continued, with an extensive review of the transmission routes for *Campylobacter* in New Zealand. Understanding the spread of this bacteria enabled an accurate evaluation of the effective risk when managing outbreaks. In 2007, it was estimated that 110,000 New Zealanders were affected by *Campylobacter*, often through eating

Markers indicate possible body fluids for low copy number (LCN) DNA forensic testing.

Luminol highlights the body fluids in the crime scene, left.

Collecting DNA evidence at a crime scene.

Campylobacter *was often contracted through eating infected chicken.*



ESR developed a new test for identifying norovirus in local shellfish.

infected chicken. The development of a new molecular typing assay to distinguish different strains and species of *Campylobacter* enabled a fast and cost-effective way to identify isolates to the species level.

A new test for norovirus and other disease-causing viruses in local shellfish and waterways was developed by ESR in 2007. An ESR study had found that 50% of shellfish samples tested positive for one or more human enteric viruses, especially those that had repeated exposure to sewage contamination. The study and the new test led to a number of local authorities developing testing regimes for their areas.

In 2008, ESR's DNA capabilities were enhanced by automation. A number of highly repetitive manual processes in the DNA Forensic Laboratory were roboticised including DNA extraction from crime scene samples and DNA amplification. Robots enabled faster throughput and ensured consistency, leaving ESR forensic staff to focus on case interpretation and increasing capacity.

The National DNA Profile Databank, established in 1996, had also grown, and by 2008, ESR had provided intelligence links for more than 10,000 unsolved cases and loaded more than 20,000 crime sample profiles at a rate of about 200 a month. In 2008, the database held more than 85,000 profiles.

New robotic equipment for analysing influenza specimens was being used to run the National Influenza Centre. Previous laboratory processes took days to generate results, but using the EpiMotion machine, results were generated in hours. The centre had been recognised by the World Health Organization since 1954, and ESR (and its predecessor) had been operating the National Sentinel General Practitioners Influenza Service since 1991. The centre moved from Kenepuru Science Centre to the newly built science centre at the National Centre for Biosecurity and Infectious Disease in Wallaceville in 2008.

The same year, ESR helped address the didymo or 'rock snot' issue, developing a didymo sample database accessed on the SurvINZ platform. Didymo, the blooms of the stalked diatom *Didymosphenia*, were first discovered in the Waiau River, Southland, in 2004.

Not only did the discovery trigger a major biosecurity response in New Zealand, but it also highlighted didymo as a potential threat to rivers worldwide. The didymo database managed by ESR allowed organisations involved in sampling to post their results and information, enabling tracking of the spread.

The spread of antibiotic resistance was also an ongoing issue in 2008. The demand for ESR's surveillance and specialist laboratory services increased as hospitals strived to control antibiotic-resistant bacteria. ESR's Antibiotic Reference and Nosocomial Infections Laboratory was first established in the Department of Health era in the 1970s. Its comprehensive surveillance delivered an up-to-date picture of resistance for the Ministry of Health and the health community. It provided specialist testing services to investigate outbreaks of resistant organisms. In 2008, the government's concern about antibiotic resistance was demonstrated with a $4 million boost to health sector funding for surveillance.

As the pressure from land development and use increased along with the challenge of changing weather patterns, ESR's Water Group found their services and guidance on protecting water quality in even more demand. Work in 2008 included helping councils ensure drinking-water safety by developing scientific guidelines on the separation of sewage disposal and bores and research into how *Campylobacter* levels in drinking-water supplies change during rain events.

Further research in these area was also undertaken in 2008 when the Population and Environment Health Group researched the health issues associated with the emergence and spread of infectious diseases as a result of climate change. This collaborative project developed the Health Analysis and Information for Action (HAIFA) resource system, which provides the scientific methods and tools to respond to infectious disease threats related to climate variation and change.

A renewed focus on the justice sector needs for forensic science in 2008 was the subject of a summit led by Law Commissioner Warren Young to look at the value that forensic science provides to the New Zealand criminal justice sector and how more forensics research could be funded. As part of the summit, expert forensic scientist John Buckleton presented results that showed Police were close to clearing 100% of burglary cases where DNA crime scene evidence is processed.

ESR faced a more challenging environment in 2009 as the first effects of the global financial crisis started to impact New Zealand. While revenue increased by $5 million from $50 million in 2007/08 to $55 million in 2008/09, profit remained static and staff numbers decreased from more than 400 to 388. Chief Executive John Hay said that these results were only reached by making substantial cost savings during the year. Surpluses that ESR generated over the previous six years were rolled into retained earnings. They provided a buffer as the organisation prepared for difficult times. Government cuts to expenditure were already affecting services. Staff worked hard to make cost savings, and the result was a return of 9%

The spread of antibiotic resistance was an ongoing issue in 2008.

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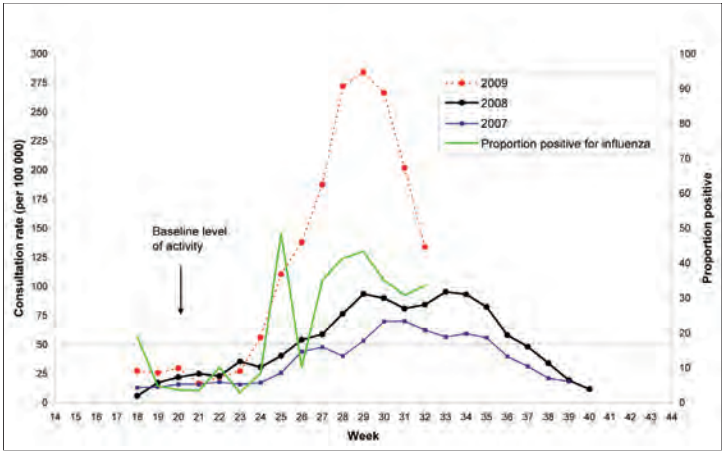


Weekly flu surveillance charting the H1N1 09 pandemic.

on equity, which surpassed the government's expectations and budget for that year.

After early outbreaks in North America, in April 2009, a new influenza virus spread rapidly around the world. The H1N1 09 influenza virus, known as swine flu, had never been identified as a cause of infection in people before 2009. Genetic analyses of this virus showed that it originated from animal influenza viruses and was unrelated to the human seasonal H1N1 viruses that had been in general circulation among people since 1977. By the time the World Health Organization declared a pandemic in June 2009, a total of 74 countries and territories had reported laboratory-confirmed infections.

ESR's investment in the National Influenza Centre, which was based at the new National Centre for Biosecurity and Infectious Disease at Wallaceville, really paid off at this time. ESR was at the forefront of the pandemic response in New Zealand. Its annual influenza sentinel surveillance system identified the first cases of the pandemic H1N1 09. Virological and epidemiological analysis and surveillance tracked the speed and spread of this new virus throughout the community. The national notifiable disease surveillance database EpiSurv collated information on a real-time basis, and its outbreak functionality enabled cases to be linked. Throughout the pandemic, EpiSurv helped identify susceptible groups in the population. ESR also developed Panda, an online system to help the Ministry of Health with planning and resource management during the pandemic.

Another achievement in 2009 was the international accreditation of ESR's breath alcohol laboratory as a calibration laboratory for evidential breath-testing instruments. It was the first laboratory in New Zealand to receive this accreditation and only the second in the world.

In October 2009, the Minister of Research, Science and Technology, at the request of the Prime Minister, established the CRI Taskforce led by businessman Neville Jordan. The Taskforce was convened to provide advice on how CRIs could increase their effectiveness in delivering benefit to New Zealand and, in particular, to assist in achieving a more innovative and higher-productivity economy.

Early 2010s at ESR

The Report of the CRI Taskforce was presented to Cabinet and accepted in March 2010. The Taskforce revisited the purpose, operation, governance and funding of the CRIs and provided a set of recommendations detailing the actions required to position them as powerful engines of future growth.

Actions included requiring each CRI to develop a statement of core purpose, which would clarify its particular role and purpose, and an associated statement of core intent that set out each CRI's long-term strategy. Greater funding certainty was promised for CRIs to deliver their core purpose, and this funding would form a more significant proportion of the total Vote Research, Science and Technology investment in CRIs. Board accountability and control over funding was to be strengthened and institutional governance improved.

The Taskforce recommended the establishment of independent scientific advisory committees with international members and end-user panels to inform the development of CRI research strategies, scientific programmes and technology transfer activities. It called for a more balanced and comprehensive set of performance indicators and a tailored approach to setting financial targets that reflected the requirement to be financially viable (rather than financially profitable). CRIs would be required to make more-effective partnerships with business and develop collaborative partnerships with other research institutions.

ESR accepted the recommendations wholeheartedly, and in 2010/11, progress was made on developing a statement of core purpose.

With the retirement of Ian Wilson in 2010 came a new Chair – Dr Susan Macken. A professional director who had previously worked at the World Bank and as a senior manager for Fletcher Wood Panels Limited, Susan faced a new regulatory regime that came out of the CRI Taskforce's recommendations. She agreed with the Taskforce's recommendation that the government should not expect CRIs to deliver financial returns but should monitor financial viability to ensure that they were able to deliver against core purpose. The Board set growth initiatives in 2010 that would enable revenue diversification and ensure ESR continued to maintain its relationships with core clients and research funders. These were in the areas of acquisitions, human biosecurity, international revenue and new clients.

Revenue in 2010 dropped 3% from the previous year, posting at $53.4 million, down from $55.1 million in 2009. This reflected the continued challenging economic environment. ESR looked hard at the services it provided as the public sector cut expenditure in the face of the recession. In response to decreased funding from government contracts and reduced research funding, it was forced to reduce costs. The need to maintain critical capabilities meant personnel reductions had to be handled very carefully and were achieved through natural attrition and reduced working hours. Eighteen positions were disestablished that year.

The signing of a new five-year contract with Police.

ESR assisted with disaster victim identification in the aftermath of the Christchurch earthquake.

ESR investigated post-quake water quality in Christchurch.

The successful negotiation of a five-year contract with Police for the provision of forensic science services was a positive event in 2010. Police was ESR's largest client and provided 40% of revenue. The new contract was a cornerstone of the organisation's balance sheet and cemented ESR's role as the critical operational science and research service provider at the heart of the criminal justice system.

Highly respected Chief Executive John Hay resigned in 2011 after 11 years of service. John had taken over the reins when ESR was at a low point and had turned the organisation's fortunes around. Chair Susan Macken said at the time that John's significant contribution, both as a scientist and leader, meant he left ESR a strong, robust organisation. Five years of year-on-year increases in earnings had stood ESR in good stead. However, the slower, more protracted recovery of the economy after the global financial crisis meant the organisation entered a consolidation period. Revenue dropped in 2011 to $51.4 million from $53.4 million in 2010. However, ESR still managed to make an 8% return on equity and a net profit of $3.2 million that year.

In 2011, another Christchurch earthquake struck. The Christchurch Science Centre came through well and was declared safe and structurally sound. ESR offered business accommodation to other CRIs and to the University of Canterbury, which took up the offer, using some of the meeting rooms for lectures. ESR staff in Christchurch, despite their own personal circumstances, re-established business there quickly.

ESR's services were in high demand during this time, including forensic staff assisting with disaster victim identification and environmental health staff assisting Environment Canterbury and Christchurch City Council by investigating post-quake water quality in the Avon River, assessing contamination risks using specialist faecal tracking tools. The security of groundwater sources in the Canterbury region and the wellhead protection around bores and aquifer movements was also investigated. In the public health arena, ESR's Health Intelligence team co-ordinated a phone survey assessing the health needs of Christchurch's residents following the quake with the results used to address problems of access to essential health services. ESR also surveilled Christchurch residents' health closely to give early warnings of local outbreaks of gastroenteritis and influenza.

A $1 million upgrade of the Kenepuru Science Centre was officially opened by Minister of Health Tony Ryall in June 2011. This ensured that the facilities were up to date and continued to meet all user and accreditation requirements.

A new Chief Executive, Graham Smith, was appointed to replace John Hay in August 2011. Graham had come from the Australian food industry. He joined AgResearch in 2001 and worked on the Waikato Innovation Park with its focus on agri-technologies before coming to ESR. He came at a difficult time for the organisation.

The acquisition of the National Radiation Laboratory (NRL) from the Ministry of Health in 2011 added a new service to ESR's offering. The newly named Centre for Radiation Science was based in Christchurch and provided expertise, advice, services and research capability in public, occupational and medical exposure to radiation as well as the performance of irradiating equipment and the measurement of radiation and radioactivity. By 2012, the NRL's work was embedded in ESR across the organisation. Services ranged from testing the safety of workplace equipment to measuring radon in groundwater to monitoring nuclear activity around New Zealand and in the Pacific.

A $5 million upgrade of the Mount Albert Science Centre also began in 2011. The new centre improved service delivery to Police and increased ESR's research capabilities in the area of forensic science. It boasted a new firearms-testing facility and space for a full range of testing and research required by Police. This included bloodstain pattern analysis, interpretation and research. Further forensic investment included replacement of liquid-handling robots and an enhanced forensic inspection area in the service centre garage.

After the adoption of recommendations made by the CRI Taskforce in 2011, a clear and concise statement of purpose was developed that placed ESR's work squarely in four areas: health and disease, justice and security, food safety and environmental health and hazards. This core purpose remained consistent in the years that followed.

In 2012, ESR marked 20 years of operation. Chair Susan Macken noted that a major difference between how ESR used to operate and 20 years later was that economic drivers were now central to the way ESR worked. ESR continued to reposition itself, moving from a science testing organisation to one that delivered science-based innovation. This reflected the government of the day's philosophy that science and innovation are key to generating growth in New Zealand.

The five-year Southern Hemisphere Influenza Vaccine Effectiveness Research and Surveillance (SHIVERS) project got under way in 2012. ESR led a successful international bid to comprehensively investigate influenza epidemiology, aetiology, immunology and vaccine effectiveness for the

Minister of Health Tony Ryall opens the upgrade of Kenepuru Science Centre, Porirua.

Radiation testing in the Pacific.

Andrew Van Schaik, Morkel Zaayman and Jacqui Horswell from the Centre for Integrated Biowaste Research (CIBR) team.

Centers for Disease Control and Prevention in the United States. With this surveillance, New Zealand acted as a sentinel for the northern hemisphere.

Research partnerships started to generate results in 2013. Working with an Australian laboratory, Forensic Science South Australia, ESR developed STRmix™ DNA analysis software, a profiling tool that applied mathematical modelling and DNA interpretation to achieve results previously not possible. The software matched mixed DNA profiles directly against the DNA Profile Databank, which, by 2013, held more than 145,000 DNA profiles. This was a breakthrough for cases where there were no suspects and there was DNA from multiple individuals in one sample. Due to the interest STRmix™ generated from forensic laboratories in Australia, the United States, Europe and the United Kingdom, this product looked to have a bright future, and in subsequent years, this was borne out. By 2017, STRmix™ was widely used across the world and was a significant income generator.

ESR had a major role in developing new technologies to help protect New Zealand's billion-dollar beef export trade to the United States. New stringent regulations had come into effect in July 2012 targeting seven groups of pathogenic *E. coli* bacteria found in beef. At the time, ESR provided verification services for all New Zealand meat producers exporting to the United States. Once again, ESR's investment in the National Centre for Biosecurity and Infectious Disease paid off as samples were sent there to be compared against the reference library – the only one of its kind in New Zealand.

The establishment of an internal Strategic Science team aimed to support and increase innovation within ESR. This team managed the initial Pioneer Fund to support ESR staff to explore new ideas that would transfer technology and knowledge to industry or government sectors and open up new commercial opportunities for ESR.

In 2012, ESR took a lead role in establishing and funding the Centre for Integrated Biowaste Research (CIBR). Through Dr Tom Spiers, ESR had been researching biowaste for many years. Led by ESR scientist Dr Jacqui Horswell, the new group built on this work. It integrated a number of biowaste programmes and, as a collaborative centre of excellence with an active and practical research programme, brought together a multi-disciplinary team of scientists and researchers. CIBR partners were ESR, Landcare, Scion, Cawthron Institute, Lincoln University, Lowe Environmental Impact, Northcott Research Consultants and Whenua.biz (Kukupa Research Limited) and the University of Canterbury.

Since 2012, CIBR has played a critical role in moving New Zealand to more sustainable management of biowaste. Of the more than 700,000 tonnes of biowaste produced each year, 62% ends up in landfills. CIBR's role was to develop innovative ways to manage this waste and reuse it to improve soil quality, as a compost and to reduce the cost of fertilisers.

In 2013, funding was made available to staff for innovative research projects that fitted ESR's strategy, addressed important problems, had scientific merit and provided solutions to problems New Zealand faced. This 'bright ideas' seed fund, known as the Pioneer Fund, continues to this day.

Mid-2010s at ESR

The 2014 financial year was another year full of challenges. For the second time in its history, ESR posted a loss. This time, it came in at a loss of $553,000. Total operating revenue declined from $62.1 million in 2013 to $61.7 million in 2014. Core government customers, reacting to the government-imposed cap on spending, experienced tight fiscal constraints. In 2014, these key contracts comprised 80% of the organisation's revenue. Lower volumes from Police and reduced services for the Ministry for Primary Industries contributed to this loss. At the same time, inflation, redundancies, investment in growth areas and repositioning contributed to higher costs and the overall loss.

The 2014 year was also one of transitions. Chief Executive Graham Smith, who had served three years, left ESR, and Dr Fiona Thomson-Carter was acting Chief Executive until replaced by Dr Keith McLea. Keith had served in a number of senior roles in the personal injury insurance and injury prevention sectors including six years where he had overall responsibility for ACC's insurance activities. With a science background, he had a PhD in human genetics and had trained as a toxicologist. Keith was fascinated by the work of ESR and was certain the fortunes of the company could be turned around. His first move was to bring in a new senior management team. This helped deliver a strategic refresh of the organisation and turn the tide on the organisation's fortunes, which, in real terms, had deteriorated over the four previous years.

It was ESR's turn to have a government-ordered four-year rolling review in 2014. As part of the Taskforce's recommendations, all CRIs had to undergo an independent review to provide shareholding ministers with an independent assessment of each CRI's current effectiveness and future potential in delivering on the purpose and outcomes set out in its statement of core purpose.

The reviews provided insights into where performance could be improved and assurance that the CRI was operating effectively in delivering

ESR provided verification services for all New Zealand meat producers exporting to the United States, targeting seven groups of pathogenic E. coli *bacteria found in beef.*

Genomics and sequencing the genome start to take off.

From left: Professor Bill Denny, ESR Board member; Hon Nicky Wagner, Minister of Customs; Rt Hon John Key, Prime Minister; Carolyn Tremain, Chief Executive and Comptroller of Customs; Dr Keith McLea, Chief Executive, ESR.

Denise Church, Chair, 2015 to present day.

outcomes that contributed to New Zealand's economic, social and environmental wellbeing. They assessed governance effectiveness, financial viability and sustainability and identified opportunities, barriers to success and alignment to government priorities.

The result of ESR's four-year rolling review was seen by the new Chief Executive as an opportunity to turn the organisation's fortunes around by implementing a strategic refresh. The document underlined the issues the organisation had to face including that, in real economic value-added terms, ESR was underfunded and operating at an unsustainable level. Key to this was that the research areas ESR's science fell under were not adequately funded by government. This was an issue that had adversely impacted ESR since it was established in 1992.

ESR continued to play a key role in New Zealand's justice system and be the sole provider of forensic services to Police. A new collaborative venture with the New Zealand Customs Services in 2014 saw the opening of the Customs ESR Screening Laboratory (CESL) within the Customs Air Cargo Inspection Facility at Auckland Airport. The new laboratory located ESR staff within Customs facilities to provide immediate screening of concealed items of suspicious origin and identification of other unknown material imported into New Zealand. By 2015, the scientific and investigative expertise at the border had made several significant seizures and in 2016 uncovered New Zealand's largest ever methamphetamine haul.

ESR also provided drug and alcohol monitoring for the Alcohol and Other Drug Treatment Court, a specialist court that diverts offenders with alcohol and drug dependency from prison into treatment. This started as a pilot in 2012 and was extended in 2015 and then again in 2017. The pilot showed that the Court reduced the likelihood of reoffending by about 15% in the short term, compared to similar offenders who went through the usual court process. Minister of Justice Amy Adams said in 2017 that "the signs are incredibly promising". Indications were that the pilots saved the cost of 61 prison beds.

A new Chair, Denise Church, was appointed in 2015. An experienced company director, leadership consultant and executive coach, she had led the Ministry for the Environment in the 1990s and had a keen interest in ESR.

In 2015, ESR's Social Systems team was commissioned by the Social Policy Evaluation and Research Unit (Superu) to develop and test a systems approach to measure the effectiveness of the whole-of-system response to prevent family violence. This was used to support discussions on the use of systems approaches to better understand complex social issues such as designing and implementing a whole-of-government approach to prevent family violence. The Social Systems team had already produced an impressive array of research including developing indicators for community resilience, working with communities on safe drinking water and looking for better health outcomes.

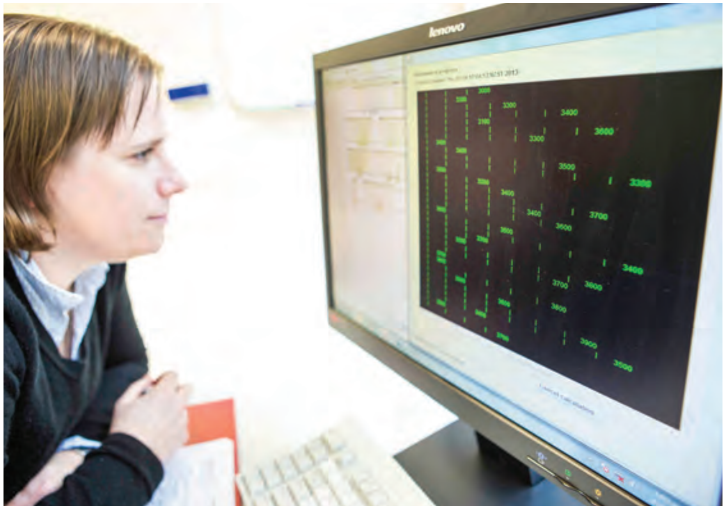
Sales of ESR's breakthrough software STRmix™ continued to track strongly. The successful commercialisation of this powerful tool was the key to ESR's return to profitability in 2015. Revenue in 2015 increased by $3.2 million over the previous year to $65 million. Profit was $3.5 million, an impressive result coming from a loss the previous year and one that was attributed to the new leadership and a refreshed strategy of improving customer focus, growing the commercial side of the business and developing new innovative science.

Genomics and bioinformatics produced a step change in how ESR delivered its science in the mid to late 2010s. In every part of the business – public health, food science, environmental health, forensic science and water quality and research – new techniques based around sequencing the genome meant faster, more accurate and better results.

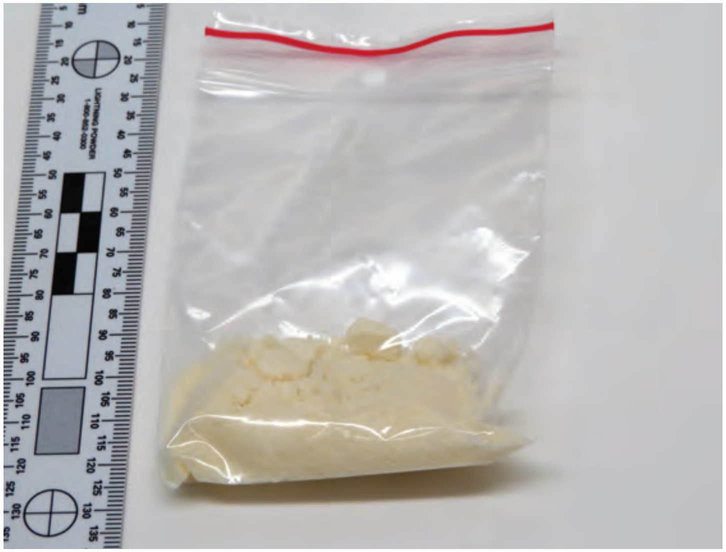
Food poisoning investigations, including the 2015 outbreak of *Yersinia pseudotuberculosis*, used tools such as bioinformatics to aid the development of a world-leading, rapid (six-hour), sensitive and cost-effective system for sub-typing major foodborne and waterborne pathogens relevant to all food sectors. More than 70 people were hospitalised with symptoms related to the illness. The ESR Enteric Reference Laboratory and Health Intelligence team were crucial in the identification and response to the outbreak, working with both the Ministry of Health and Ministry for Primary Industries to confirm cases, identify potential sources and manage the problem.

The deliberate contamination of infant and other milk-powder based formula with 1080 was another major threat that required ESR expertise as part of a government and industry response. Operation Concord saw a whole-of-ESR response including DNA testing the letter that threatened to contaminate infant formula with 1080 unless New Zealand stopped using it for pest control. Long copy number DNA testing and chemical testing using forensic isotope ratio mass spectrometry contributed to the arrest of the offender who was later sentenced to eight years in jail.

In 2016, the government reviewed CRI core funding. This resulted in core funding being moved to form part of the new Strategic Science Investment Fund. The Ministry of Business, Innovation and Employment, into which the Ministry of Science and Innovation had been subsumed, set up a new



Jo Bright, STRmix™ team.



1080 milk powder scare, Operation Concord.


Havelock North drinking-water contamination was sourced to a local bore.


Frozen berry hepatits A outbreak resulted in a nationwide product recall.


Methamphetamine crystals.

funding model, which helped boost ESR's science research funding. The Strategic Science Investment Fund allocated $7.7 million to ESR research in that year. In the 2016/17 financial year, it was increased by 20%, enabling ESR to research methods to improve water quality. However, core research funding from government still tracked below the other CRIs.

By 2016, ESR's outlook was much rosier. Revenue had risen again – to an impressive $70 million – with after-tax profit of $3.8 million and a return on equity of 8.9%. ESR had certainly matured as an organisation. It routinely tackled complex challenges in the community from potential outbreaks of communicable diseases and antibiotic-resistant superbugs to crime solving through DNA and working with regional councils to clean up waterways across New Zealand.

Forensic science was becoming increasingly high tech. The drug screening laboratory at Auckland Airport tackled the issue of designer drugs using chemical bonds to conceal illicit substances.

ESR assisted with the response to an outbreak of hepatitis A associated with frozen berries by providing epidemiological advice as well as testing the berry samples. Work with the Ministry of Health and Ministry for Primary Industries resulted in a nationwide recall of berries, protecting New Zealand consumers and limiting the outbreak of the disease. As part of this work, ESR established a new process to obtain sequence data on the viruses isolated from human cases, which enabled the interpretation of epidemiology linking cases.

The New Zealand Food Safety Science and Research Centre, a collaboration between ESR and seven organisations, launched in 2016 at Massey University in Palmerston North. The centre's purpose is to protect and enhance the reputation of food produced in New Zealand.

In 2016, ESR responded to a large campylobacteriosis outbreak in Havelock North. More than 5,000 Havelock North residents were infected by the *Campylobacter* bacterium and became seriously ill. ESR's cross-organisational approach brought together clinical, environmental and microbiological expertise and genomics capability to respond to this emergency. ESR was recognised as the pre-eminent scientific adviser in New Zealand in relation to drinking-water safety.

Part of ESR's strategy for growth was to vigorously pursue commercial opportunities in overseas international markets and leverage opportunities for cross-border collaboration. This included continued work in the Pacific, especially in the area of sustainable water development. China became increasingly important to ESR as it joined the New Zealand-China Food Protection Network, established to enhance communication between research scientists, government organisations and industries in both countries. The network of nine organisations led to collaborative research in food safety and security with 51 Chinese partners. ESR extended its relationship with China, signing a memorandum of arrangement with the Chinese Research Academy of Environmental Sciences during Premier Li Keqiang's visit to New Zealand in March 2017.

By 2017, STRmix™ had grown 400%, with laboratories all around the world using it in their forensic work. This was a very successful example of the commercialisation of a product developed by ESR. It showed the organisation what was possible in this area and also what was necessary if the organisation was to survive.

Water science became increasingly important as the quality of New Zealand's waterways continued to deteriorate due to the runoff from farms, domestic waste and industry. ESR had always been at the forefront of water science and water quality, but new DNA-based technology took this to a new level with research projects using cutting-edge techniques such as synthetic DNA to trace pollution in water. Research into how natural products such as bioreactors could be used to filter the runoff from the land into the waterways and remove nitrates, as well as using mānuka's special antimicrobial properties, was looking promising.

From environgenomics in the early 2000s to whole-genome sequencing in 2017, the field of genomics accelerated from the mid-2010s. Changes in DNA sequencing technologies generated more detailed and accurate data about life's basic building blocks. At the same time, the area of bioinformatics grew exponentially to enable this data to be collected and analysed.

ESR increased its investment in genomics and bioinformatics and grew its expertise, particularly in the areas of microbiology, human forensic science and human non-communicable disease. The science encompassed metagenomics, RNA, epigenetics microbiomics and other 'omics'. The acquisition of state-of-the-art equipment to provide next-generation sequencing capacity meant a wide range of applications could be sequenced rapidly. Scientists say that the ability to sequence genomes and analyse the data through bioinformatics brings us to the brink of a whole new way of doing science. It will be fascinating to look back in another 25 years to see where this has led us.

ESR joined the New Zealand-China Food Protection Network in 2016.

New DNA-based technology enables ESR to trace contaminants in our waterways.

SIR CHRISTOPHER MACE

Founding Chair
1992–1999

In November 1991, Chris Mace, an Auckland businessman, was asked to chair an establishment committee for an entity to be formed as a Crown Research Institute.

Initially called the Institute of Environmental Health and Forensic Sciences Limited, known as EHFS, the new CRI came into being on 1 July 1992.

"I never sought the role, and while the opportunity came at a particularly busy time in my commercial life, the restructuring of the science system caught my imagination so I accepted the challenge."

"The Honourable Simon Upton was the Minister of Research, Science and Technology. He was one of our youngest politicians and the architect of the Crown Research Institutes. A thinker and passionate about science, he could see the contribution science could make to the wellbeing of New Zealand. Working with him was a privilege."

Chris says that the fact that EHFS was made up of disparate groups was acknowledged by the government. "They were the pieces left over. Unlike the other research institutes that were strongly aligned to certain sectors, EHFS was a provider of science services in public health, forensics and epidemiology. EHFS was not initially funded to undertake research."

"We had these brilliant people with superior knowledge and great ideas they would like to develop. Unfortunately, research funding was extremely limited."

"The first thing we did was to develop the business model. It was a matter of bringing the different groups of science service providers into a more focused format. There were real opportunities to harness the benefit their skills brought to New Zealand and also to get a better handle on the financial management associated with the services provided. The challenge was to get recipients of these services to provide a fair price to allow us to invest and develop our science, technology and research activities."

Chris pays tribute to his first Board. "We had John Haigh QC who was a highly regarded criminal lawyer, Professor Ralph Cooney, DVC University of Auckland, Professor Linda Holloway, Dean of Medicine at Otago University in Wellington, and Sir Robin Irvine, VC University of Otago. These directors understood the science and research sector and were highly respected – this helped hugely."

"We were set up with a belief that to survive would be a significant challenge, and we didn't know if we could make it work. The Board respected the skill of the scientists. We were charged by our political masters with establishing a sustainable business, and we were prepared to go into bat for the organisation in an effort to achieve this."

Chris says that part of the culture change that needed to happen was to move to a more collaborative way of working. "Scientists had to respond to the client by listening to their needs rather than tell them what was best for them."

One of the big challenges of the time was that ESR could not charge a commercial fee to cover the cost of the work being undertaken for their major clients, Ministry of Health and New Zealand Police, because these organisations just simply couldn't afford it. "So there were two challenges: scientists were not funded to do research that would help develop the services they offered, and our clients could not afford to pay the full cost of the scientific services ESR provided."

Chris says Police was under serious financial pressure during the 1990s. The government put strict controls on spending. Police had a cap on its spending without any strategic analysis at all about the size of the Police force and so on. "Police struggled with this. They had to cut down on external services and focused their resources on serious crime. This meant lower levels of criminal activity flourished. The ramifications of this are still being felt today," he says.

For ESR, this was problematic as the company didn't have the funds to subsidise the services provided to its clients. "It was not just about making a profit, we needed to put in the financial disciplines to be able to maintain a sustainable business – so anything over the margins could be invested back into the business."

Chris says that Minister Upton fully understood the fact that "if we were not a sustainable business, we couldn't keep up with the cutting-edge technology and the research, needed to come up with new, innovative ways of delivering our services".

Chris says ESR went through some very challenging times from establishment through into the mid-1990s, and for a period, the company needed support to stay afloat. "Take the Police, for instance. The relationship between our forensic scientists and Police at the service level was sound, but there was a misunderstanding regarding the cost of providing these services. We reached an impasse, and Police investigated the option to buy forensic services from Australia instead. This turned out to be no threat to our business as Police soon found out what an efficient operation ESR was and how expensive Australian forensics services were at the time. The impasse was finally broken when both sides commissioned economic consultancy BERL to do an independent review. The result of this was the support of Police at all levels, and a contract was finally signed." A similar process was also followed with services to public health.

A lot has happened to Chris since ESR days. A founding member of the Sir Peter Blake Trust, he undertook the establishment of Antarctica New Zealand and chaired the board through until 2003. He even has a mountain named after him, Mount Mace, in recognition of his services to Antarctica. In 2009, he became chair of NIWA. He is a commissioner for the Tertiary Education Commission. In 2011, he was awarded Māori Business Leader of the Year. In 2015, he was inducted into the Business Hall of Fame. In 2016, he was made Knight Companion of the New Zealand Order of Merit for services to science and education.

As Sir Christopher looks back on his time at ESR, he says it was an absolute privilege to work with the scientists. "I am not surprised at all that ESR survived. We had the science skill sets that the country needed, plus the passion of individual scientists, a remarkable and committed executive team led by the talented and hard-working Mark Templeton and a supportive Board on the governance side."

He says, "ESR continues to provide outstanding service in the areas of communicable disease, epidemiology, forensics and environmental health and water management. Our scientists are national treasures. What would have happened if we weren't able to bring this disparate group of sciences together? New Zealand could have been worse off."

JOHN HAY

Chief Executive 2000–2011

When people at ESR recall John Hay, they still speak of him with warmth and respect. Leading the company for nearly half of its existence, his influence is still being felt today.

John says that the ESR job came along just as he was needing a new challenge. “I was a plant breeder/agronomist at DSIR, working for the pastoral sector and seed industry, producing grasses and clover. When DSIR was reorganised in 1990, I became the general manager in charge of Grasslands, which then became part of the CRI AgResearch, and I stayed there for some years. Then after 27 years with one research organisation, I was at the stage where I was either going to reinvent myself or go for the softer option and stay where I was. The ESR job came up, and I was attracted to it because the different sciences looked exciting. So I threw my hat in the ring and got the job, starting in early 2000.”

“For me, being a chief executive is all about relationships and leading people. I didn’t make big changes, I believed in doing things incrementally. There were some excellent appointments made when people left, and we developed a very good team.”

“One of my early memories at ESR was when we went to the prison out at Rimutaka. We had a three-day senior leadership retreat there. ESR’s revenue at that time was $27 million, of which only $1 million was for research. I said this is what we are going to do in the next five years because if we stay at $27 million, it is too small and they will merge us or do something silly.” John says the target was $38 million in five years, and the company surprised everyone by meeting it, but it was helped along by Peter Hodgson, the Minister of Research, Science and Technology.

“I just happened to be sitting next to Pete on a plane. This was in the early days. And he said to me, what are your main concerns? Actually, he was quite strict. He said, “I need 30 minutes to read through and sign off these Cabinet papers and then I will talk to you.” And he did just that, 30 minutes later, he shut his briefcase and turned to me and asked me what my concerns were. I said we can’t actually do anything to change or start a new research initiative that we need for ESR because we only have $1 million in research of which 10%, $100,000, is discretionary funding. And Pete said, how can you fix that? I said, well it would be a huge change to have 10% of all government funding that we get from Police, Health, MAF and so on, not just from FRST funding. Pete said it would be tough and there would be screams, but in a remarkably short time, MORST called up and said, ‘My God, John, what have you done?’ So instead of getting

$100,000 discretionary funding for research, we ended up getting $2 million, and we used that money to employ good researchers. Suddenly, we were in the game of getting research contracts from FRST (which became MBIE). So it went from $1 million in research funding to, when I left in 2011, $13.5 million. It was a big jump."

John talks about what the three main challenges were for him when he came to the job. "The first was that ESR was three silos – Christchurch, Kenepuru and Mount Albert in Auckland. The groups didn't really speak to each other. So the first thing I did was make sure that my general managers were national, not local, in terms of their responsibilities. Breaking down the silos meant encouraging people to shift to other centres if they wanted to. It took some time, but it did work."

"The next challenge was to get a new state-of-the-art DNA laboratory in Auckland. DNA analysis was being done all over the place when I first started. So we had to consolidate and rationalise. Luckily at Mount Albert, the current building had a concrete top and it could support another storey, so we could build a new DNA lab right on top. The Board Chair at the time was a very smart money man, and he was not all that keen. When he left, we got Ian Wilson, who was an excellent Chair, he understood the urgency."

Two years earlier, before John had started, there had been a problem: a case in which DNA had been ascribed to the wrong person. No one could understand how it happened, and after a top-level enquiry, the only reason they could come up with was that the labs were old, and there was a possibility of DNA contamination. "They were not ultraviolet scanned then as they are now to kill any stray DNA. And this led to the conclusion that ESR desperately needed a state-of-the-art facility. So, I gave Ian Wilson the report, and he came back and said it was a no brainer, we have got to do it."

The third thing John thought was needed was access to a level three physical containment public health laboratory – what is known as PC3. ESR at the time only had PC2 labs, and John worried that, if a flu pandemic struck, ESR would need a specialist facility and a higher level of containment. "The only PC3 available was out at Wallaceville where MAF and AgResearch owned land. I was pushing to build a state-of-the-art virology, bacteriology and fungal lab out there, which could have PC3 access. However, there was push back from certain government quarters, and it didn't look like it was going anywhere." Enter Peter Hodgson again and another fortunate encounter between John and the Minister. "All the CEOs got invited to the Chinese Embassy for their New Year celebration. It was pouring with rain as I was leaving, and Peter offered me a ride down to the station. So when we were in the car, I said to him, 'Pete we need this new lab out at Wallaceville.' He said, 'I have seen some stuff come across my desk but the advice has been not to have it.' I said these are the reasons that this is critical for New Zealand and gave him three or four reasons. As we got to the station, he said, 'How much do you need?' I said you know we will go to the bank to get the $6 million we need to build it, but that is not the issue. It is the annual cost of maintaining and running it that we need money for."

"Hodgson said 'How much?' And I just made up a number right there from the top of my head, 'One and a half million,' and he said right, and that was it. And the irony of it all was the new lab was in place six months before swine flu hit New Zealand, and suddenly it became the focal point for samples to be sent from all around New Zealand."

Besides ESR's critical role in public health, John also points out that ESR has an equally critical role in the justice sector and says he was lucky to have Wayne Chisnall as Forensics GM. "We were leading edge with the United Kingdom, and when I travelled overseas, I realised that ESR was punching way above its weight. Places like the UK and Netherlands were keen to collaborate. The Netherlands even used ESR as a model. They really looked up to us and treated us with huge respect."

The same happened to John when he visited the FBI in the United States. "I was talking to an Australian at a conference who was my equivalent. I told him I was visiting the FBI. He said, 'Who are you going to visit there?' I gave him the name of the person, a Deputy Director. The Aussie said, 'Wow, I get the third level and you are getting the second level'."

John says the FBI were very interested in why New Zealand DNA database hit rates were so high. "The Deputy Director said to me, 'When criminals commit crimes, you guys seem to nail the criminals very quickly.' I told him that there were good reasons for that – the smallness of our country and that we basically know who all the crims are and they are all pretty much on our database. I said our database is also clean, and the Deputy Director just rolled his eyes. In the USA back then, people supplied their own blood samples, and they could submit samples that were not necessarily their own, using animal blood instead. This meant their database was compromised so not as effective."

John ends on a positive note, saying that he is pleased to see the Science Vote has been increased to 2% of GDP. "It is not just government money, it is also industry money and the government has put in tax incentives to encourage industry to invest in research. At the same time, the Endeavour Fund, Catalyst Fund, partnership programmes and university research funding will increase, and that is good for science and really good for New Zealand."

KEITH MCLEA

Chief Executive 2014 to present day

When Keith McLea earned his PhD in human genetics 40 years ago, little did he know that, one day, he would be leading a science and technology organisation that put DNA at the centre of what it did.

Keith came to ESR when it was at a particularly low point in its history. "I was two weeks into the job, and the CFO came to me and said, 'Keith, we have a problem, we won't have enough money to pay staff next payday.' When I look back on that day, nearly four years later, I marvel at how far we have all come. It wasn't easy, we have had years of rebuilding, but now, for the first time since I was here, we are in position where we have money and can now decide how to reinvest it back into the business."

Like his boss, Board Chair Denise Church, he decided there were three things that needed to be done to get the organisation going. They were to focus more on international opportunities, to grow the revenue and to keep a tight control on costs. "I can tell you I was under huge pressure to slash and burn, and I resisted this because my feeling was the place was at a pretty low depth, and if I did that, it would disintegrate."

Keith's considerable experience and expertise in a wide range of organisational development programmes has come to the fore at ESR. His strength in his previous career at ACC had been to ensure the customer is at the centre of change. Keith says that it is not just the financial indicators that have improved over the last three years. "When I came here, I found that some of our key customers were grumpy with us. Now the relationships have lifted remarkably, and they love us to death."

Over his four-year tenure, Keith reflects on some of the significant things that happened under his watch. "STRmix™ is a big one. Breaking into overseas markets and being able to demonstrate to the world that this organisation is full of wonderful scientists producing really useful innovative products.

"It is also part of our international strategy to grow our revenue from markets overseas. We are now looking for other contracts internationally and not limiting ourselves to the traditional markets of Australia, UK and USA.

"Then there is the contribution we made to the Havelock North drinking-water crisis. The thing for me is that New Zealand does not know what an amazing job we did behind the scenes. When the announcement on TV came saying that the water was contaminated with *Campylobacter* and it seemed to have been derived from sheep from a certain paddock, well it was ESR that had provided that information," says Keith.

He singles out the commitment of the people that work at ESR. "The people in this organisation have a real, deep-down commitment to do good things. It is really interesting work that makes a difference to New Zealand. I don't think New Zealanders realise the difference we make because a lot of it is behind the scenes. You know I can remember a case where a little boy was sexually assaulted after school, and I knew that, within three or four days, through ESR's forensic work, they would nail that person. They had the DNA, they were just waiting for us to do our science. This is what makes a difference to people's lives."

Keith has recently been invited to be a special adviser to the China Council for International Cooperation on Environment and Development. He notes that the person who chairs the group sits on the State Council and so is one of the top political people in China. "So you have an organisation overseeing 1.4 billion people, and a New Zealand organisation has been appointed to this. It says a lot about the high regard ESR is held in internationally."

Keith is now looking towards the future, and in 2017, he initiated a change programme that looks at future trends and how ESR will meet the challenges of tomorrow. The ESR into the Future programme will include a major investment in ESR facilities and science. Keith says that new technology will be a big factor in science going forward. "Technology has always been an enabler for science but it is much more now. Things like artificial intelligence mean that a lot of interpretation will be done by machine, but at the end of the day, it is the scientists that have to understand what the machine has done, how the results were arrived at and what it means for the community."

Keith reflects on the history of ESR, which was once considered to be a group of disparate sciences left over from the disestablishment of the DSIR conglomerate. "In 25 years, we have taken something that looked disparate but that actually had a lot of common threads. These common threads, such as genomics and 'omics', go across just about anything we do. Then there is all the data that is generated from this work and the need to do something with it. Going forward, there are big opportunities for us to harness the data and provide a much better integrated data set that will be useful for a whole lot of organisations," he says.

"Ultimately, it is what binds us that brings us all together."

DENISE CHURCH

Chair 2015 to present day

Denise Church is the sixth person to chair the Board of ESR, taking up the position in July 2015. She came with strong credentials, having led the Ministry for the Environment in the 1990s, being involved in science funding agency the Foundation for Research, Science and Technology and having deep experience over many years in governance and leadership.

"I have had a long-standing interest in ESR," says Denise. "It is a fascinating organisation and one that you cannot possibly know well from the outside. After two and a half years in the role, I have a better appreciation of ESR now. It touches so many areas of interest to New Zealanders, and it has such a deep expertise in those areas."

When talking about ESR, Denise comes across with passion and clarity of vision. "I had a good look at the organisation and saw that it had a very long and proud tradition and considerable expertise, but there were some signs that it was challenged by re-equipping itself. There had been an old way of working that had worked well over the years, but what I saw was an organisation that needed to change – and the change was challenging. We were facing a double whammy. Our partner agencies were operating under very tight budget constraints, so we had to find really smart ways of serving them that would keep us financially sustainable, and the nature of science and technology was changing rapidly, so we had to re-equip ourselves for the future of the science we were involved in.

Denise set out three areas of focus for the Board over the past three years. The first was forging strong, strategic relationships with partner organisations such as Police and Health. "We share an interest in the health, safety and prosperity of New Zealanders with a number of other organisations, and the best way for us to jointly solve the challenges that New Zealanders face is to tackle them together."

The second challenge was to equip the science, including reinventing technology and supporting ESR people to transform the business. “As a CRI, our job is to be on the front foot with that. We have made big strides in the last three years in our thinking and in our investment. I am very proud of the team for turning around the financial sustainability of the business, as this has opened the door for investing in the future.”

The third area was taking the novel services and products developed at ESR out to New Zealand and the world. Denise says that STRmix™ is a great example of this. “It was born out of some scientists saying, as I hear it, ‘I wish we could solve this problem. The community would be safer if we could solve this problem.’ So they set their clever minds to how they could do that. STRmix™, the product they developed, is not only used intensively here in New Zealand, with very measurable impact, but it is now going out to the world. The success of that product and the future success of STRmix™ and other ventures will keep us reinvesting in New Zealand-based science.”

Denise says she has been impressed by what the strong science teams have achieved during her tenure. “In Christchurch, I learned about the work of the Environmental Science team and how we took our water quality expertise out to the Pacific. I got the impression that these people were not only smart scientists but they were smart innovators with a passion for taking their know-how to places that really make a difference.”

Denise says she could go on and on about ESR’s know-how and impact: the ESR/Customs lab in Auckland, the drugs and wastewater programme, the response to the Havelock North drinking-water crisis, helping solve the 1080 baby formula contamination and the work of the Public Health team combating infectious disease such as the SHIVERS programme. “I have to say that it is kind of scary being acquainted with the risks we face, and I rest a little easier knowing about the deep expertise of the people we have to tackle issues such as disease outbreaks.”

The fact that ESR is able to attract significant outside investment such as from the Marsden Fund, the Health Research Council and others is recognition to Denise that ESR holds its own. “While we operate at the applied end of research across a wide range of areas, we definitely hold our own in terms of the quality of our science.”

Denise tackles head on the idea that ESR was just a bunch of disparate sciences that were left over after DSIR was disestablished. “What defines us is that we are the CRI in the people and community space. What may look like a great bag of unconnected things is in fact all about people and their wellbeing.”

Denise says that the ability to mobilise the whole resource of the organisation to solve New Zealand’s problems is a very powerful place to be. We now recognise that the problems facing New Zealand communities are not distinctive ones. They are joined up ones. To tackle challenges that are joined up and complex, the science needs to be able to face the reality of integration and complexity. I believe we are getting better and better at doing that.”

On the CRI model, Denise reflects that, 25 years ago, the organisations were deliberatively set up to both deliver impact for New Zealand and through innovation to be highly successful organisations. “What I feel really proud of is that Keith and his team have grasped the nettle to make those two things work together. Our CRI is capable of doing everything from the hard yards on challenging community issues, where there may not be a huge commercial return, right through to developing highly successful commercial products. If you can embrace that in one organisation, you really have something special.”

The CRI model, as Denise sees it, is a good model for New Zealand. “It fits New Zealand’s needs as a small country, but it also allows for the personality and culture of science in New Zealand, oriented towards practical solutions. Innovation to practical solutions.” She admits that, with stronger streams of core funding that went right to the science behind these big community challenges, more could be done, but as a country, choices have to be made to how we collectively invest. “Our job is to do the most powerful things that we can, both from the funding available from government but also from what we can create from our own ingenuity, taking it right out there to commercial products. It is a structure that allows us to do both those things. It is a very exciting place to be.”

Paying tribute to previous ESR Boards, Denise says that ESR has been very well served by committed and able directors. “Everything we do is founded on the shoulders of the people who went before us.” Denise points out that the current ESR Board is drawn from a variety of sources. Some are academics, others entrepreneurs. “For me, the most important thing is that we are not only future focused, but we are able to have challenging conversations where we look at things from different angles and hear different points of view. Like Team New Zealand, we have a Board that is focused on making the ESR boat go faster and further, not just commercially, but in terms of long-term sustainability and impact. So in the years ahead, when people reflect on how New Zealand cracked the drugs issue or the approach to infectious disease control, ESR will be a significant part of that story. We don’t just want to be proud of this 25 years, we want an organisation that stands out for the next 25.”

MARY ROSS

Management Accountant
1978 (DSIR) to present day

Behind the scientists and technicians at ESR lies a backbone of support. The corporate functions and business services that enable the place to run range from the ever-important executive assistants, the human resources people that recruit and develop staff, payroll, the communications group that ensures that key messages get across to clients and wider audiences, information and technology services and the property people that manage the facilities and ensure they are fit for purpose and safe. And of course there are those in accounting.

Mary Ross is one of ESR's longest-serving employees. She has been in the finance section of ESR from its inception. In fact, she had been with DSIR long before that, starting as a Budget Control Officer in 1978 in head office and is currently ESR's Management Accountant for the Health and Environment Group.

If we believe the adage that history can be told through ledgers and accounts, then Mary would be considered a primary source. "We first worked out in Gracefield while they fitted out new offices in town for head office. Then we moved into the Clear Building in Murphy Street in Wellington. A few years later, corporate moved out to Kenepuru Science Centre, and Business Services moved back to Gracefield for two to three years." The move back to Kenepuru was controversial at the time. "Corporate office took over the upstairs area where the library was. The people here, mainly in the public health area, did not want the library moved because it was close to their laboratories. There were petitions and all sorts of debate, but of course, the library moved downstairs and corporate got refitted out to where it is today."

Mary has seen businesses come and go at ESR. "We sold off the analytical lab to AsureQuality in 1999. I think it was profitable, but management decided that it was not our core business. ESR needed to be doing the value-added bit."

In 1998, ESR upgraded the finance system. "No one wants to know about changing the financial systems. It's a big deal for us but a pain for them."

Moving to SAP was hugely beneficial to the business. "Everything now runs on SAP – payroll, HR, finances – it integrates all business operations throughout the organisation."

The first Chief Financial Officer at ESR was Neil Wanden. According to Mary, it was a challenging time for him. "Scientists had to get used to changing from a government model of bulk funding to a commercial model where they had to apply for their funding and make a margin. Some were very resistant to this massive change in culture."

Mary says things are very different now. "People no longer think making money is a bad thing. They have to go out and find business, do negotiations and network. They understand the strategic targets and the commercial nature of some of our work. Making a margin on a project helps the organisation be sustainable so they can get on doing good science."

Mary refers to the marketing side of the business. "Our logo has changed quite a bit over the years. It first started out as three circles, then changed to ESR in a blue bubble with sub-brands. Then someone came up with triangles and black boxes and a strapline that caused a bit of controversy, 'the science behind the truth'. Scientists did not like it at all, and eventually they stopped using it. Now it has changed again – it is much simpler and sums up what we do, 'science for communities'."

Mary says she has enjoyed her time at ESR. "It is a fascinating place, and there have been many amazing people that I have worked with and have made some very good friends. There is always new stuff coming on – new diseases, new outbreaks – different stuff that makes life interesting." Mary has been in the science business for over 40 years. "I was going to win the big Lotto last week so I could retire. We took a ticket in Business Services – 19 people at $2 each, we could each win $2 million. Someone said that is not enough to retire. I said, '$2 million, sweet, that would be plenty enough for me'."

MARJORIE MCLEOD

Hygiene Consultant
1998 to present day

In a place like ESR, a clean and hygienic premises is a top priority. Although the laboratories use specialised equipment such as UV lighting to eliminate any pathogens or other contaminants, ESR's team of cleaners, under contract to OCS, work every day to ensure a top-quality and productive workplace.

Marjorie McLeod is one of the team. She has been cleaning the Kenepuru Science Centre (KSC) for the better part of 20 years. "I started cleaning KSC in 1998. I have seen a few people come and go in that time," she says. "The people at ESR are a friendly lot, and I get to know some of them really well. We talk about our lives and family."

Marge says she has also seen big changes in the building. "The whole reception area was built in my time, and the labs were all upgraded. We are very careful when cleaning the labs. There are things we do not go near, like the benches and tables and equipment."

Celia Wellington, ESR General Manager, People and Communications, says that having someone like Marge cleaning the facilities really adds to the place. "In many places, the cleaning service can be invisible, but they deliver a really important service. Marge is a gem. She takes an interest in the staff and has become a real friend to us all."

Marge has been cleaning for as long as she remembers. "It is important for me, and OCS, that I do a good job cleaning, but the people here make the difference to a job that can be hard on the back and legs. This job really is a means to an end."

While here, she has raised four children and has 10 grandchildren and eight great-grandchildren. "My family has been busy, and I am really proud of what they have achieved. They are worth all the hard work," she says.

Photo courtesy NZ Police


Photo courtesy NZ Police

JOHN BUCKLETON

Senior Forensic Scientist

If ESR had a star, it would be John Buckleton, one of ESR's top forensic scientists, who has helped to transform the field of forensic science not only in New Zealand but internationally too.

As John tells it, before he was a forensic scientist, he was a shepherd working on a farm near Rotorua. Personal circumstances caused him to dust off his master's in chemistry, and in 1985, he got the job of junior forensics caseworker at DSIR.

"Starting on casework, I was thrown into the fray with little formal training. Back then, training consisted of an ad hoc mentor system where established forensic scientists kept an eye on the newbies," says John. How things have changed. In 1990, with his colleague Kevan Walsh, John wrote much of the early forensics training standards. In 2005, he co-authored a seminal text entitled *Forensic DNA Evidence Interpretation* – the second edition was published in in 2016. These days, forensics scientists in New Zealand have to score 90% in theory and 100% in practical before they begin on casework. This is a world-class training standard.

John's 34-year career as a forensic scientist includes more than 190 academic papers and articles in the forensic area (shoeprints, firearms, DNA, blood grouping, tool marks, fire debris analysis, glass and paint,) six books, a couple of thousand crime scenes and over 200 court appearances. His primary research passion is DNA profiling – the molecules that encode genetic information, interpreting DNA evidence and applying new technology methods he developed to analyse other types of evidence. John is considered a world leader in the interpretation and analysis of forensic evidence.

A number of stints in the late 80s and early 90s working at the United Kingdom's well-resourced

Forensic Science Service saw John involved in high-profile cases such as the Romanov Russian Imperial Family, assessing evidence in the OJ Simpson trial and identifying US soldiers who died in the Korean War. Returning home, John brought with him expertise to work with the ESR team setting up the National DNA Profile Databank in 1995. This involved collecting DNA profiles from convicted offenders and volunteers and placing them on a central database, which then could be matched to DNA profiles obtained from unsolved crimes. This was an attempt to identify any individual that could be linked to an offence through biological material left at the crime scene. New Zealand was the second country in the world to create a DNA Profile Databank, and this proactive approach to crime has resulted in a high success rate in producing valuable leads for unsolved cases. It now holds about 189,000 samples and about 40,000 DNA profiles from case samples. New Zealand leads the world in DNA matching with nearly 70% of all unsolved cases loaded to the crime sample databases successfully linked to individuals and 30% linked to another crime.

John says that DNA is the gold standard when it comes to crime solving. “Linking shreds of evidence together, forensic investigators can provide reliable proof that ties an offender to a crime or exonerates the innocent. DNA testing has become the bread and butter of forensic investigations.”

In 1999, John and others spearheaded the development of the low copy number (LCN) DNA technique. John says this technique enables the tiniest of DNA traces left at a crime scene to be identified. Using the PCR test, it amplifies a sample numerous times until the DNA code can be read. John was part of the team that developed the process in the UK, and to ESR’s benefit, his name is on the patent, enabling the organisation unfettered access to the technique. In 2007, John was quoted in a *North and South* magazine article saying that LCN was the pinnacle of his career, but he spoke too soon, because in 2011, along came STRmix™.

STRmix™ – a software program that interprets complex DNA profiles – was developed by John, Dr Duncan Taylor of Forensic Science South Australia and Dr Jo-Anne Bright from ESR. It was created in response to a lab closure in the state of Victoria that occurred as a result of a mistake. Duncan and John were initially tasked with producing a tool based on the drop model (when both alleles of a heterozygote fail to PCR amplify) that could deal with two-person mixtures. A suggestion from the head of the service that such analytical transformations had been superseded by big computing sparked a new direction for the project. Armed with invaluable advice from the application of the Metropolis-Hastings algorithm, which was to become the centrepiece of mathematics in STRmix™, a core software was developed that could do four or more person mixtures.

John points out the challenges to DNA testing. “Poor-quality samples or partial profiles containing degraded DNA can make it difficult to identify who the DNA came from. So too can complex DNA mixtures containing genetic data from multiple persons.” This is where STRmix™ comes to the fore.

STRmix™ interprets an evidence sample containing multiple sources of DNA. By using probabilistic modelling of DNA, STRmix™ determines on the evidence how likely it is that the genotype combinations present within a DNA will occur, removing the need to make subjective decisions about what genotypes are present in a DNA profile.

It revolutionises DNA interpretation by flipping the conventional wisdom of how to do it on its head, allowing the analysis of complex mixtures and DNA profiles recovered from minuscule amounts of DNA that are so vital to many criminal investigations. It removes the cognitive bias and other contextual influences to which DNA mixture interpretation is susceptible. When STRmix™ is used to interpret profiles, it reduces the likelihood of discrimination of suspects and wrongful implication in criminal activities.

In 2014, STRmix™ became available commercially and has been one of ESR’s biggest success stories. It has been used in thousands of cases worldwide and has even helped crack cold cases. At the time of writing, 45 laboratories around the world are using STRmix™ as their predominant method for interpretation of DNA profiles. This includes the United States, Australia, Canada and the United Kingdom.

Since STRmix™ has been used in ESR’s Forensic Biology Group, there has been a 300% increase in the resolution of profiles recovered from evidence that can be searched against our DNA database. There is a 75% success rate for these profiles when searched against the database.

John has appeared as an expert witness about STRmix™ in a number of cases. He says some have been extremely challenging. Keith Bedford, who was John’s manager for some time, says John has a commanding court presence. “He is known for translating complex technical information clearly and unflappably in challenging, adversarial situations.”

John says, “In criminal trials, the defence lawyer speaks for the defendant, the prosecutor speaks for the Crown but there is a third voice, that of forensic evidence – it speaks for fact.”

When asked what’s next and whether there are other problems to solve, John, who has turned 60, says no. “This is my life’s work.” Of course, he said that in 2006 about LCN, and so we look forward to what this brilliant scientist will come up with next.

SALLYANN HARBISON

Senior Science Leader and DNA Technical Leader

"You are always learning new things," says SallyAnn Harbison. The pace of change – in methods and technology – is the most important aspect of her job. "Almost all I do is DNA related, and it is the variety of tools and techniques we can apply to case types that makes it really interesting."

SallyAnn came to New Zealand and became a postdoctoral researcher at the University of Auckland on a short-term contract. The DSIR was about to implement DNA profiling and the Forensic Manager was looking to recruit people who had the relevant technological experience. SallyAnn had been doing DNA profiling both in England and in Auckland. She was recruited and started in the DSIR's Chemistry Division in 1988.

She had originally been a plant virologist. "But it doesn't matter if you are dealing with plants, fish, fungi, even microbes – the underlying science is similar across all of biology and the techniques are the same," she says. "That's one of the reasons why I like working at ESR. You have people in the health area, food and water areas, and the biology people among us are able to understand each other's work and in some cases to work together on different projects."

At first, she did crime scene and evidence examinations. "We identified body fluids, blood and semen and did blood grouping. We worked on our first DNA case in 1989. We started to transition our work to DNA profiling, and then from the early 1990s, we ramped up quite fast. From the mid-1990s, we did nothing but DNA work.

"I had to pick between working on crime scenes or with DNA and decided on the latter. But I attended crime scenes as well between 1988 and 1997, and that gave me a grounding in what forensics is all about. You don't get that sitting in a lab. It gives you the bigger picture.

"I worked on the first homicide case we solved using the DNA Profile Databank in 1999 – Operation Sundown. A young mother on the North Shore had been killed by an intruder. I also did the crime scene and DNA work on the Susan Burdett homicide and on the Police Complaints Authority investigation reviewing the David Bain case. We went back over everything that had been done because we did not have the same DNA methods the first time."

She finds having a direct impact on the justice system in providing the evidence that might exclude someone or identify someone challenging and satisfying.

"We have a strong impact in the courtroom. It is quite a responsibility to present the evidence so that the jury understands the limitations of the evidence. Sometimes our evidence is not particularly decisive, and there can be alternative explanations. Being able to convey that accurately and simply can be quite hard. The words you use are important, but not everybody is tuned to words. If you are too nuanced, somebody might misinterpret what you are saying by putting too much weight on something – or too little – simply because of the way you said it."

Periodically, the team reviews old cases. "The DNA process has become more sensitive and more specific over time, and we are able to solve cases that we would not have been able to solve 20 years ago. I was the case manager for some of them. For example, in 2001, ESR was able to solve the Teresa Cormack case, 15 years after her murder."

SallyAnn says she is fortunate to be able to do both casework and research projects. She has supervised many students at both MSc and PhD level. "At the moment, I am working on the next generation of DNA profiling, which has the potential to transform the evidence we provide and the way we work. This is where being both a researcher and the quality leader for the biology laboratory pays off."

STEVE CORDINER

Manager, Forensic Service Centres

Steve Cordiner describes how he entered a fascinating career and the developments in forensic science he has experienced.

I was at high school, deciding on my post-school options, when one of my teachers suggested that I pursue biochemistry. It was a rapidly evolving discipline, and my teacher had the foresight to see its potential over the proceeding decades.

I did my PhD at Victoria University of Wellington on the biochemistry of the livestock disease facial eczema, which is caused by a fungus and has a big impact on the health and productivity of cattle and sheep. I was keen to follow a career in agricultural research, but there was always a part of me that had an interest in forensics. When I was growing up, books such as *Famous New Zealand Murders* and *No Remedy for Death: The Memoirs of a Pathologist* were avidly read by my father, who would then pass them down to me. I still have a number of them on my bookshelf in the office as a bit of a reminder of where it all began.

In 1983, after finishing my PhD, I was offered a position at DSIR's Chemistry Division Forensic Group at Gracefield, Lower Hutt. It was the early days of forensic science, and I was doing things such as identifying ABO blood groups and enzyme types in blood samples. In those days, if we said that a type of blood on the sample occurred in 10% of the population, we would think we had done a great job. It was exceptionally rare to get to 1%.

Compare that with a recent court case I was involved in where the DNA findings were 4,000 million times more likely if the DNA sample originated from the suspect rather than from some other person selected at random from the New Zealand population.

DNA profiling, a more advanced technique of identifying individuals by the characteristics of their DNA, had a big impact from the mid-1980s. I spent 1987 at Victoria University studying this technique on a Claude McCarthy Fellowship. In 1988, the late Margaret Lawton, who established DNA profiling at DSIR and was the inaugural leader of the ESR Forensic Biology Group, organised for half a dozen of us to spend six weeks being trained in forensic DNA profiling at the Home Office Forensic Research Laboratory in Aldermaston, England. It was very hands on – making a gel, running the DNA through it and separating it with an electrical current. When we came back, we set up the DNA labs in Auckland, Wellington and Christchurch and began using profiling for semen stains and large bloodstains. Like a lot of new techniques, it was a time-consuming process in the beginning, and it would be several weeks until we got a full result. And of course, like a lot of new techniques, there were challenges in court. Margaret Lawton was the first scientist in New Zealand to give forensic DNA evidence in court, and there was a stiff challenge by the defence, attacking her on the reliability of the results.

When the DSIR was broken up in 1992, most of the Chemistry Division went to Industrial Research Limited, but Forensics and the National Health Laboratories were combined to form ESR .

It was a culture shock to move from the DSIR to a Crown Research Institute (CRI). The tension between forensic scientists – who get their satisfaction in taking a case from crime scene to court and don't want to know about charging – and managers – who say that we have to make money to survive – was challenging. The other tension was that our only client, New Zealand Police, was also motivated to keep their costs down, being a government department. In the DSIR days, the Director General met with the Police Commissioner once a year and they agreed on funding, and Police would then send in all their exhibits. As a CRI with a charging model, they had to think more about what to send in to us, and we often worried about the cases or evidence that we didn't get the opportunity to assist with.

A major achievement was the establishment of New Zealand's DNA Profile Databank in 1995 – the second in the world behind the UK. Following that, the Criminal Investigations (Bodily Samples) Act 1995 was passed, which meant Police could ask a suspect for a sample for the databank. Once the databank started, we restructured, and all the DNA work was centralised in the Auckland laboratory. It was a tough call, but I decided to stay in Wellington. My children were at school, and I didn't want to uproot the family, so my focus shifted to crime scene and evidence recovery work.

Crime scenes are an aspect of the job that's always stressful. It's hard work and long hours, but it's very rewarding too, particularly working with Police at the investigation stage, sorting out how to analyse a crime scene to ultimately (hopefully) catch the offender.

The DNA amplification methods of the mid-1990s meant we could work on smaller sample types gathered at the scene such as hair roots and saliva on cigarette butts, and second-generation multiplex methods meant six DNA sites could be tested in one reaction, which greatly increased the ability to discriminate between individuals.

Luminol testing is another technique commonly used at crime scenes by ESR scientists. It's a chemical that glows in the presence of blood but only in complete darkness. This means often returning to a crime scene at night to spray it with luminol, sometimes closing motorways to eliminate light pollution from car headlights and street lamps. It is often worth putting in that sort of effort as it tends to pick up what the naked eye can't – minuscule amounts of splatter, blood that someone has attempted to mop up or a trail of blood. Operation Awa, for example, involved a man being hammered to death by teenagers in Waitara. A clear trail of drag marks was identified from where the witnesses said his truck was parked to the river where his body was found.

Since 2014, I have been managing ESR's three Forensic Service Centres in Auckland, Wellington and Christchurch. The centres process all the incoming evidence from serious crime across the country and are available 24/7 to assist Police at scenes when required. The move to a desk job was a bit of a change, but I don't miss the call-outs. I missed a couple of my daughter's birthdays in a row because of crime scenes. Scene work is quite physical too and gets a lot tougher as you get older. The last time I went to one, I found myself clambering down into a ravine on a rope – there was a body down there. Police at the scene were taking bets on whether I'd get back up again. They can be a cheeky bunch, but that sort of banter helps us all get through the difficult aspects of scene work.

Looking back across the 25 years at ESR and before that at DSIR, forensic science has come a long way, especially with the huge leaps in DNA techniques. The next big thing is massively parallel sequencing for analysing DNA samples – giving more information from a crime scene sample with a faster throughput. Working out how science – and the resulting knowledge – can help Police catch offenders and even prevent crime is the best part of the job.

KEITH BEDFORD

General Manager, Forensic Science

Keith Bedford says the best thing about ESR is the people. "You don't join ESR to become rich. People self-select into this organisation who want to make a difference – to make society safer, fairer and more just. That's a very special motivation and is reflected in the quality of our staff."

Keith, who is formally retired but does project work, says he has had a "fantastic career" since joining DSIR Chemistry Division in the Auckland branch lab in Broadcasting House in Durham Street in 1976. His PhD on physical-organic reaction rates and mechanism was a useful background for drugs and toxicology work when it came to considering drug metabolism.

"In those days, any drugs Police intercepted had to be passed to the DSIR for analysis, so we did a huge number of cannabis cases. In toxicology, more than half the deaths involved barbiturate overdoses. Barbiturates were widely used as sleeping pills and were lethal in overdose, even more so when combined with alcohol. We tested what would be regarded today as gross volumes of blood and liver to determine how much drug was in the system," says Keith.

In 1984, he spent a year in London on secondment to the Metropolitan Police Laboratory. "While there, I went to my first overseas conference, at Oxford, and presented a paper on behalf of my New Zealand colleagues on the determination of the geographic origin of imported cannabis from the identification of insects trapped in the plant material resin."

When ESR started, the new form was challenging. "ESR was a combination of areas of activity that lacked a coherent framework, so the first years were turbulent as we were coming to grips with making the new regime work. There was a lot of change – in the areas we wanted to focus on, in becoming more overtly commercial and in management structure and responsibility."

In the final years of the DSIR, there had been a new focus on financial performance, but the CRI form brought a shift from bulk funding to user pays. "That provoked some real angst – for example, in our relationship with New Zealand Police. The BERL report had to be commissioned to work through the issues, and Police eventually accepted that they were getting value for money," says Keith.

ESR took on the Communicable Disease Centre on the Kenepuru site, and the Health Department became the Ministry of Health, ceasing most operational/service delivery functions.

"In Mount Eden, the DSIR had taken on a Health Department lab for environmental work, including industrial hygiene, air pollution and audiology services. ESR struggled to find its feet in that space, and eventually it exited that work and the Mount Eden site. The site had once been a dental nurses' training school, and it turned out there had been significant mercury contamination. There was local concern about that. The chief financial officer of ESR took it on in a private capacity after leaving ESR, as a developmental site, and there were a lot of questions about how things were done.

A huge restructuring of Forensic took place soon after ESR was formed. "I was the restructuring implementation manager. We centralised into specialised labs and set up Forensic Service Centres – a fundamental change to the previous model of regional full-service laboratories. For many of the staff, it was traumatic and a time of turmoil as we moved from a project model, where an individual scientist worked on a case and was largely responsible for seeing it through to reporting, to a process/workflow model where there were more technicians contributing to the work coming through the area and it was more of a collaboration.

"In forensic science, there was an underlying driver for change apart from the financial one: the paradigm shift that came with the introduction of expensive new technology and analytical instrumentation, notably with the introduction of DNA science," he says.

"We could not afford to have duplication or triplication of expensive equipment and expertise hence the huge restructuring and the centralisation of the DNA work in Auckland. The DNA Profile Databank was established in 1996, initially in Wellington, and then moved to Auckland to become in due course part of the new national forensic DNA facility opened by then Prime Minister Helen Clark in 2002.

"Overall, this paradigm shift involved massive investment and the introduction of sophisticated analytical equipment and techniques, and also increased specialisation rather than 'expert generalists'. We laugh at the portrayal of forensic science on television where one person knows everything. Increasingly, a combination of people with different specialities collaborate to deliver the product."

ALLAN STOWELL

Science Leader, Alcohol Analysis Unit

When Allan Stowell started at the DSIR after postgraduate work overseas, he discovered New Zealand was completely up to date with the best alcohol analysis equipment. With two subsequent replacements of equipment during a working life of 40 years, he saw a combination of the best-quality equipment and very high standard of reporting.

Allan did his PhD at Professor Dick Batt's alcohol research unit at Massey University. "My interest was acetaldehyde, the first breakdown product of alcohol and a highly toxic compound. It was implicated in the addictive effect of alcohol, but no one knew how much was in the blood after drinking, and I developed new analytical methods to measure it.

"I continued this work in Helsinki, in the physiological research lab of the Finnish state alcohol monopoly – the largest company in Finland because the government had the monopoly for the import, manufacture and sale of all alcohol. My office overlooked a home for alcoholics!

"The availability of acetaldehyde is minimised in humans, although every molecule of alcohol is converted to this toxic compound. Enzymes work to keep its circulating level very low. If they didn't, drinking even a small amount of alcohol would make you very sick. Alcohol itself is also a poison, but not as potent as acetaldehyde," says Allan.

From Finland, he moved to the northern-most university in the world, in Tromsø, Norway. "The library was located on the top floor of the northern-most brewery in the world. When I wasn't frequenting the library, gazing awe-struck at the Northern Lights or skiing, I studied the effects of alcohol on protein synthesis.

"Alcohol inhibits key metabolic pathways in the liver to the extent that, when it is processing alcohol, some of its key functions are severely restricted. This can cause major health problems for people who drink heavily and frequently. I am not a teetotaller, but the more I learned about alcohol, the less I drank. Alcohol is just another drug that can kill if you overdose. It is also an industrial solvent, fuel, antiseptic and preservative. Why would you drink such a thing?"

He started at the DSIR on his return to New Zealand in 1982. "I found the same alcohol analysis equipment I used overseas – the best in the world – and a computer system linked to the analytical instruments and the whole process fully automated. In my time with the DSIR and ESR, I have overseen two major replacements of this equipment, improving efficiency and reliability with the best-available equipment."

While looking after the alcohol lab, Allan also became an illicit drug analyst, identifying and quantifying drugs in samples submitted by New Zealand Police. "My research experience gave me confidence in developing methodology for the analysis of different drugs. We used to identify everything from imported LSD to the odd cannabis cigarette butt picked up at a rock concert. If we got more than a few grams of heroin or cocaine, we thought it was a huge seizure. Now, our Auckland lab routinely deals with drug seizures up to hundreds of kilograms."

'Homebake' heroin labs took up much of the lab's time in the late 1980s and 1990s. "P was not heard of in those days. Police and Customs severely restricted importation of heroin, so local users turned to making it themselves using stolen morphine tablets and medicines containing codeine. Whoever worked out how to do it had been trained in chemistry. We once saw a copy of the original recipe, hand-written by a prisoner. It was relatively simple chemistry, and the 'bakers' perfected the methodology, but we, as mere scientists, found it difficult to get a good yield."

Allan became supervisor of the alcohol analysis unit, looking after the blood-alcohol lab and breath-alcohol calibration lab. "ESR no longer calibrates the Police breath alcohol testing devices, but the laboratory was the second in the world to be accredited by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board to perform calibration of Police breathalysers."

There was only one blemish on ESR's excellent record of reporting correct test results, says Allan. "I know of only one case where we reported the wrong blood alcohol result. We got the right result, but it was incorrectly reported as a result of a data transposition error. At the time the report went out, I was working on a new revenue-generating project and was distracted from my role as gatekeeper. The driver opted to have his B sample privately analysed, and our error was revealed. Apologies were required, and ESR agreed to pay the cost of the private analysis.

"It just shows you can have the best quality assurance procedures in the world, but to be effective, they have to be followed."

LIPING PANG

Science Leader, Christchurch Science Centre

When Liping Pang joined ESR's Groundwater team at Christchurch in 1994, there were only three people in the group. "I had a Master in Earth Science from Waikato University, and when I arrived at ESR, there was just Murray Close, a technician and me in the team. We did everything together: field work, laboratory work and computer modelling. It was a special time."

For the first 10 years, working as a groundwater scientist, she was involved in a number of research projects. "I worked on determining setback distances of water supply wells/springs and bathing beaches against microbial contamination. I evaluated and modelled microbial transport in soils and groundwater under different land uses, such as effluent irrigation, on-site disposal systems, on-farm livestock burial and so on. I also worked with Murray in investigating different models to simulate pesticide leaching through soils at a number of field sites in New Zealand and transport of heavy metals in different aquifer systems."

She says the Groundwater team at ESR has gained a great reputation with end users. "Our expertise is recognised at a national level. The end users such as regional councils often ask advice from us. We are doing applied research so results can be directly used for water quality management."

In 2003, Liping gained her PhD in Civil Engineering from Canterbury University – no small feat when doing it part-time while working. Her thesis topic was modelling contaminant transport in saturated pumice sand and alluvial gravel aquifer media. Liping used computer modelling, assisting colleagues at ESR and other institutes both in New Zealand and internationally on various projects, in particular, projects related to microbial and colloid transport. "From modelling results, we can understand better the processes of contaminant transport and removal in subsurface media," she says.

In 2006, Liping received her first Marsden Fund grant for research looking at whether colloids (particles suspended in water) could facilitate the rapid transport of viruses in drinking-water wells. The Marsden Fund is a contestable grant for excellent fundamental research administered by the Royal Society of New Zealand. It was the first time ESR had received this prestigious award. Liping's research revealed the dual roles that colloids play in virus transport and removal. When viruses hitch a ride on colloids in sewage, they can move through large pores or cracks in aquifers, arriving at drinking wells faster than viruses travelling alone. At the same time, the colloid-associated viruses can be removed to a greater extent than the free viruses when they are excluded by small pores in the aquifers. The findings have major implications for assessing the contamination of New Zealand's groundwater, which accounts for over a third of drinking-water supplies.

"We needed an accurate way to assess the contamination risk for viruses and other disease-causing pathogens in groundwater. Obviously, we couldn't introduce real pathogens into groundwater field studies. So I came up with the idea of making mimics – harmless mock viruses or surrogates that behave like a virus but don't infect the water." The mimic idea was generated from the first Marsden project. The M2 phage which had been used traditionally as a virus surrogate was not at all accurate. Liping says they initially tried to make virus mimics but viruses were so small. Thus they decided to first make a surrogate for *Crypotosporidium parvum* protozoan, which is much larger in size. Protozoan-size polystyrene beads were coated with glycoprotein to mimic the size and surface feature of *Crypotosporidium* as glycoprotein is a major type of protein that *Crypotosporidium* oocysts produce on their cell surfaces. Studies of Liping's team and her oversee collaborators in Vienna and Australia have independently demonstrated that the new *Cryptosporidium* surrogates significantly outperform the most used existing surrogates in different aquifer media and water treatment. "This gave us the confidence to further research this area," says Liping.

In 2011, Liping and her team received a second Marsden grant to further develop tools for investigating how disease-causing viruses travel through aquifers. Little was known about the retention and transport behaviours of rotavirus and adenovirus due to a lack of representative surrogates. Both these viruses are important viral pathogens for the risk analysis of drinking water in porous media (sand filter used for water treatment and groundwater aquifers).

Liping's team developed surrogates consisting of 70nm sized silica nanoparticles with specific proteins and a DNA marker for sensitive detection. Filtration experiments using beach sand columns demonstrated the similarity of the surrogates' concentrations, attachment-detachment kinetics and filtration efficiencies to the target viruses. They were easily and rapidly detected at concentrations down to one particle per polymerase chain reaction (PCR) and were readily detectable in environmental waters and even in effluent.

The micro mimics are a very useful and cost-effective tool for studying pathogen retention and transport in porous media, for example, assessing filter efficiency in water and wastewater treatment systems, tracking pathogen migration in groundwater after effluent land disposal and establishing safe setback distances for groundwater protection.

Liping says that ESR is constantly looking at ways to improve the quality of water, which is tied so closely to our health and prosperity. Understanding how disease-causing microorganisms move and removal in our waterways and how effective water treatment processes are in removing these pathogens helps improve the safety of New Zealand's drinking water.

"Our micro mimic technology has a great potential to benefit the water supply business, especially with our current development of pathogen surrogates using food-grade biopolymer particles. It will enable water suppliers to test the effectiveness of their water treatment systems, such as filters, in an accurate, cost-effective and safe way." Funded by a $1.06 million HRC project, Liping's team has been applying the new surrogate technology to real-world settings, including a pilot drinking-water treatment plant and domestic filters used by rural communities. For the first time, New Zealand's drinking-water filtration systems (also commonly used overseas) are being assessed for their efficacies in protozoan and virus removal. As there are about 2 million people in New Zealand that rely on filtration systems to keep their water clean, now, thanks to Liping and her team, they will have more confidence that their filters are actually removing pathogens from their drinking water.

"Once the concept of proof had worked successfully with protozoan and virus surrogates, I thought what about looking at bacteria such as *Legionella pneumophila,* which is a real problem in man-made water systems." This was the subject of the third Marsden grant Liping won in 2017.

The annual incidence of legionellosis appears to be relatively higher in New Zealand than in other developed countries. It is a respiratory infection caused by the *Legionella pneumophila* bacteria that can range from a mild respiratory illness to severe life-threatening pneumonia. It is found in water systems and soil. The bacteria especially like lurking in warm stagnant water such as found in plumbing systems, and they can stay there for a long time. The can also travel through common water filters and are chlorine resistant, making them both dangerous and difficult for water treatment systems to eradicate.

Working with leading scientists in this area such as Professor Nicholas Ashbolt of the University of Alberta, together with the Universities of Canterbury and Calgary, Liping's team is developing a non-living surrogate made of food-grade biopolymer microparticles for the *Legionella* bacteria. These tiny engineered micro-particles mimic the adherence and persistence of the bacteria in engineered water systems. Their surfaces are modified to change how the particles adhere, combine with one another and physically resist disinfectant processes. The surrogates even have their own traceable DNA labels so that researchers can detect when the disinfectant has 'worked' to kill them.

Liping says the end result will be new understanding of how *Legionella* bacteria adhere and persist in our water systems so we can develop appropriate water treatment methods to remove them. This new method of studying this pesky pathogen will be cheaper, less labour intensive, less risky than analysing the actual pathogen and more accurate than the traditionally used *E. coli* indicator. The new approach will also be useful for other bacterial pathogens in water systems, with the ultimate goal of reducing human infection.

In parallel with the Marsden and HRC projects, Liping has been leading a Ministry of Business, Innovation and Employment Smart Idea Project to develop novel synthetic DNA tracers for tracking water contamination. The synthetic DNA tracer technology, once properly established and validated, will allow scientists to quickly and accurately track multiple water contaminant sources through all types of freshwater for the first time in New Zealand. "The tracers are unique, environmentally safe, versatile and relatively inexpensive," says Liping. "They are not derived from the genome of any organism, so they don't have any genetic functionality and had no background in the environment, yet can be detected with extreme sensitivity using qPCR. Using multiple DNA tracers, each with a unique identifier, allows concurrent tracking of multiple water contamination source locations and pathways," she says.

With significant achievements under her belt and three major projects in train, Liping says she doesn't have time for much else. "I really like music, and I used to do a little bit of singing and play a little classical guitar. I also like poems and biographies," says Liping. "But I really enjoy being a researcher. I think research is like solving puzzles. That is why I devote my energy to it. I don't care how much time I put into it. I just want to get it solved because I have a burning desire to get the answers."

JAN GREGOR

Science Leader, Christchurch Science Centre

The story of ESR in the Pacific begins with Dr Jan Gregor, a water scientist with a PhD in chemistry who works out of the Christchurch Science Centre. Jan has been with ESR and its predecessor, DSIR, for 28 years. She was one of a group of scientists well recognised as experts in the management of water quality. In the mid-90s, the Ministry of Health passed the responsibility for water quality monitoring over to the water suppliers themselves. This changed ESR's role from monitoring and testing the quality of water supplies around New Zealand to supporting the government to develop the tools to implement the Ministry's national drinking-water quality management programme.

Jan saw a gap in this new approach, with the potential to put a huge burden on small communities. "I spent quite some time in the Social Systems group, helping others understand that different people and different organisations have different perspectives," she says. Through the late 1990s into the early 2000s, she started to turn her attention to the small communities around New Zealand who didn't have the might of local government engineers and had to run their own water supplies. She looked into how these small communities could manage their water quality in a practical way. This technical knowledge was one of the threads that led her to working in the Pacific.

In 1999, Jan was serving on the board of the New Zealand Water and Waste Association (now known as Water NZ). Just by chance, their meeting in Auckland coincided with a meeting of the Pacific Water Association, who were preparing to develop a Pacific regional wastewater policy and action plan. The New Zealand association hosted them for drinks that night, and Jan decided to stay the next day and sit in on their meeting. As she says, "By the end of the meeting, I was co-opted to support this thing, and that thing and the other thing! That was how I started working in the Pacific."

Over the next five years, ESR supported Jan to contribute to a number of regional Pacific strategies and action plans, specifically on wastewater, sustainable water management and water quality and health. She worked in the background of these consultations, often ending up facilitating sessions and running workshops. A real lesson for Jan was learning how to engage with a gathering of implementing agencies, consultants and Pacific Island representatives, all at different stages of development, different resources and different cultural ways of doing things. Each country had a technical adviser plus a senior policy adviser. Jan says it was really an art to manage those meetings and come out with something at the end that was of use to them. "For the most part, ESR funded me to do this, I didn't get paid by outside agencies. At first, it was expenses only."

Finally, after essential building of relationships and credibility, Jan started getting funded by other organisations to do this work. She says, "You can't just go in and work in a developing region and think you know it all, because you don't. You might know what is in a textbook or how it works in New Zealand, but that is such a small part of supporting change, making things different, for the better of the Pacific people."

A grant from the New Zealand Official Development Assistance Fund in 2005 to the Ministry of Health, in partnership with the World Health Organization (WHO) and SOPAC, enabled Jan to provide practical drinking-water quality risk management training throughout the Pacific, drawing from her expertise in providing advice on New Zealand's drinking-water quality management programme. Between 2006 and 2010, this programme was delivered to four Pacific countries – Tonga, Cook Islands, Vanuatu and Palau – and was then extended to Samoa, Malaysia and Fiji. WHO continued to support the region in subsequent phases of the programme.

Wastewater management was a critical issue across the Pacific, impacting on the environment and public health. One project worked with Fijian villages. Village piggeries, sewage and hotels would dump tonnes of pollutants on the coral reef, killing corals and promoting the growth of algae. The ESR Water Management team, along with NIWA and the University of the South Pacific, developed a sustainable community wastewater treatment solution for coastal Fijian villages in 2006. Jan says the solutions developed with local communities were appropriate to local situations and culture. "We helped villagers to integrate traditional indigenous knowledge and approaches with western science and engineering."

As ESR's reputation in the Pacific grew, so too did demand for its services. These services were funded by the Pacific countries themselves, the Ministry of Foreign Affairs and Trade (MFAT) New Zealand Aid Programme, and other donors.

Drinking-water quality management advice was provided to New Caledonia between 2006 and 2010 as it developed a comprehensive programme for ensuring safe drinking water. In Kiribati, ESR contributed to a NIWA-led project that investigated the links between water quality and diarrhoeal disease. In 2011, ESR led a project that detected viral enteric pathogens occurring in humans in New Caledonia. It also monitored viral contamination of the environment. The study reported for the first time the presence of norovirus and other enteric viruses in New Caledonia and highlighted at the time the presence of enteric viruses in popular beaches.

Building public health resilience in Tonga's tourism sector was the focus of a three-year New Zealand Aid-funded project that commenced in 2012 and was led by ESR. Tourism is an important part of Tonga's economic growth, so the pressures on infrastructure and environment needed to be carefully managed in order to protect the health of both guests and Tongans.

The project brought together the tourism and health sectors to produce guidelines for Tonga's many tourist accommodation businesses to provide them with best practice and advice on safe rainwater harvesting, controlling mosquito-borne diseases and food safety and hygiene. This was a really important collaboration and helped inform ESR's commitment to supporting the sustainable development needs of the Pacific region. "It's crucial that accommodation businesses can identify and manage the public health risks to the thousands of visitors Tonga receives and those that work with and around them," says Jan.

Near the end of the project, environmental scientist Matt Ashworth, in a staff-initiated project, arranged for 10 decommissioned ESR computers to

be donated to the Health Inspectorate in Tonga, and with a little help from a generous staff collection, they were repurposed and freighted over to the islands to start a new life with the environmental health programmes in Tonga. "This created enormous goodwill," says Jan.

ESR partnered with UNICEF New Zealand to deliver a range of programmes to help improve WASH (water, sanitation and hygiene) practices in the Pacific. The Kiribati WASH in schools project ran from 2014 to 2017 and aimed to improve water sanitation in 36 outer-island schools, reaching 4,500 school children. ESR produced a technical toolkit resource to help the schools choose affordable, sustainable and safe water, sanitation and hygiene systems.

Jan says that the basics we take for granted are not there in the Pacific. "Many island children go to a school with no toilet facilities, no running water and no way to wash their hands. The WASH project is about taking them through a journey to learn about washing their hands, cleaning their teeth and those sort of things. It is also about making sure they have the facilities. Many schools don't have toilets in schools, and there is a huge amount of open defecation. Even if they use toilets at school, they haven't got them at home. So it's about using the school community to improve the health outcomes of the children through better WASH practices."

Building on the Kiribati WASH in schools programme, ESR again partnered with UNICEF, as part of the MFAT Partnerships for International Development Fund Solomon Islands Better Learning Environments (SIBLE) project. The project aimed to support the development of resources to help schools and communities mobilise around the importance of better WASH practices, install WASH facilities and train students, teachers and committees to use and maintain the facilities. Jan says it's about helping communities think about what, from a water and sanitation perspective, would put their health at risk. "So it is things like needing to clean your rainwater tank, not putting water-based toilets in situations where your freshwater is coming from the shallow groundwater, which is underneath your flushing toilets. This is the sort of thing we are working on with them, and it can make a real difference to the health and prosperity of a people." The WASH in schools support is now moving into Vanuatu.

In 2016, following on from the Healthy Tonga Tourism project, ESR commenced a five-year MFAT Partnership Fund activity aimed at reducing disease in Tonga caused by environmental exposure to hazards including consuming contaminated food and water sanitation and solid water management and vector-borne diseases, especially those that relate to climate change. The Healthy Tonga Environments project is enhancing the capacity and capability of Tonga's Environmental Health Unit so it is able to respond, prepare and prevent disease outbreaks. This includes developing an inspectors' operations manual, formal qualifications training as well as on-the-job practical skill-building advice and mentoring.

While most of the work in the Pacific has been in environmental health and water, the Healthy Pacific Environments programme is an ESR-wide programme. ESR supported initiatives like the Pacific Regional Influenza Pandemic Preparedness Project and fighting the regional Zika virus outbreak in 2015/2016 and continues support for mosquito-borne outbreaks. The Enteric Reference Laboratory has also provided a reference laboratory service for enteric bacterial disease for the Pacific for a number of years. Laboratory staff have also been involved in the Pacific in a number of different ways including contributing to the sustainable improvement of public health laboratories and acting as trainers and technical advisers.

ESR's National Influenza Centre (NIC) in Wellington, led by Dr Sue Huang, has also been involved in the Pacific. Since 2006, this has included laboratory training and influenza reference testing for the Cook Islands and Tonga. During the influenza pandemic of 2009, NIC provided international reference-testing services for the Cook Islands, Tonga, Samoa and Niue. The flow-on from this was further laboratory training for these countries in 2010 along with American Samoa, Western Samoa, and Tokelau to strengthen lab-based surveillance of influenza in these countries.

Other parts of ESR also work in the Pacific. The ESR National Centre for Radiation Science (NCRS) has been responsible for monitoring radioactivity levels throughout the South Pacific since the 1960s. ESR Forensics also has a strong presence in the Pacific. An internally funded Pacific Forensic Capability Project was piloted in the Cook Islands in 2017.

Jan says the work ESR is doing doesn't have to be limited to the Pacific. "The next wave might be Asia. But that would be a lot harder job to start because relationships are so important in this work. We are part of the Pacific community and culture, New Zealand is recognised by Pacific Island nations and we have good relationships with them, built carefully and respectfully over the years. This is why ESR has been able to make a difference in the Pacific."

MURRAY CLOSE

Principal Scientist, Food, Water and Biowaste Group, Christchurch Science Centre

Considered by some at ESR to be the godfather of groundwater science, Murray Close, the leader of the Groundwater team, has been at ESR almost from the beginning. His journey started at the Ministry of Works and Development, where, as a newly trained chemist, he worked on groundwater quality and contamination for the Water and Soil Division of the Ministry of Works and Development. When the Ministry was, inevitably, reorganised in 1988, the Groundwater team was transferred to the Geophysics Unit of DSIR. In 1992, when DSIR was disestablished, this unit went to GNS with the exception of two people who were transferred to the Christchurch Science Centre at ESR – Lester Stinton and a technician.

"The people at GNS wanted me to go with them but that would have meant a move to Wairakei, and due to family reasons, I didn't want to do that," says Murray. "Along came ESR General Manager Bill Swallow, who wanted to establish a Groundwater team there. At that time, Lester Stinton was it, and so I was hired to bolster the team and I am still here doing that today."

Murray says that, while GNS puts more emphasis on groundwater dating, geology and geological mapping, providing a lot of information about the groundwater system, ESR specialises in microbes in groundwater and the contamination and denitrification processes. "We care about how clean the water is so we are much more interested in the quality of groundwater and how it affects drinking-water supplies and people."

"We have a great mix of skills in the Groundwater team: chemists, like myself, microbiologists, groundwater modellers, hydrogeologists, and a good bit of geochemistry is mixed in there too. We largely look at the assessment of water quality and water contamination. How much contamination gets into groundwater systems? How is it transported through those systems? Is it attenuated, that is, does its virulence weaken or does it go straight through the system? Contaminants we look at include nitrogen, phosphorus, pathogenic bacteria, viruses and protozoa and indicator bacteria. We also look at organic compounds, like pesticides, and in the past, we have studied heavy metals. Over the past five years or so, we have been investigating groundwater ecosystems – what lives down there in the dark. There is a whole bunch of natural bacteria, protozoa and stygofauna. We are looking at their function and how they are impacted by contamination."

The leaching of pesticides through soils was a big issue in the 1990s. Murray was the first person in New Zealand to start surveying pesticides in groundwater when he was at DSIR in 1990. He has conducted this four-yearly survey ever since, and after 24 years, has seven surveys under his belt.

"Pesticides were found in surface waters, but everyone assumed they would be adsorbed or degraded by the soil and wouldn't get through to groundwater. We found that there was a class of pesticides that had sufficient mobility and persistence to get through to the groundwater. Luckily, it was mostly the herbicides that got through, and generally in low concentrations, which was good. The small number of insecticides that got through were more toxic so they were of more concern to people.

The survey has proved its value. Murray points to procymidone, a pesticide that was thought to be immobile and not persistent in water, so it should not be turning up in groundwater. But it was. "So we tested it in a range of trials across different soils and climatic conditions, and we found that, in fact, despite what the literature had said, instead of a half-life of one to two weeks, this pesticide had a half life of six months. It was also four or five times more mobile. This meant that this pesticide had been wrongly classified as a non-leacher when it fact it was a real leacher.

The importance of understanding leaching pesticides was highlighted in the last three surveys when Murray found out that dieldrin, a pesticide that had been used extensively in sheep dips for foot and mouth disease, was exceeding the limits allowed in drinking water. Dieldrin hadn't been used since the 1960s, but the survey found that it was very persistent and toxic. It had been slowly leaching its way through the soil and into the drinking-water wells on farms throughout New Zealand for many years.

The movement of heavy metals through soils was studied intensively in the 1990s. "We wanted to find out if this was an issue in New Zealand. So we mostly did laboratory experiments. We collected material from alluvial gravel systems, pumice sand aquifers and coastal sand aquifers – this covers most of the aquifer systems in New Zealand. We found that cadmium was the most mobile metal through groundwater, with zinc and lead having limited mobility unless there were low pH conditions and they could move a lot faster." Murray says when the results of the study were put together with the major sources of metals, the mines and landfills, they were able to see it was not a huge problem in New Zealand.

At the same time, with his team, Murray studied the microbial contamination of groundwater, examining the effluent to pinpoint the source of contaminants. "I started looking at things like fluorescent whitening agents that are used in domestic household products, different types of bacteria and bacteria ratios, which would indicate whether the contamination was a human or animal source, then Brent Gilpin came along in about the year 2000 and he took the work a lot further with faecal source tracking."

The Groundwater team at ESR was part of the Water Group, which was managed for a long time by a scientist called Alistair Sheat. The Social Science team was initially part of this group too. "We had a combined surface water/groundwater project, which went on for seven years – looking at microbes and their sources."

"Elaine Moriarty was employed at that time, and she and Lester Stinton researched how many *E. coli, campylobacter* and *Salmonella* bacteria dairy cows, sheep and birds produce. This was to better understand the faecal input into the environment."

In 2004, ESR was part of a research group called Integrated Research for Aquifer Protection (IRAP). The group was a collaborative venture involving ESR, Crop and Food, Environment Canterbury, AgResearch, Dexcel, Landcare Research and Lincoln Ventures. The aim was to create a farm-scale model to find out the effect of changing land uses on groundwater quality. ESR's main role was to investigate nitrate within the vadose zone – the area between soil and the groundwater table. Nitrates that are applied to the land as a fertiliser can be transported long distances in groundwater systems and can potentially contaminate drinking water. Murray says that, at the time, little was known about this stage of groundwater nitrate contamination. “Our work was to assess and model how nitrate can leach through the vadose zone and how much nitrate is affected by transformations in this zone.”

In 2007, the organisation decided to split surface water away from groundwater. “Our team decided to put a joint bid in with Lincoln Agritech and Aqualinc Research to look at the capacity of groundwater systems to cope with contaminants, especially nitrates. At the same time, we were working with these two organisations and the University of Auckland on a project with Hanyang University in Seoul, South Korea. This was a fun piece of work. We exchanged visits and knowledge. It was a wonderful experience.”

The Korean project researched in situ groundwater remediation processes. “They were looking at industrial-related contaminants like trichloroethene, and we were mainly interested in nitrates. We developed a technique called recirculating wells because a lot of these degradation rates are very slow and the reaction rates were too slow to detect. So we recirculated water between two wells to basically increase the times for the reaction so we could see it. We tested the technique at a number of sites around the country, and we finally saw the denitrification processes at a site near Taupo.

In recent times, Murray’s work on the denitrification processes has come under the groundwater assimilative capacity programme, a joint research project between long-standing research partners Lincoln Ventures and Aqualinc Research. This project brings together water quality management and land-use planning by improving the scientific understanding of the linkages between land use, subsurface environment and groundwater.

“We are looking at microbial attenuation, how the pathogens are removed as they move through the systems and also what actually happens to the pathogens in groundwater. Some of Liping Pang’s microbial mimics were developed in this programme.”

“We have continued to look at the structure of aquifers and how they affect contaminants and the water movement. The conclusion was that, in many areas of New Zealand, you had oxic water, and you were never going to get rid of nitrates. So we needed to do something to change the conditions to reduce nitrates getting into the system and that led to our current project, Enhanced Mitigation of Nitrates in Groundwater, which was funded by the Ministry of Business, Innovation and Employment in mid-2016.

The new project aims to develop technologies to stimulate denitrification in alluvial gravel aquifers. Murrays’ team is also developing innovative approaches such as biogas-induced denitrification in groundwater and denitrifying permeable reactive barriers. These are being coupled with aquifer characterisation using advanced shallow-depth geophysics, DNA tracers and groundwater microbial community analysis to enable the effective design, delivery and implementation of these mitigation tools. A third technology being trialled is the use of denitrifying bioreactors to treat nitrate from artificial drains.

Past research includes developing a method for predicting reduced groundwater zones, assessing the assimilative capacity of groundwater with respect to different contaminants, developing tools for testing water quality, working on an international project looking at measuring denitrification rates in groundwater and developing a new method to study the structure of alluvial gravel aquifers.

“Most of the research I am involved in has practical applications for local government, industry and communities,” Murray says.

“Regional councils have the responsibility to implement the government’s freshwater reforms, which seek to balance the goals of maintaining or enhancing water quality and increasing production from agriculture. Knowledge of the assimilative capacity of the groundwater system is crucial to estimating loads of contaminants entering into river and lakes.”

“It is important for us to develop an understanding of the whole subsurface system so that we can predict what will happen as contaminants leave the soil layer, where they are transported and what processes will affect them. As part of this, we are working on ways to measure and model land-use impacts on groundwater quality,” Murray says.

JACQUI HORSWELL

Science Leader, Food, Water and Biowaste Group

Jacqui came to ESR in 1997 from Aberdeen University where she had done a PhD in microbiology. "I wanted to come to New Zealand, so I wrote to any New Zealanders who had published papers in scientific journals asking if I could do a postdoc with them."

ESR Principal Scientist Tom Speir replied. In January 1998, Tom picked her up from the airport. "I stayed with him and his wife Susan for a week. They were determined to find me a boyfriend so I would stay. ESR has always been a people place. I met my husband Björn at work. He's at ESR and manages STRmix™. Now we have two children."

Jacqui had worked with Professor Graeme Paton at the University of Aberdeen on new biosensor technology, which ESR brought to New Zealand in 1998. At the heart of this technology were tiny organisms called biosensors that, in normal conditions, bioluminesce (give out light). These biosensors can determine whether toxic material is present in soil and can show when sites contaminated by industry or agriculture have been cleaned up. This helps to protect the health of the soil, which affects the quality of the food grown.

Jacqui used the soil bacterium *Rhizobium*, which was sensitive to heavy metals in the soil, in her research. This bacterium had a special lux gene, acquired from marine bacteria, inserted into it. When the soil was healthy, the bacteria would glow. When it was not, for instance, when it contained heavy metals, the biosensor light went out. This very simple research tool provided a new and relatively inexpensive way to measure the relevant health of the soil.

Jacqui's first job at ESR was looking at the impact of heavy metals in sewage sludge on microbes in the soil. "One of the things I loved about working at ESR is that you get the opportunity to take what you do and apply it to something different. I have done a number of research projects with forensics and Dr Steve Cordiner.

"About 10 years ago, we worked on dating how long a body had been dead using microbes. Flies are attracted to a body. They lay eggs, and new flies hatch. So you can work out how long someone has been dead from the insects. We showed that you could do the same with microbes because, as the body decomposes, different food sources become available for different microbes. We tested on pigs, and then a PhD student, Rachel Parkinson, went to the Body Farm at the University of Tennessee, which is the only place in the world where you can work on decomposing human bodies.

We were the first in the world to do that work," says Jacqui.

With the retirement of Tom Spier in 2008, Jacqui took over the biowaste programme at ESR. In 2009, the ESR biowaste programme joined up with the Scion biowaste programme to work collaboratively on the wicked problem of the sustainable use of waste. The programme went a step further in 2011 with the decision to form a virtual Centre for Integrated Biowaste Research (CIBR). CIBR was a launched in 2013 as a collaborative centre of excellence with an active and practical research programme. It has proved to be a successful model, with a number of different scientific disciplines working together towards a common aim.

The purpose of CIBR is to research better ways of dealing with organic waste – everything from leftover food to sewage sludge – "to make sure, that, when it goes on land, this is done safely and does not impact the environment".

ESR manages the running of CIBR, with Jacqui the first programme leader. CIBR shows how social, cultural and biophysical elements can work together to address major environmental issues. Partner organisations with long-standing working relationships include Scion, Cawthron Institute, Landcare Research, NIWA, the University of Canterbury and Lincoln University and a couple of independent consultants.

Projects completed under CIBR include a trial to evaluate whether vermicomposting is effective in reducing pathogens in biosolids while still retaining beneficial nutrients and organic carbon. A long-term project led by Scion, starting in 1997, applied biosolids to a *Pinus radiata* plantation on the sandy, low-fertility soil of Rabbit Island, near Nelson, six times over 24 years. Forests are considered suitable for receiving organic wastes because they are not part of the food chain. Monitoring these trees 25 years later showed the biosolids application significantly improved soil fertility, tree growth and site productivity without any obvious adverse effect to the soil and groundwater quality. These types of long-term trials are few and far between and generate significant data sets and new knowledge.

Engaging with communities around the sustainable use of waste is a primary focus for the CIBR team. Working with two different communities – Mōkai, near Taupō, and Kaikōura – on the real-time and real issue of what to do with their sewage sludge, the team hoped to further understand the social and cultural concerns surrounding land application of biowaste. In particular, it aimed to better understand how reuse decisions were considered and debated by a community and especially by tangata whenua, Māori waste managers, other business operators, local communities and the wider community. Ultimately, a framework was developed for community engagement for biowaste reuse, enabling key stakeholders to play a role in decision making and allowing sustainable biowaste solutions to be found.

Ground-breaking research by ESR scientist Jennifer Prosser in 2014 looked into whether the New Zealand native *Leptospermum scoparium* (mānuka) could be grown in waste-amended soil to mitigate microbial contamination. Pot trials of mānuka, kānuka and rye grass were spiked with *E. coli* and *Salmonella*. Die-off of these pathogens was assessed over time, with results showing that *E. coli* and *Salmonella* survival was significantly reduced in mānuka pots compared to pasture control. The time taken to achieve 90% reduction in *E. coli* was just 5–8 days for kānuka and mānuka, compared to 93 days for rye grass, likely to be caused by the antimicrobial properties of mānuka. The research is being applied to clean up water in polluted rivers and lakes and investigate whether this can work on a large scale.

"Discovering that mānuka's antimicrobial properties could help with water pollution was an exciting moment," says Jacqui. We knew mānuka produced antimicrobial compounds in honey and essential oils, but working with Lincoln University, we have discovered these properties are in the root systems as well.

"When we filter water through a tub with mānuka growing in it, the mānuka seems to kill bacteria and, most importantly, reduce nitrate. Organic nitrogen is in cow-pats and urine, and the microbes in the soil convert it into nitrate, which goes through the soil and ends up in the water, feeding the algae and resulting in algal blooms.

"Mānuka seems to actively do something beyond just sieving out the pathogens, so if we were to plant it (or kānuka) along our waterways, as they used to do, we might see an improvement in the health of our rivers and lakes. We have got funding from Waikato River Authority, Waikato Regional Council and Greater Wellington Regional Council. We are running a trial in Lake Waikare, near Huntly, working with Waikato-Tainui, and at Lake Wairarapa."

The CIBR team has been working together for more than 20 years. Jacqui says, "When we first started, it was as if we each spoke a foreign language. We had to learn to communicate with each other. We now talk to each frequently and meet up twice a year. We enjoy learning from each other and have ended up being friends. When we have meetings, we stay at each other's houses. There is money to stay at hotels, but we prefer to stay with each other."

ROB LAKE

Risk and Response and Social Systems Group Manager, Christchurch Science Centre

When Rob Lake started at the DSIR's Chemistry Division in 1988, many of his analyses were about the composition of food products to make sure they complied with a raft of regulations. Today, the focus is firmly on food safety, and with the formation of the New Zealand Food Safety Science and Research Centre, he and his colleagues are poised for greater direct engagement with agriculture and industry.

Rob recalls the advent of the new Crown Research Institute in 1992 as an uncertain time for the food safety staff. "We spent the first 12 months waiting to hear if our jobs would be confirmed," he says.

"We also found ourselves grouped with unfamiliar entities, the most important of which, from my point of view, were the Public Health Laboratories (PHLs), which did a range of microbiological work. The Christchurch PHL soon moved from the public hospital to join us at the Christchurch Science Centre, and eventually those in Auckland, Wellington and Dunedin were consolidated here."

After several years of projects using analytical chemistry, during the 1990s, Rob expanded his capability into two particular areas: taking advantage of antibody-based immunoassay techniques for chemistry and microbiology and providing the Ministry of Health with up-to-date information on genetically modified (GM) foods.

GM foods were appearing on the market, and initially, no one was sure whether safety assessments were needed or how to do them, says Rob. "In the USA, the approach was that existing legislation on new foods coming to market was sufficient, while other countries, particularly in Europe, considered that special safety assessment procedures were needed. Detection methods were also in rapid development, particularly for products claiming to be GM-free, and we needed a way of assessing whether that was true."

During this time, Rob went to two meetings in Japan of the Codex Alimentarius Commission International Task Force on Biotechnology. This was creating a safety assessment approach for GM foods. "I was fascinated by the international meeting formalities for consensus building, the negotiations back and forth to reach an agreed text, with potentially important commercial results for biotech companies." He was also impressed by the translators, listening, translating and speaking in a different language, more or less all at the same time.

The Ministry of Health had asked ESR to develop capability for the detection of GM foods. "Before commercial test kits were available, working in collaboration with Paula Scholes and the molecular biology lab, we set up and validated several DNA-based assays from scratch. We also managed to complete documentation of process and quality control in time to become the first in Australasia to achieve accreditation for GM food testing from International Accreditation New Zealand (IANZ)."

A major change came in 2001/02 when the New Zealand Food Safety Authority was formed from the food safety parts of the Ministry of Health and the Ministry of Agriculture and Forestry (MAF). "ESR's focus on analytical laboratory work became much broader, with everything contributing to a risk-based approach to food safety issues, driven by the MAF staff involved with the safety of our export products.

"We had to rapidly develop capacity in risk profiling, risk ranking, exposure assessment, quantitative risk model building and burden of disease estimation. We had to understand and use data from the notifiable disease surveillance system, which included several foodborne diseases.

"We also had to increase our international networks. We connected with food safety experts, particularly in Europe and North America, and became involved with food safety projects led by the World Health Organization and the Food and Agriculture Organization."

The food safety core contract continues – now with the Ministry for Primary Industries – but the New Zealand Food Safety Science and Research Centre is bringing a new orientation to ESR's food safety work. The collaborative centre was set up after what turned out to be a false alarm about botulism in a dairy product and consists of three universities, three Crown Research Institutes and a private research institute.

"This is creating our next major change – while continuing to provide science for the regulator, we expect a much greater engagement directly with agriculture and industry," says Rob.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KLAUS HERMANSPAHN & CRIS ARDOUIN

National Centre for Radiation Science

ESR added another jewel to its crown with the acquisition of the National Radiation Laboratory in 2011. The NRL had a long history in New Zealand starting in 1933 when it was established as the Dominion X-Ray and Radium Laboratory by the British Empire Cancer Campaign Society to produce radium isotopes for cancer treatment. In 1950, it was taken over by the Department of Health and was based in Victoria Street, Christchurch. In 1963, it changed its name to the National Radiation Laboratory (NRL). ESR acquired the laboratory from the Ministry of Health in 2011, and it became the National Centre for Radiation Science (NCRS).

Dr Nikolaus Hermanspahn (Klaus) joined the NRL in 2001. He had earned his PhD at the Johannes Gutenberg University in Mainz, Germany, and undertook postdoctoral study in the fine structure of helium at Harvard before joining NRL. At ESR, he became a Science Leader, heading the Environmental Radiochemistry Laboratory, which measures naturally occurring and man-made radionuclides. It was accredited to the international standard ISO/IEC 17025 in 2003. Klaus recently left ESR to take up a position at the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) in Vienna.

Klaus recalls there was always a bit of discussion as to how the NRL fitted with the Ministry of Health. “The Ministry was a policy-making organisation, and scientific research and services don’t fit easily within core government,” he says. The move to ESR created some disruption for the NRL team, as part of the team of 30, for legislative purposes, was left behind at the Ministry. “Like any change, there were some uncertainties. We were a close team and had been fairly independent, doing our own processes and our own development.”

In the year preceding the move to ESR, the NRL was heavily involved in the New Zealand response to the Fukushima Daiichi nuclear power plant accident, which was heavily damaged as a result of the great east Japan earthquake that struck on 11 March 2011. The accident resulted in the release of several hundred PBq of activity in the environment with radioactivity dispersed in the atmosphere and ocean, and subsequent traces of radionuclides were detected all over the world.

Cris Ardouin, a senior scientist in the radiation protection section, joined NRL in 2001. He says that the laboratory was heavily involved in the Fukushima accident, with the whole team working 24/7 in the immediate aftermath of the accident providing support to MFAT and the New Zealand Embassy in Japan. The work continued even after the shift to ESR. The new acquisition was a win-win situation for both ESR and the NRL, with the new team soon working right across the organisation. Chief Executive Grant Smith said in 2012, “NRL’s offering is enhanced by being part of ESR, and with our collaborative approach, the rest of the organisation is reaping the benefits of these new colleagues with complementary skills.”

As the main provider of radiation services in New Zealand, the NCRS’s expertise centres on radiation exposure, equipment and radioactivity. Much of the group’s work is regulatory, centred around assisting ministries, other Crown Research Institutes, regional government and the export and import industry to meet their needs on measurement of low levels of radioactivity. “We are the main provider of radiation safety and measurement of radiation in New Zealand. GNS does a bit with measurements to date groundwater, but the overlap is very small,” says Klaus.

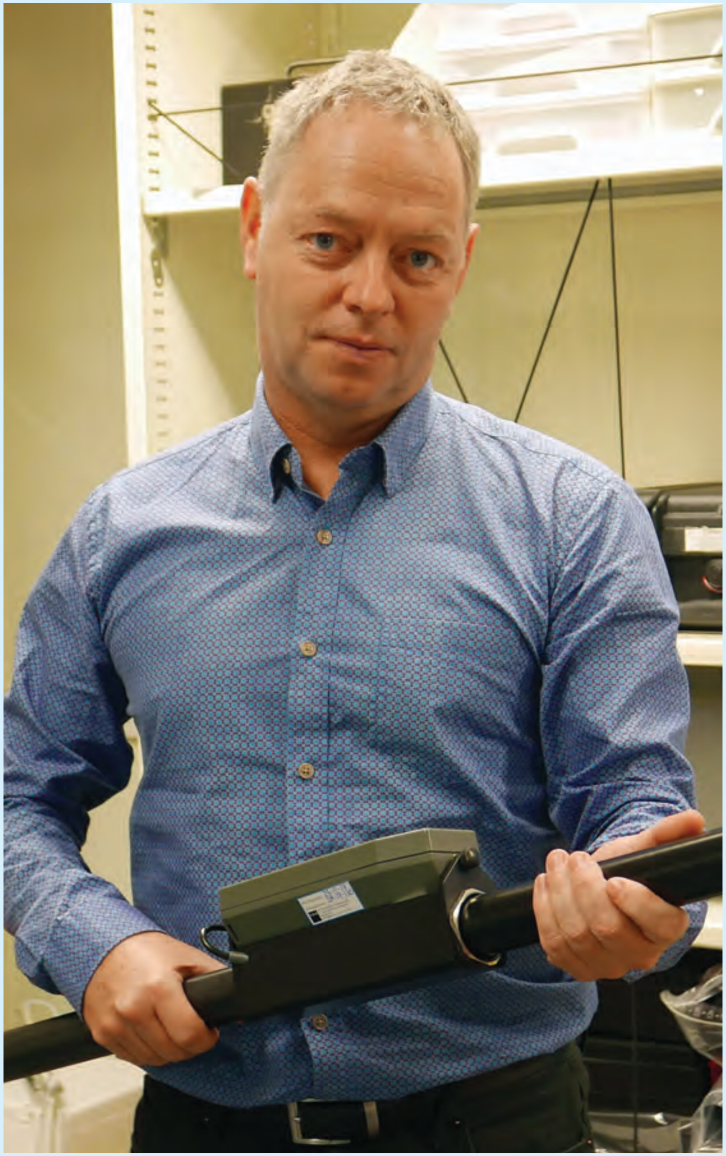
Radiation is naturally occurring and all around us. ESR works across a wide range of sectors providing radiation science advice, services, training and research. Services cover public, occupational and medical exposure to radiation, performance assessment of radiation protection equipment and the measurement of low-level radiation and radioactivity.

ESR’s tailored training courses and equipment calibration help employers protect their employees using radioactive equipment. The Personal Dosimetry Service (PDS) measures and records the ionising radiation doses employees are exposed to in the workplace. This ensures a safe work environment and that recommended dose limits are not exceeded.

Klaus says they can measure radioactivity in any type of material including water, soil, sediment, mining ore and products, environmental biota, sediment and air samples.

“One thing we did for ECan (Environment Canterbury) is to measure an isotope in the soil, Cs-137, which is left over from the radioactive fallout from the nuclear testing that occurred in the 1960s. This measurement can be used to determine rates of erosion. ECan does the science behind the erosion, we do the radioactive measurements. We can also use radioactivity measurements to determine the sedimentation rates in lakes and oceans. We do a lot of work for NIWA, research institutions and universities in this area,” he says.

The NCRS also tests food imports and exports to make sure they are within the limits of acceptable radioactivity levels. “We authenticate levels of radioactivity in foodstuffs for the export market and monitor imported food products,” says Klaus. “Through robust testing, we provide public and private sector clients with certification to protect their reputation and that of their export products.”



Beyond testing food in New Zealand, ESR also takes a proactive research role. In 2014, NCRS was engaged by Forage Innovations Limited, a joint venture between PGG Wrightson Seeds and Plant & Food Research, to research crop mutational breeding to explore the benefits of using ionising radiation to induce mutations as opposed to using chemical methods. Work was also completed for Steritech, an Australian provider of irradiation services, and the New Zealand Fresh Produce Importers Association to research the irradiation of taro exported from the Pacific Islands. In 2014, an ESR-led student project measured radiation concentrations in fish and sea cucumbers in Wallis and Futuna, Tonga and New Caledonia to see if radiation levels were higher following the Fukushima Daiichi nuclear reactor accident.

Another area of work for the NCRS team is ensuring New Zealand's drinking water is safe. Radioactivity in drinking water is principally derived from two sources: the leaching of radionuclides from rocks and soils into water and the deposition of radionuclides from the atmosphere.

In 2016, the team worked with the Water Group on research that used groundwater radon as an indicator of aquifer recharge rates. The research had important implications for looking at the impacts of land use on groundwater quality and also to help councils make vital water decisions. The project, in collaboration with ECan, trialled the measurement of radon to gauge surface water recharge to groundwater. The surface water from braided rivers, such as those in Southland, Canterbury, Nelson/Marlborough, Wairarapa and Hawke's Bay, constantly replenishes the groundwater along some sections of their length. In order to make important decisions about water allocation, local bodies would benefit from knowing how much water is being replenished. This had always been hard to measure, but using the NCRS's specialised equipment and expertise, the team was able to measure small quantities of radon-222, which has a half-life of 3.8 days. Radon occurs at very low levels in surface water, but as it recharges into groundwater, its levels increase through interaction with mineral grains in alluvial gravels. If groundwater is sampled at different points over a specified time, the radon levels can be used to estimate the amount of flow occurring under the ground. The project is ongoing, but so far, measurements support the hypothesis. If this proves to be a good estimation method, the measurement of radon could give regional councils another way to manage water.

The NCRS has been involved in a number of international projects with the International Atomic Energy Agency (IAEA) and has a strong involvement with the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) based in Vienna. Klaus says, "We provide technical support to the CTBTO as one of 16 labs that have been assigned to help verify compliance with the Treaty."

NCRS operates the National Data Centre (NDC) under the Treaty and examines and collates data from the International Monitoring System (IMS) established by the CTBTO. This work, which reports directly to MFAT, assesses the significance of any detected events. Radioactive monitoring involves measuring radioactive particles and gases collected from the atmosphere. There are 80 stations set up around the world to monitor atmospheric radioactivity, and they are capable of picking up even the smallest nuclear test. NCRS operates six of them, located in Kaitaia, Fiji, Rarotonga, Kiribati, Chatham Islands and Mauritania. ESR sends two technicians out to the stations a least once a year to maintain the equipment.

Klaus says that the job of the NCRS is to make sure the stations are operational. "Local people operate the stations, which send the data to the international data centre in Vienna, from where it is passed on to the national data centres, such as the one at NCRS. If there is something happening, like the tests in North Korea, we will advise MFAT of the technical details."

In 2015, New Zealand was one of two countries asked by the IAEA to participate in an exercise to gather seawater and marine sediment samples as part of the response to the Fukushima disaster. The IAEA has a marine radioactivity laboratory in Monaco, and New Zealand had dealt with it as part of their work training developing countries and setting up monitoring network activity in the Asia Pacific area after Fukushima. Klaus, representing New Zealand, was asked to go, along with another scientist from a laboratory in Ireland. They gathered samples of seawater and sediment in an area outside the power plant and prepared the sediment samples by drying them and grinding them up using a mortar and pestle, so they were homogenised. Then the samples were sent to laboratories in Japan as well as internationally so that results could be compared.

Cris was born in Wales and spent 12 years working in the British nuclear power industry as a health physicist, specialising in radiation safety before coming to New Zealand. He says his main emphasis is to ensure the safe and secure use, storage and transport of radioactive materials and use of X-ray equipment in industry, research and education. "I am the technical lead on the industrial side of radiation, and my colleague, Glenn Stirling, is the lead on the medical uses, such as radiology, radiotherapy and nuclear medicine. In total, we have eight scientific and technical staff in the radiation protection section, and Brent Le Vert, who works out of MASC, oversees the national inspection programme set by the Ministry of Health."

Besides providing advice to government and users on radiation safety and security, the team participates in international committees on radiation safety standards, including the transport of radioactive materials and dealing with radiation incidents as duty officers under the National Emergency Response Plan. The team inspects facilities that use radioactive sources and X-ray equipment in New Zealand that require source licences under the Radiation Safety Act 2016.

Cris says, “For example, this week I inspected a number of engineering companies in Taranaki that perform industrial radiography where they use powerful radioactive sources to radiograph welds in steel structures. Obviously, these need to be done in a controlled way or people could be exposed to high radiation doses. That is where we come in. We perform these inspections on behalf of the regulatory authority, the Ministry of Health, who we work with closely to promote high standards of radiation safety and security in New Zealand.”

The NCRS also offers radiation safety training through the Radiation Training Institute, which was established in 2015. Training ranges from medical radiation protection to radiation incident and emergency response for first responders to the safe transport of radioactive material.

Cris says that one of the highlights of 2016 was the setting up of a regional network for the Pacific Islands to implement radiation safety and security in the region. “We did this with the International Atomic Energy Agency to enable Pacific Islands to meet international standards of radiation safety and security. Cris says the Pacific Islands have much to catch up on, and ESR has helped develop a regional action plan and held a number of training workshops to help these small Pacific Island nations more effectively manage radiation safety and security including the import, export and transport of radioactive material needed for medical and industrial applications. Cris notes that MFAT has a strong interest in this project and has been very supportive of the NRSC’s efforts to date.

An important NCRS service is the receipt of sealed radioactive sources that are obsolete and cannot reasonably be reused or exported to the country of origin. The NCRS assumes responsibility for operating the national radioactive waste store, which is owned by the Ministry of Health, and facilitates, where possible, the export of high radioactive sources back to the supplier of the source. In 2016, ESR facilitated such an event when a redundant but high-activity cobalt-60 radiotherapy source contained in an AECL Theratron T-80 teletherapy unit had reached the end of its useful life. The machine, which was historically used for cancer treatment of patients in New Zealand and later as an instrument calibration source, was decommissioned by ESR. The transport of this radioactive material back to where it came from – the Australian Nuclear Science and Technology Organisation (ANSTO) – was treated extremely seriously. After all risks, costs, issues and options relating to the disposal were considered, the machine was exported back to Australia safely, carefully guided by the NCRS radiation protection team.

DARREN SAUNDERS

Senior Scientist, Environmental Science

The first time Darren worked at ESR, he was a student studying chemistry. “I came to ESR over the Christmas holidays and worked on a project looking into synthetic colours in children’s confectionery and the link to concentrations of colour and hyperactivity. I found it very interesting.”

Darren left, finished his first degree in analytical chemistry at Canterbury University, then went on to work at the School of Medicine in Otago. During that time, he also managed to complete a master’s degree in pharmacology.

In 1997, a job came up at in the Food Chemistry Lab at the Christchurch Science Centre, and he remembered his positive experience working there as a student. “I applied, won the job and have been here ever since.”

In the 1990s, the Food Chemistry Lab did a lot of regulatory-based work, especially for products coming into the country. “We tested ceramics for leaching of lead and cadmium, which can come from the glaze. We also tested on a regular basis for toxins that come from moulds in nuts. Aflatoxins are found in peanuts, and they are one of the most potent naturally occurring pathogens known. You get a big dose of these in your peanuts, and you could end up with liver cancer,” says Darren.

The team dealt with food complaint issues for the Ministry of Health. “A member of the public would go to their local public health office and say, ‘I found a mouse in my soup’, and that soup would often end up in our laboratory.”

Regulatory work became less important over time as New Zealand began accepting certificates of analysis from other countries who were importing products into New Zealand. “There were agreements between laboratories, so if they had already tested it, we wouldn’t have to test it here.”

“On top of the regulatory work, we dealt with emerging health issues for government agencies such as the New Zealand Food Safety Authority and then the Ministry for Primary Industries. These would change from year to year, and many would originate overseas. For instance, a while back, there was a huge issue with horse meat being found in pies in Europe, so to find out if it was happening here, we had to develop a meat species test for New Zealand.”

Another example was the huge issue over carcinogenic, industrial soluble dyes that were found in food products in the United Kingdom and led to one of the biggest recalls in UK history in 2005. The UK Food Standards

Agency recalled 418 products – including ready meals, pizzas, sauces and sausages from all the main supermarket chains – as they were found to be contaminated with the cancer-causing red food dye Sudan I. Darren says that a little routine testing would have been able to pick up the problem and save an awful lot of money and embarrassment for food producers. In New Zealand, ESR is the only lab in the country that tests for both legal and illegal synthetic colours for the spice market.

Whilst the Food Group does regular commercial work, the methods they use tend to be high end. "We have looked at things like taints and smells in wine. Off-smells in wine can be produced by certain varieties of fungus."

"We do emerging food issues investigating such things as how high-end rice, like basmati, which is quite expensive, is faked. This may include replacing it with a plastic substitute or with potato starch. The faking and adulteration of food is part of our bread and butter when it comes to food forensics," says Darren.

Another issue the Food Safety team investigated was cyanogenic glycoside levels in food. Some plants produce cyanogenic glycosides, a natural insecticide that repels insects. If levels of this, when made into food, are too high, they can be converted by the microbes in the stomach into hydrogen cyanide, which is very poisonous and can be fatal. Darren says it all started with ready-to-eat cassava chips that were imported into New Zealand and had higher than allowed cyanide levels due to incorrect testing by the manufacturer. This was seen as an emerging health issue, and along with testing the levels in food, ESR, in collaboration with the Australia New Zealand Food Safety Standards Authority, undertook a number of surveys looking at the levels of cyanogenic glycosides in ready-to-eat cassava chips as well as in other plant-based foods, including apple juice and apricot kernels.

Darren says that, as the regulatory work decreased, the food chemists turned to what they term food forensics. "We are like a CSI without the bodies," says Darren. "Our commercial clients will come to us if they get a complaint they can't solve. They will be concerned about their reputation and will genuinely want to know what is going on. This is what makes it incredibly diverse work. We investigate everything from foreign matter to funny taints and smells."

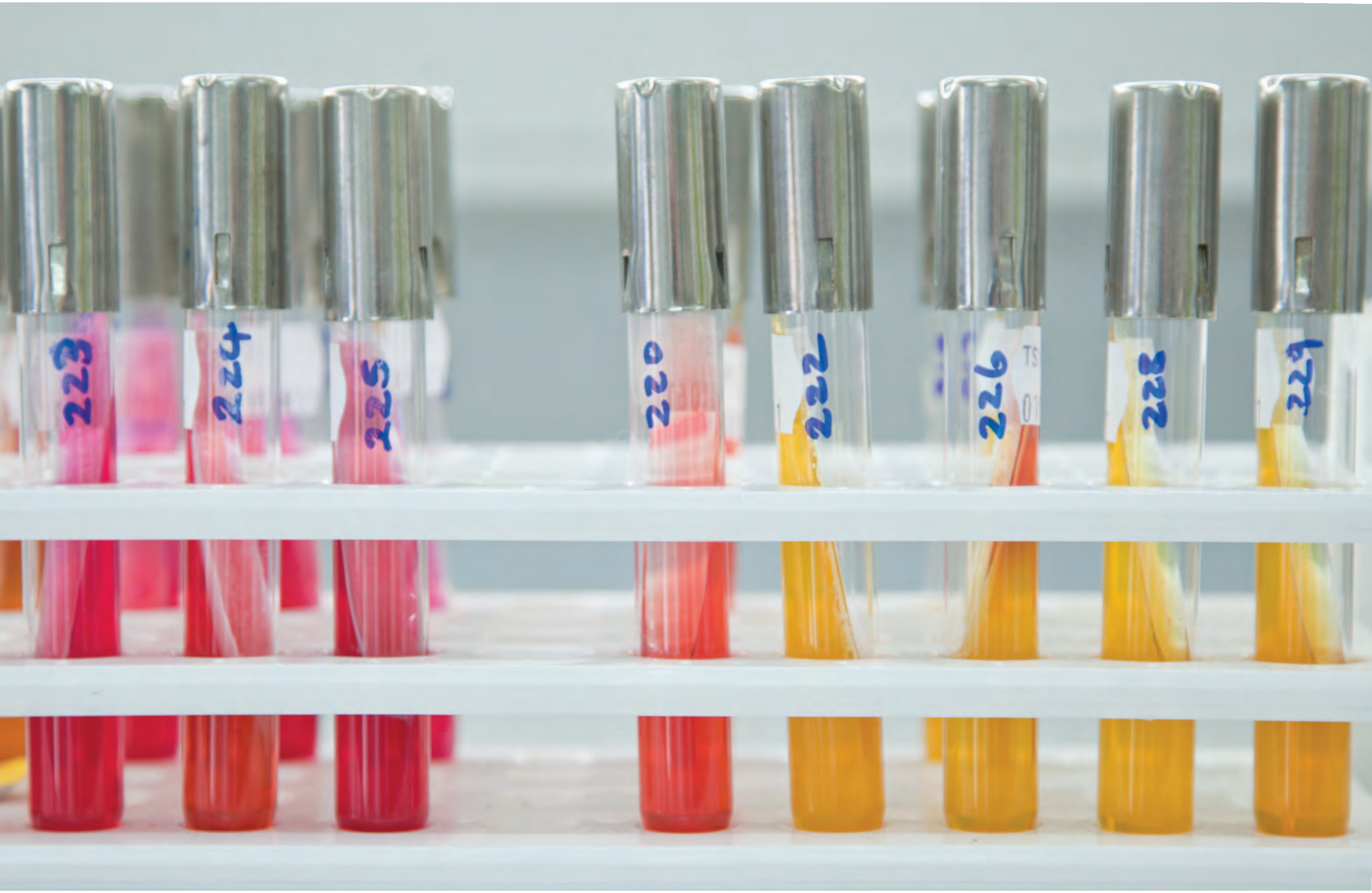
"We also do work for industry clients too. For instance, for Fonterra alone, our environmental radiation laboratory analyses milk powder, and we in the chemistry lab test all sorts of dairy products for export.

The diversity of the work of the Food Chemistry Lab is shown by the work they do analysing wastewater for drugs. "This is a really interesting area ESR is getting into," says Darren. Andrew Chappell, one of our scientists, is becoming an expert in wastewater epidemiology. City wastewater treatment plants have revealed fascinating insights into New Zealanders' use of illicit drugs. ESR has been funded by NZ Police to deliver a drugs in wastewater programme to measure the population use of methamphetamine, cocaine, heroin, alpha PVP and MDMA. Darren says there are countless other discoveries waiting to be made in the burgeoning field of wastewater-based epidemiology. Information about a whole population's exposure to agents and disease can be revealed by picking up signature biomarkers among collective wastewater samples.

Like much of ESR, the food safety programme has learned to adapt to changing circumstances. As the export certification work decreased with a change in the regulatory environment, ESR adapted. Darren says they look for new opportunities such as the work he is doing with investigating natural components and developing tests for authenticating mānuka honey. "We are setting up MPI's method as the lab of reference, and we have looked at other areas expanding on similar chemicals. How do you tell fake mānuka from real mānuka. How do you tell our mānuka from Australia's mānuka?"

"I have also done work on polyphenolic compounds, which have a lot of health benefits. Polyphenols are reducing agents, and together with other dietary reducing agents, such as vitamin C, vitamin E and carotenoids, referred to as antioxidants, they protect the body's tissues against oxidative stress and associated pathologies such as cancers, coronary heart disease and inflammation. A while back, there was an issue with sachets of green tea that were being sold as a weight-loss product. The labelling was a bit deceptive as they were claiming 90% of polyphenols in their product. This was strictly true, but in fact, the majority of polyphenols came from the colour of the berries in the product, not the green tea. When we tested the green tea, we found the polyphenols were only 10%. They would have been better drinking a cup of tea!"

Although Darren is part of the analytical chemistry team, he says there is a quite a lot of cross-over with other parts of ESR. "While we do the chemistry, other parts of ESR do the microbiology and virology and so on. It's great being part of the same group of so many disciplines, it makes the morning tea table quite fun. ESR people all have a job to do, and we come together very well. Everyone pulls their weight – we are all working for the good of people and community."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HEATHER DAVIES

Principal Technician, Health, Kenepuru Science Centre

"It's like being a detective," says Heather, of strain-typing for disease-causing organisms, "investigating the organisms to see how they behave and how they form the picture of the disease burden in New Zealand. I like the typing and data analysis, working out what is happening. You never know what will come in the door tomorrow. There could be a major outbreak of a disease."

Typing has moved from phenotypic to genotypic in the past few years. "We used to do physical-based typing of organisms. Then we could look at their genes. Now, we can do whole-genome sequencing. I can look at the whole genome of a bacteria rather than doing a separate test for each gene, and once it is sequenced, I can look at any part of it. If a different gene becomes important later, I can go back and look at what I already have. I don't have to start again."

Most of Heather's work is in the surveillance of notifiable diseases, looking at the strain an individual patient has in order to determine whether there is a vaccine available for that particular strain. This informs the immediate public health response to an outbreak of a disease.

"We keep a watch over the country to see what strains are circulating and over the world to see if we have any that other countries don't and if we have any that might start causing real problems because they have become more virulent. It is a continuous survey of circulating strains, because these organisms mutate willy nilly. Sometimes, there is a new vaccine that covers a new strain. Then we look at whether an even newer strain is replacing the one the vaccine knocked out."

Heather began in the National Health Institute looking at *E. coli* types in neonates in New Zealand on a Health Research Council grant. She gained a permanent position in the Mycology Laboratory in 1981 and did a New Zealand Certificate of Science in Microbiology in 1982 part-time while working. When the National Health Institute moved to the Kenepuru site in 1982, Heather worked in the Nosocomial Infections Lab, looking at hospital-acquired infections, and then in the Invasive Pathogens Laboratory. She works on meningococcal disease. New Zealand had an epidemic from the early 1990s to the mid-2000s. A vaccine specially targeted for the strain was introduced in 2004 with a national vaccine progamme.

After the epidemic waned, Heather stayed in this lab half-time. The rest of the time, she works in the Special Bacteriology Lab doing diphtheria toxin testing, *Listeria monocytogenes* typing and the identification of other pathogens.

Notifiable diseases that are monitored include meningococcal disease, listeriosis and diphtheria. ESR manages the EpiSurv surveillance system for the Ministry of Health, a national database for Medical Officers of Health. Diseases are notified to the Ministry of Health by the lab or clinician, and ESR typing results are notified, so the results are all in one place.

Heather says the introduction of desktop computers was a major highlight. "There was some high-level computer work done off site by whizz-bang consultants years before we got PCs, but all the surveillance and analysis done at my level was done using handwritten sheets and calculators!

"Our first Laboratory Information Management System was not really a LIMS. We did double entry of everything into separate Paradox databases for which we had one IT person on staff, and we had to get outside consultants to write the programs. One could only do it on weekends, so I had to come to work while she wrote it. We made a huge whiteboard diagram of the algorithm needed for her to develop the data extracts.

"What would take me days to do before I can do in minutes now! But I still have to draw the algorithm onto the whiteboard so the Business Intelligence developers can translate it into code."

Heather was a PSA delegate when ESR was set up, and she has been chair of the Porirua and Greater Wellington branches of the Public Service Association.

HELEN HEFFERNAN

Science Leader, Antimicrobial Reference Laboratory

Helen Heffernan has seen resistance to antibiotics become a major issue in four decades of work in the Antimicrobial Reference Laboratory.

Helen started in the National Health Institute, formed as New Zealand's public health laboratory in the 1950s, in 1975. "We were in an ancient building opposite Wellington Hospital. At first, I was in the lab that checked the quality of medicines. Within two years, I applied for a job in the lab that monitored antimicrobial resistance. I was appointed on condition that I also continued with the medicines testing. Since then, monitoring antibiotic resistance has been the one constant in my work.

"I have seen antibiotic resistance develop as a huge issue. People take antibiotics to combat a bacterial infection, but bacteria have various means of developing resistance to antibiotics. One way is through a mutation in the bacteria's own genes that results in a change in the part of the bacterial cell that the antibiotic acts on and so the antibiotic is no longer effective. Another way is through genes from a resistant bacterium transferring horizontally to another type of bacterium, and that second bacterium becomes resistant."

In the 1970s, resistance was evident, but now it is a serious concern. "People used to worry about it then, but it wasn't a crisis because there were other antibiotics in the tool box. But bacteria have become more resistant, and the options are narrowing. We face the prospect of multi-resistant bacteria for which there is no treatment.

"There are two fascinating exceptions: the two bacterial species that cause meningococcal disease and rheumatic fever are still treatable with penicillin, first discovered by Alexander Fleming in the 1920s. No penicillin resistance has developed in these two bacteria, while other bacteria have accumulated resistance to one antibiotic after another," says Helen.

She also works in the Nosocomial Infections Laboratory, looking at hospital-acquired infections. "We run a specialist typing service for hospitals, investigating outbreaks of infections, trying to track the source and routes of transmission of infections. There is a big overlap between this work and antimicrobial resistance, as many hospital-acquired infections are caused by resistant bacteria."

While hospital and community diagnostic labs do the initial testing that determines whether bugs are resistant or not, ESR's Antimicrobial Reference Laboratory confirms resistances and provides specialist testing.

"But our most important function is the monitoring and surveillance of trends in antimicrobial resistance and detecting new emerging resistances," says Helen. "New Zealand is under constant threat of travellers returning with multi-resistant bugs, especially after being in countries where such bacteria are now common due to less-stringent controls on the use of antibiotics. This surveillance work is what I really like because I am a detailed data person, and it involves setting up various surveillance systems, data collection and analysis, and reporting."

There were no computers when Helen started work, and she now wonders how she and her fellow scientists managed without them. "All data analysis was done manually with great lists and literally counting things up. I jumped on the bandwagon in the early 80s when we had access to the government's mainframe computer for the first time and learned to use data and statistical analysis programs. To access terminals to the mainframe computer, I had to go into a building in Museum Street behind Parliament, where the original Dominion Museum had been. We got the first PC here in the late 1980s.

"Computers were the first leap forward, transforming what we do. The next big leap forward is well under way – the move into genomics. We are now making the move from traditional lab techniques to sequencing the whole genomes of bacteria. That is starting to become the standard. It has been a steep learning curve, but we are now poised to move into the next era," says Helen.

PHIL CARTER

Chief Scientist and Chair of the Strategic Science Team

Phil arrived from Scotland in 2001 and saw the need for rapid upgrading of sequencing capacity and capability. In the past few years, genomics has taken off, and the near future will involve decisions on how to use its amazing potential for ESR's clients, he says.

Phil came to ESR from running a unit doing molecular biology and typing of organisms by DNA sequencing at the University of Aberdeen where he was a lecturer in medical microbiology. "We had three sequencing machines that could do 300 samples a day. ESR, at that time, had one machine and could analyse one sample a day.

"We needed to persuade senior management that this was the way things were going and upgrade our sequencing capability," says Phil. Today, instead of sequencing individual genes, we are using whole genomes to do typing of bacteria. That has been a big move in 16 years – from partial use of sequencing for typing to whole-genome sequencing for the characterisation of organisms.

"In terms of highlights, one was getting a big grant from MBIE around 2003 to look at horizontal gene transfer in the environment. This was around genetically modified organisms and their potential impact on environmental organisms, how genes can move within the environment," says Phil.

"It was a completely new system for me, coming from the United Kingdom where I was used to open applications going to various funding bodies. You would have an idea, develop it, submit it – and it was successful or it was not. In the New Zealand system, there was funding for particular areas of work or aligned with various sectors – such as high-value nutrition, water, food, agriculture and so on. The funding sources were much more limited."

Phil's wife, Fiona Thomson-Carter, had been running the Scottish Reference Laboratory for *Campylobacter* and *E. coli* O157. When the Scottish Office did not renew the contract, she was on the hunt for another job. Says Phil, "She looked on the web and saw there was a position as programme leader at ESR in New Zealand. They interviewed her on the phone, and then we came across for a week and they showed us round all the sites.

"We loved New Zealand when we came for that week. I had been fascinated by what I saw of New Zealand on the telly as a kid: Rotorua mud pools, volcanoes, fiords. One country with so many different landscapes!

"I was in a tenured position at the university, and we had two children, aged six and 10. Fiona said she would love the position, but her husband needed a job in New Zealand too. So they offered me one. It is not often in life that you would be offered a chance to move to the other side of the world – with two such wonderful positions.

When he arrived, Phil helped work out how ESR would invest in the new sequencing technology. He moved from running the sequencing unit to microbiology co-ordinator for the Kenepuru Science Centre reference labs. Here, he watched increasing numbers of organisms being typed by sequencing.

In 2012, he was appointed Chair of the Strategic Science Team, in addition to his co-ordinator role, and in 2015, he became ESR's Chief Scientist.

"We have just seen genomics take off now across all of ESR: food, water, health, forensic. And we are at the beginning of this journey. It is going to be fascinating to see where it goes in terms of human health and ESR's role in that. We have to think about the miniaturisation of sequencers, point of care testing and the amount of data being produced, which has lots of issues around access and storage. Then there are issues of analysing the data. We are producing enormous amounts of data and have to work out how we can analyse it and provide insight and context for our clients," says Phil.


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DAVE DUNCAN

Senior Technician, Enteric Reference Laboratory, Wallaceville

"The future is here," says Dave Duncan, casting back over the different kinds of testing he has used in a career almost as long as ESR. He started as a technician in the Biological Standards Laboratory in 1993 and has worked in the Enteric Reference Laboratory for 23 years, moving from Kenepuru to Wallaceville nine years ago.

When he first started work, he used phenotypic testing – "how the genes of the bacteria express themselves". In the mid-1990s, the polymerase chain reaction meant starting to look at the genes themselves, identifying toxin genes in *E. coli.* Today, the era of whole-genome sequencing has arrived.

This year, the phage typing method – a phage being a virus that infects bacteria – is being superseded by whole-genome sequencing. "Our lab has used this typing method for some *Salmonella* serotypes since at least the 1970s, but the lab in England we got the phages from no longer does phage typing. We have just received the last order of phages we will ever get. So phage typing will be superseded by whole-genome sequencing. The future is here!"

Dave describes his job as "looking at food poisoning bacteria: the ones that give you the runs" – *Salmonella, Shigella*, *Vibrio*, verocytotoxin-producing *E. coli, Yersinia* and *Campylobacter*. They are usually transmitted via the faecal-oral route. Animals can be reservoirs for these bacteria. The bacteria are easily killed by heat, so thorough cooking will kill them. But a classic spread of food poisoning is putting cooked food on a dirty chopping board that has had raw meat on it or using utensils that have been in contact with raw meat.

"We are a national reference laboratory. Isolates of enteric bacteria identified usually to genus level are referred by diagnostic laboratories. We then type the isolates with the aim of looking for isolates that are the same. Information related to a cluster of isolates that are the same is passed on to Health Protection Units.

"So we play a preventive role to help stop more people from becoming infected and therefore stop them ending up in hospital or having time off work and potentially costing the country money."

Looking back to the human culture he found when he started at Kenepuru, Dave remembers that health and safety rules were laxer. "It was OK to hang your lab coat on a hook right outside the tearoom entrance door. Now a lab coat would not get out of the PC2 lab area. And safety glasses were not compulsory in the Enteric Reference Lab.

"IT was one guy. If we had a problem, we would call him and he would come straight round. Before we had Excel spreadsheets, we did annual tables manually. The printer would be on a spool with yellow paper. They were buggers for jumping off the spools. You would print off the year's results, leave the room and come back an hour later and find one line of black.

"You would get a huge printout and manually count the different types of bacteria. Then you would write it in pencil and total it – very slow. If I wrote to a client, I would hand write a letter and pass it to Barbara the secretary, who would type it out nicely and put it on letterhead and it would be posted out. Clients expected an answer back at the end of the week. Now, people send an email and expect an answer within an hour.

"There was a real family feel and lots of traditions when I first started. In the weeks before Christmas, a choir would form and sing carols at a morning tea. A concert followed the Christmas lunch. Every department would do an item, usually a skit, a poem or a song. There was a real pine tree in the foyer, and on the last day before we left for the holidays, we had Christmas cake and a nip of sherry.

The 'leaving morning tea' was another tradition, with a special table cloth kept for these occasions. "The tearoom was set up with a top table where the person who was leaving and others from their department would sit. It was a bit like a wedding reception," says Dave.

SUE HUANG

Science Leader, Director of WHO National Influenza Centre, Wallaceville

When ESR Public Health Physician Don Bandaranayake wrote that Sue Huang, ESR's Science Leader and the Director of the WHO National Influenza Centre, was "the most dedicated, hardworking, knowledgeable and enthusiastic person I have worked with in all my 50 years as a Public Health Medicine practitioner and researcher", he would have been echoing a sentiment many people felt around the world of science and virology.

"I have been working on viruses all my life," says Sue. She came from China to New Zealand in 1995, via the United States, where she completed her doctorate in molecular virology at the University of Pennsylvania. "I completed my master's degree in China on hepatitis B and then my doctorate working on the herpes simplex virus and its molecular mechanism of latency."

In 1998, she joined ESR, heading the Virology Laboratory, a World Health Organization-designated laboratory. "Although we are a relatively small lab, we fulfil quite a few major World Health Organization functions including being the WHO National Influenza Centre and the national reference laboratory for polioviruses, enteroviruses, adenoviruses and arboviruses. Although we don't have vector viruses in New Zealand, we often have people who travel to the Pacific or Australia and who come back with an arbovirus like dengue fever, Ross River or a related illness, so we do need to monitor these." With all the different functions, Sue says, "There is lots happening all in one laboratory."

One of the first things Sue did when she arrived at ESR was to introduce the polymerase chain reaction (PCR) test into her laboratory. This new test was recognised as one of the most important scientific advances of the 20th century. It created a quick, easy way to create unlimited copies of DNA from just one original strand. Millions of copies of a section of DNA can be made in just a few hours. The copied DNA can then be used reliably in a wide variety of tests to diagnose or monitor diseases or for basic molecular biology research. However, in the early days, the PCR was not real time. It involved setting up the gel, then using a DNA probe to make up a hybridisation. Once this is completed, you have to work out from the band what the strain is, so for influenza, whether it is strain A or B. The real-time PCR test cut down the time taken to analyse the strands of DNA and work out the strains from one week for a viral culture to four hours from time of amplification to producing the assay and writing the final report.

For many years, Sue's main interest was in the polio virus. "Globally, we all wanted to eradicate polio from the planet," she says. The WHO's Western Pacific Regional Office, which took in the areas of New Zealand, China, Pacific and Australia – about 47 countries – wanted to certify that the Western Pacific was polio free.

Sue tells the story of a four-month-old baby who was paralysed by acute flaccid paralysis in 1998. The baby had been vaccinated with the oral polio vaccine (OPV), which, in very rare situations (one in two million probability), can cause this condition. The OPV was given to fight against wild polio viruses. A year later, in 1999, a woman who had never been immunised for polio was infected by her baby when she was changing its nappy. The baby had previously been given the OPV vaccination. The woman became paralysed in both arms and legs. Sue says that, although the timing of this, with two cases in a year, was coincidental, it made them wonder if it was now time to stop the OPV for wild polio, which had now all but been eradicated in the Western Pacific. So in 2001, the government made the decision to switch from the OPV to the inactivated polio vaccine (IPV) – essentially a dead virus so a safer version than the OPV, which contains a live virus and that, if it mutates, can cause paralysis.

The WHO was considering the 'end game' question regarding polio and the OPV. What happens when polio is eradicated and you withdraw OPV? How long will OPV persist in the population? New Zealand was the perfect country to answer these questions as it was making the switch from OPV to IPV. With WHO funds, Sue and her team took sewage samples pre-switch to measure the OPV circulation in New Zealand. They also followed hospital patients. Sue's study showed that, when the switch was made to IPV, OPV in the environment decreased very quickly. The big takeout from the study was that, after six months, OPV had completely disappeared from New Zealand.

The outcome of this study was published in the prestigious *The Lancet* journal, and accolades followed, with *The Lancet* editorial commending it as an excellent study. The New Zealand study was repeated in a number of other countries, which came up with the same result. Sue was invited to be an adviser to some of these countries, along with advising the WHO advisory panel for polio eradication. The decision was made to co-ordinate a global withdrawal of the OPV vaccination in 2002. This strategy was used in 2016 for the eradication of polio 2.

In 2009, the influenza pandemic, known informally as swine flu, hit globally. This was the second of two pandemics involving the H1N1 influenza virus (the first being the 1918 flu pandemic), albeit in a new version. First described in April 2009, the virus appeared to be a new strain of H1N1, which resulted when a previous triple reassortment of bird, swine and human flu viruses further combined with a European pig flu virus, leading to the term swine flu.

Initially called an outbreak, widespread H1N1 infection was first recognised in Veracruz, Mexico, with evidence that the virus had been present for months before it was officially called a pandemic. The Mexican Government closed most of Mexico City's public and private facilities in an attempt to contain the spread of the virus. However, it continued to spread globally, and clinics in some areas were overwhelmed by infected people.

Sue remembers she was in Geneva for a WHO meeting when they became aware it was a pandemic. "We had a group of school children coming back from Mexico, and one of my colleagues from America asked me if I thought they could bring the flu pandemic to New Zealand. I said, 'I don't think so.' I always assumed we were too far away on the globe and we would get it much later. But it only took a few hours for it to come to New Zealand. The students arrived back Friday, and on Saturday, they went to their GPs because they felt unwell. The GP had seen the story that something strange was happening in Mexico so he called the health authorities and they took immediate action. They quarantined the children and took samples and sent them to us. Of course, we didn't have an assay for H1N1 yet, and we worked with the Australian collaborators who had a good test for it. We quickly realised it was the influenza A pandemic flu. Imagine if that GP had not acted so quickly? The students would have had gone to school, and the flu would have spread through New Zealand like wildfire."

Sue says that the decision of Chief Executive John Hay to build a purpose-built centre that could cope with emerging pandemic viruses was very fortunate. "John Hay was a man of vision. He foresaw that, given SARS in 2003 and the bird flu in 2005, we would need a facility that would enable us to cope with high-risk pathogens and respond to health emergencies."

The National Centre for Biosecurity and Infectious Disease (NCBID) was opened in 2008 at Wallaceville in Upper Hutt. It was a collaboration with MPI and AgResearch, among others. Its purpose was to be able to respond to an emerging heath crisis. NCBID had access to a high-containment PC3 facility that would protect workers and protect the environment. "When you have a pandemic," Sue says, "you don't really know the likelihood of the consequences and what damage it could cause the community. You need to contain it as much as possible, and that is what NCBID was about."

Then one year after NCBID opened, the 2009 flu pandemic struck. "The timing was impeccable," says Sue. "Collaboration with MPI was the key. The group of microbiologists, virologists and technical staff out there meant we share resource in an emergency response. Our response to the pandemic was one of the best in the world. Our flu surveillance system is able to give one complete national picture, whereas somewhere like Australia, with each state having their own different system, means it is very difficult to get a national picture of what is happening."

Sue says that the United States keeps a close eye on what is happening in the New Zealand flu season. "The pandemic happened in April in the USA then moved to New Zealand in June, and I remember the Centers for Disease Control and Prevention in the United States reading our flu reports to see what was happening here." In 2010, Sue 's good friend and collaborator Richard Webby, a New Zealand researcher working at St Jude Children's Hospital in the United States, sent an email to her around Christmas time. Sue says, "I didn't even open it until after Christmas. His email said, 'This is a very good opportunity. I think it would be good for New Zealand.' And that is how we got into SHIVERS – the Southern Hemisphere Influenza and Vaccine Effectiveness Research and Surveillance project."

Sue assembled a team of people who had been long-time collaborators from places like the Universities of Auckland and Otago, Auckland District Health Board, Counties Manukau District Health Board and St Jude to name a few. "We applied to the US Department of Health and Human Services, through the Centers for Disease Control and Prevention, and our proposal had what they needed, so despite the international competition, we were successful. I think it was because New Zealand has a very good public health infrastructure, our NHI numbers link us from primary care to hospitals to laboratories – and that gives us a rich data set – plus all laboratories in New Zealand do PCR, so our study scored highly."

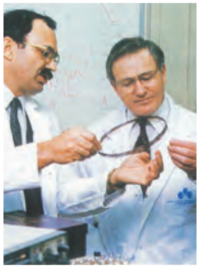
SHIVERS evaluated influenza and other respiratory diseases in the Southern Hemisphere. As the largest and most comprehensive influenza research project ever undertaken, at a cost of $9 million over five years, it gained a lot of attention both at home and internationally. Dr Wayne Mapp, then Minister for Science and Innovation, said the successful bid was international recognition of the quality of the New Zealand scientists working in this area. "We have a glimpse at just how good the New Zealand teams are during the response to the swine flu pandemic in 2009, and this is an opportunity to make even greater advances in flu planning," he said.

The aim of the project was to better understand influenza and other respiratory viruses and related illness in the hope of curbing future outbreaks and pandemics. This multi-agency and multi-disciplinary collaboration drew national and international experts from different disciplines (virology, epidemiology, immunology, infectious diseases), which resulted in innovative approaches synthesising cross-cutting and novel scientific outcomes that demonstrated value through high-quality outputs and publications. SHIVERS resulted in international and domestic changes in the way public health authorities prepare for, identify and respond to one of the highest-impact diseases in human health. The research challenged existing paradigms in the field and changed the way influenza is managed now and in the future, both in New Zealand and globally. The results guided improved methods for disease surveillance, improved clinical case management and laboratory diagnosis, informed vaccine strain selection and vaccine development, guided targeted vaccination strategies for populations and subgroups and identified better immune diagnostic markers of host immune responses.

Sue says that the project has not yet ended, and the SHIVERS legacy has spawned a number of other studies, including the SHIVERS-II study that will help better understand the immunity or protection people have against the flu through infection or vaccination. Findings will help the New Zealand Government make choices about what and when it is best to recommend when people get their current flu vaccinations. The study will also provide information that can be used to make better flu vaccines in the future.

As if she does not have enough accolades to her bow, Sue has also been a member of the Australian Influenza Vaccine Committee for the last 20 years. “I am part of the group that makes recommendations for New Zealand about what strains of flu should be included in the vaccine each year. Along with South Africa and Australia, we discuss our epidemiology and virology and make our own recommendations about which vaccine strains are to be used for the following year. This is because sometimes the WHO recommendation may or may not be adopted as it is necessary for individual countries to approve the specific vaccine strains to be used.”

Looking back on her career, Sue says that she feels the team at ESR have made a contribution to New Zealand. “That is what ESR is here for – we are about working for the public good, and through our research, we can make a real difference to people’s health.”



1992

- DSIR is disestablished
- 10 Crown Research Institutes established including Institute of Environmental Health and Forensic Sciences Limited, later renamed ESR

1993

- Prime Minister Jim Bolger visits the Gracefield laboratories
- Five business units set up: Public Health, Food and Water, Environmental Consulting, Environmental Analysis and Forensic Science
- New Zealand's first outbreak of poisoning from toxic shellfish
- DNA evidence used to identify a murderer, who was the 400th person to be DNA tested from 450 suspects
- ESR identifies Christchurch smog sources as coming mainly from domestic fires rather than factories and industrial plants

1994

- School-based rheumatic fever programme begins (early detection of streptococci from throat swabs)
- Water Information New Zealand (WINZ) integrated drinking-water quality database established

1995

- National DNA Databank (second in the world after the UK) established for crime solving in New Zealand
- First-generation STR (short tandem repeat) DNA profiling implemented for forensic casework
- Drinking-water standards adopted on 1 January
- EpiSurv, ESR's electronic notifiable disease surveillance database, goes on stream
- ESR and University of Auckland develop postgraduate course in forensic science

1996

- Public Health Commission disestablished on 1 July, and the Ministry of Health confirms ESR as its preferred provider of core scientific services
- Forensic labs earn ASCLD/LAB (American Society of Crime Laboratory Directors/Laboratory Accreditation Board) accreditation
- Mt Ruapehu erupts, and ESR leads water-quality testing
- Nationwide drug testing of jockeys undertaken
- Landfill gas emissions tested for methane
- ESR's wine-testing laboratory tests and certifies products for export

1997

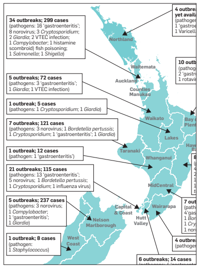
- Research establishes guidelines for safe and productive uses for sewage sludge
- Research into meningococcal risk factors begins
- New building for ESR at Mount Albert Science Centre
- ESR tracks the rise of antibiotic-resistant bacteria
- Major rheumatic fever research project under way
- Specially trained squad set up to dismantle clan labs
- New techniques used to pinpoint viruses responsible for food-related gastroenteritis
- Heroin from Thailand found in picture blocks

1998

- DNA crime sample database established
- ESR applied epidemiology course rolled out
- ESR invited by WHO to advise on streptococcal disease
- Prison inmate drug-testing programme begins
- ESR identifies source of *Cryptosporidium* outbreak in public swimming pools
- Review undertaken of microbiological standards for food safety
- New toxin in algal bloom in Wellington Harbour identified by ESR
- First successful match between crime scene DNA and the offender databank

1999

- Corporate Office and parts of Gracefield operation complete shift to KSC
- Meningococcal epidemic
- Marketing office opens in Melbourne
- The first case using the DNA Profile Databank 'Operation Sundown' is solved
- Three Principal Scientists appointed: John Buckleton, Murray Close, Tom Speir (joining Diana Martin and Michael Bates)
- Ministerial Inquiry under way to provide independent reassurance of the integrity of forensic DNA technology
- ESR website launched
- Amalgam dental filling research under way



2000

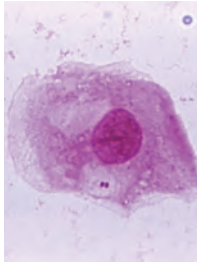
- EpiSurv surveillance reveals whooping cough epidemic
- Three-year New Zealand Total Diet Survey for the Ministry of Health completed
- Detection of human caliciviruses (Norwalk-like viruses) in oysters
- New methods to detect marine biotoxins
- 16S RRNA sequencing introduced to Culture Collection Laboratory
- Remaining Gracefield groups transfer to KSC
- ESR employs two social scientists, Jeff Foote and Virginia Baker, laying the foundation for the current Social Systems team

2001

- Cold case solved using improved DNA technology – a minute sample from the Teresa Cormack case was able to be profiled, and 15 years after the six-year-old's death, Police arrest Jules Mikus for her murder
- Report on risk factors of meningococcal disease released
- ESR completes four-year study on pesticides in human breast milk
- ESR establishes system of active disease outbreak surveillance
- Disease modelling work undertaken for hepatitis C infections in New Zealand
- Liquid chromatography mass spectrometry and cell-based assay methods used for shellfish testing

2002

- Prime Minister Helen Clark opens new forensic DNA laboratory in Auckland
- Work begins on a nationwide study of *Salmonella* gastroenteritis
- National DNA Databank reaches 25,000 convicted offender or volunteer DNA profiles
- ESR scholarships available to Ngāti Whātua, Ngāti Toa and Ngāi Tahu
- ESR contributes to development of meningococcal vaccine
- ESR uses advancements in biosensors to track land contaminants
- ESR and Ministry of Health's New Zealand Public Health Observatory online tool goes live



2003

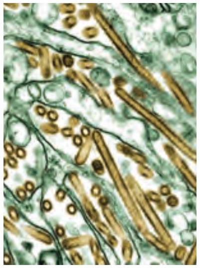
- ESR commended for its role in the SARS virus outbreak
- Workplace Drug Testing group continues to grow its customer base
- ESR's Clan Lab team deals with a 143% increase in illicit labs manufacturing methamphetamine
- ESR commissioned to investigate human exposure of contaminants at Paritutu
- ESR collaborates with Whirinaki community on drinking-water solutions for isolated communities

2004

- ESR staff provide forensic expertise to Thailand after Boxing Day tsunami
- ESR's forensic chemists play role in huge P bust in Fiji
- ESR discovers lead-contaminated baby custard during New Zealand Total Diet Survey
- ESR facilitates public workshops on revisions to drinking-water standards

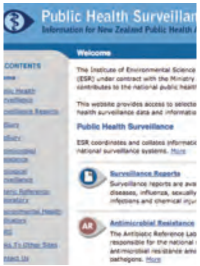
2005

- Malaysian Police purchases ESR-developed DNA databank system
- ESR begins work on investigating nitrate levels in groundwater
- ESR begins research with Te Iwi O Rakaipaaka on high rates of disease in the community



2006

- ESR responds to the global spread of H5N1 (bird flu)
- Low copy number DNA testing introduced into forensic casework
- Ngāpuhi welcomes final ESR report on contamination of its local shellfish beds
- ESR secures its first-ever Marsden Fund Grant to look at viral contamination of drinking-water wells
- ESR runs more than 150 workplace safety workshops for companies on effects of drugs and alcohol



2007

- Familial DNA testing introduced
- Launch of SurvINZ – integrated surveillance platform
- First royalty cheque received from ZyGEM (DNA extraction product)
- ESR invests in chemical, biological, radiological and explosive (CBRE) science
- ESR involved in two national pandemic response test exercises
- Development of PulseNet Asia/Pacific portal under way to support microbiological research in the region

2008

- ESR opens new science facility at the National Centre for Biosecurity and Infectious Disease (NCBID)
- ESR's didymo samples database launches
- ESR organises nationwide workshops for investigators and medical professionals on sexual assaults
- Results from three-year study on the effects of heavy rainfall on drinking-water contamination released
- ESR involved with five food safety programmes with the European Commission

2009

- ESR's Virus Hunters team established
- ESR responds to global H1N1 influenza pandemic
- Comprehensive drug-driving testing commences
- 100,000th individual profile loaded to the National DNA Database
- Familial DNA testing leads to a conviction in Marie Jamieson murder
- ESR's Marsden-funded study gives insight into spread of viruses in groundwater

2010

- ESR monitoring notes a dramatic increase in MRSA bacteria in the community
- ESR marks 20 years of DNA in the criminal justice system
- ESR science contributes to New Zealand Food Safety Authority's advice on energy drink consumption
- Survey results of pathogens found in fruit and vegetables released
- ESR enhances its testing and surveillance of antimicrobial resistance
- ESR identifies undeclared medicines in 'herbal' erectile dysfunction products

2011

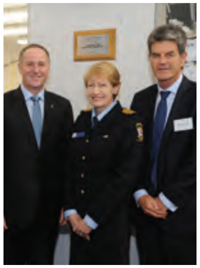
- ESR's forensic, health and environmental staff respond to Canterbury earthquake
- Official opening of refurbished laboratories at KSC by Minister Tony Ryall
- ESR's social scientists review opioid substitution treatments in New Zealand
- World-leading RNA analysis transferred from research to operational use
- Training programmes on blood splatter analysis delivered to USA forensic agencies
- Roll-out of a consolidated LIMS platform
- ESR acquires the National Radiation Laboratory

2012

- SHIVERS project launches to understand flu virus in New Zealand
- STRmix™ first implemented in case work (ESR and FSSA)
- ESR begins drug testing for Alcohol and Other Drug Treatment Court
- New USA legislation calls for 'Super 7' *E. coli* testing, which ESR provides
- ESR identifies new variant of norovirus circulating in New Zealand
- Centre for Integrated Biowaste Research established
- Virtual walk-through of crime scene piloted at Rotorua homicide trial

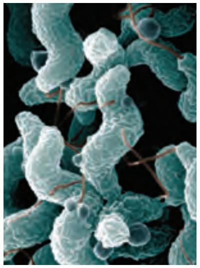
2013

- Strategic Science Team established
- Fund established to explore new ideas
- HAIFA project delivers proof of concept for health impacts from climate change
- Two ESR scientists appointed by the International Atomic Energy Agency as co-ordinators in Asia/Pacific



2014

- Joint Customs/ESR Drug Screening lab opens at Auckland Airport
- STRmix™ first commercial release
- ESR responds to infant formula 1080 contamination threat
- Launch of STECleanz™ for protecting meat exports
- ESR responds to New Zealand's biggest outbreak of *Yersinia pseudotuberculosis*
- ESR's Radiation Training Institute established
- New firearms testing laboratory opens at MASC
- ESR becomes member of FoodHQ, an international collaboration on food research

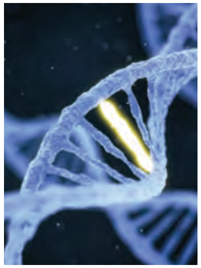


2015

- Five-yearly New Zealand Total Diet Survey commenced
- ESR hosts international conference on *Campylobacter*
- ESR's science is behind launch of two guidelines to support Tonga's tourism sector
- ESR selected to assess effectiveness of family violence preventions
- IANZ accreditation given to testing for species found in meat products

2016

- ESR plays key part in emergency response to Zika virus outbreak
- *Forensics NZ* documentary series goes to air
- ESR completes comprehensive summary of antibiotic consumption in New Zealand
- 'Making services reachable' project to support social services launched
- Dr Michael Taylor becomes the first New Zealander to be named Distinguished Member of the International Association of Bloodstain Pattern Analysis
- ESR assists with response to hepatitis A associated with frozen berries



2017

- Havelock North drinking water contamination response
- Drug testing in wastewater research
- Memorandum of arrangement signed between ESR and the Chinese Research Academy of Environmental Sciences
- Bioreactors for removal of nitrates from drainage water research gets under way in Canterbury
- Forensic intelligence project established to gain insights into sexual violence cases
- ESR celebrates 25 years

Acknowledgements
The following sources have been used in the writing of this book:

- Interviews with staff members.
- ESR annual reports 1992–2017.
- ESR briefings 1992–2011.
- *Delivering a science business: how ESR, a provider of specialist scientific services, manages its relationships with clients and develops a viable business;* Anne French and Richard Norman; Innovation Case Studies; Victoria University of Wellington through Victoria Link, 1999.

ESR would like to thank all staff members, past and present, who have contributed to this book.

Further e-publications are under way that will record the history of the different areas in which ESR works – these include forensic science, infectious disease, health surveillance, water management and environmental health, forensic toxicology and pharmaceuticals.

This book was written by ESR Senior Communications Advisor Nicola McFaull.

Design and artwork by ESR Senior Graphic Designer Jenny Ralston.

E/S/R