Origin Energy NZ Ltd

Rimu Pipeline Leak, October 2010: Cause, Remediation and Learning Points

May 2011
Doc # 864029

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1. Introduction

1.1 In October 2010 an estimated 200-500 litres of well stream fluid, namely produced oil and water, was found to have leaked into an unnamed tributary of the Manawapou River, with a visibly affected area reaching 80 m downstream from the discharge point. The spill was noticed by a local farmer.

1.2 The unauthorised discharge was sourced to a 100 mm (4 inch diameter) NB pipeline operated by Origin Energy Resources New Zealand (OENZ) connecting the Rimu A wellsite to the Rimu Production Station (RPS).

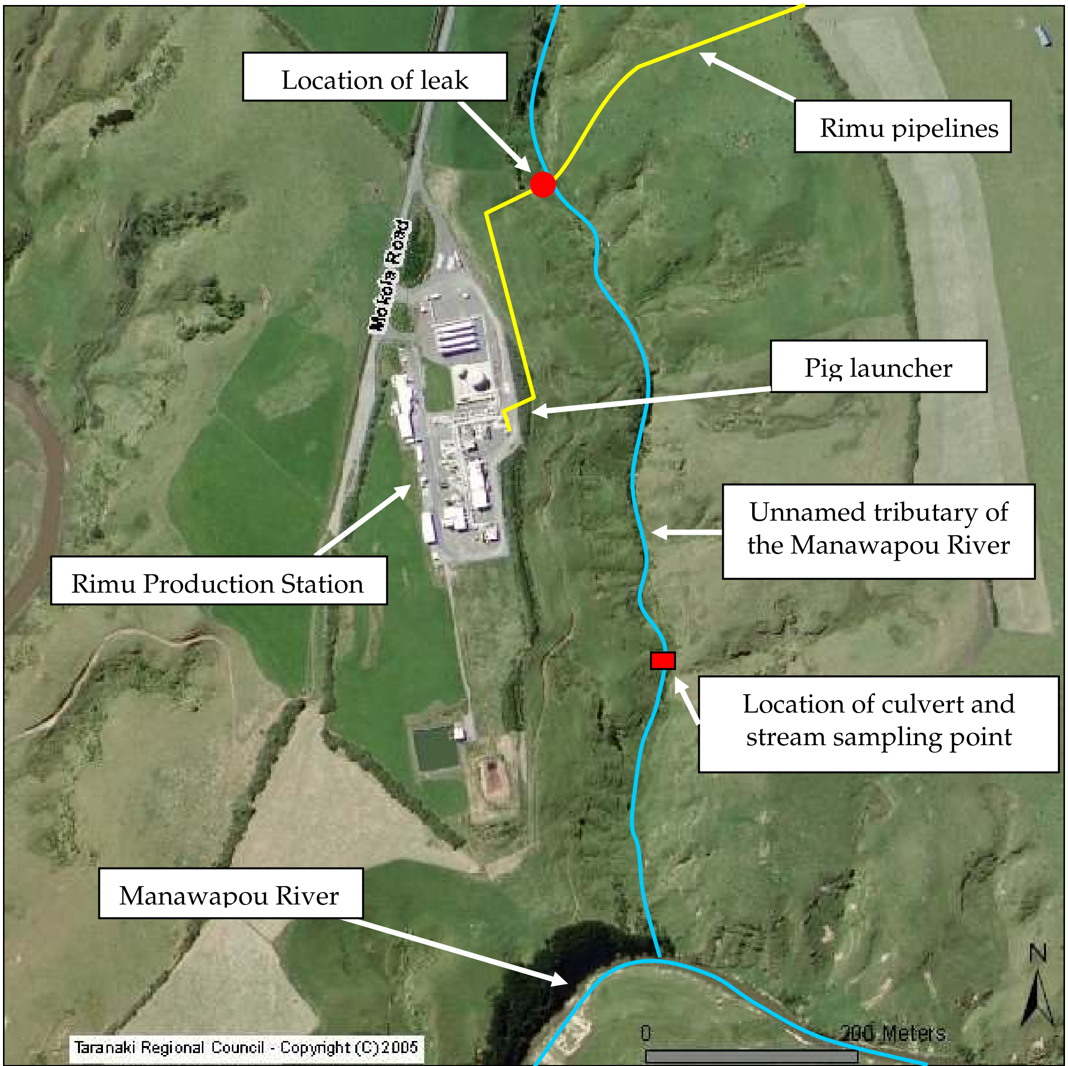


Figure 1 *Rimu A pipeline and leak location*

1.3 This report covers the clean-up response and investigation process associated with the pipeline leak from 8 October 2010 when the leak was initially reported. Details of the leak and the Council's response, inspection details, and environmental effects are provided.

1.4 Section 2 describes the leak. Section 3 sets out the sequence of oil spill response events and section 4 summarises the response and clean-up. Section 5 outlines the results of chemical and biological monitoring undertaken. Section 6 assesses the pipeline failure and Section 7 sets out the regulatory requirements for Origin. The pipeline failure incident is assessed in section 8 and learning points for the industry are provided. Finally, section 10 provides conclusions.

1.6 It was agreed with OENZ that the learning points from the incident would be recorded in this report and shared with the oil and gas industry.

1.7 The leak was a Type Two leak under the OENZ Production Station and Pipeline Spill Contingency Plan. The leak also instigated the 'OENZ Emergency Response Plan' and an emergency response team was formed.

2. Leak

2.1 The leak occurred in a valley bottom and discharged into an unnamed tributary of the Manawapou River located at the end of Mokoia Road, beside the RPS. The property is owned and farmed as a dairy unit by Mr Mark Hawken.

Photograph 1 – Affected area of the unnamed tributary - 8 October 2010

2.2 The pipeline was installed in August 2001 and came into commission in April 2002, so was only 9 years old at the time of the leak. This type of leak is a rare occurrence in industry terms and has never been experienced by OENZ.

2.3 The unauthorised discharge was found to have a waxy consistency due to the nature of the oil and a melting point of around 18°C. Exposure to ambient temperatures meant the oil solidified and settled in the bottom of the stream. This discharge included produced water and hydrocarbons, the exact ratio of each is unknown.

2.4 OENZ received notification of the leak from a farming neighbour to the site, David Steele, on Friday 8 October 2010. The 'OENZ Production Station and Pipeline Spill Contingency Plan' was immediately put into action and an emergency response team formed. Notification was received by the TRC at 2.02 pm with immediate inspection and advice about the clean-up sought by OENZ.

2.5 After discovery of the leak OENZ mobilised a cleanup crew, machinery and equipment. Spill booms and hay bales were put in place to contain the spill and the Oscar unit from the Port Taranaki storage site was also mobilised.

2.6 Mr Steele first noticed an irregularity with the unnamed tributary a week prior but assumed it to be discolouration due to heavy rainfall until viewing it again on the 8th October.

2.7 The leak was notified to Ngati Ruanui Iwi, under the OENZ spill notification procedure, at 4.10 pm on 8th October so there was no need for the Council to notify the Iwi as is the usual case for incidents with environmental effects.

2.8 The Vector flyover pipeline inspection on the 14th September 2010 did not observe anything of concern along the pipeline easement, so it can be assumed the leak started approximately between 14th September and 8th October.

2.9 Immediately after the leak was discovered, three pipelines located in an easement, close to the leak point, were depressurised and use suspended. Two carbon steel 'Insapipe' pipelines: a 100 NB oil/produced water/gas line and a 200 NB gas line; and a polyethylene yellow jacket 50 NB gas line.

2.10 Pressure in the pipeline was around normal levels so the leak was undetected by the Wellhead Safety System. This system senses the flow line pressure and shuts down the wellhead under abnormal pressure conditions that imply a leak has occurred.

2.11 During the initial inspection the first priority was to establish the extent of the contamination and to contain contaminants that had leaked. The next priorities for OENZ staff were to continue containment, and undertake stream clean-up, water monitoring and sampling. Clean-up operations commenced immediately and continued over the following two weeks. During this time excavation around the leak location commenced so that the leak point could be determined, examined, and repaired.

2.12 The quick response by OENZ to shut the pipeline down and contain the contaminants minimised downstream contamination. Hay bales and absorbent spill booms were immediately deployed to contain the contaminants, limiting adverse effects on the ecology and aesthetics of the stream and preventing the discharge from entering the Manawapou River.

3. Sequence of Oil Leak Response Events

3.1 The following is a detailed account of the spill response from the initial notification up to the reinstatement of the Rimu A 100 NB pipeline.

Friday 8 October 2010 – Day 1

3.2 The TRC received notification at 2.02pm, from OENZ Community Stakeholder Manager Anthony Joines, that a pipeline had leaked between the Rimu A wellsite and the Rimu Production Station (RPS).

3.3 Investigating Officer Tim Payne and Compliance Manager Bruce Pope responded and arrived on-site at approximately 2.40pm, both showed their warrants and signed in at the RPS control room.

3.4 Mr Payne and Mr Pope inspected the site with OENZ staff and suggested the installation of additional primary and secondary containment points and the use of associated oil spill response and containment equipment.

Photograph 2 – *Inspecting the affected area - 8 October 2010. Pipeline leakage point upslope of white sheet*

3.5 Mr Payne and Mr Pope attended a briefing and teleconference with the OENZ Emergency Response Team at 4.00pm. During this briefing it was noted that the TRC staff needed to undertake daily inspections to monitor clean-up, remediation and environmental effects. Anthony Joines noted there was no problem with the TRC staff inspecting at any time and being involved in the clean-up. It was also noted that all the staff time associated with monitoring and reporting on the incident would be charged to OENZ.

3.6 Investigating Officer Rik Caskey arrived on-site at 4.15pm and attended a briefing with Mr Payne, Mr Pope and OENZ staff.

3.7 Mr Caskey was introduced to Mr Joines and they inspected the discharge point and also along the affected unnamed tributary. Further hay bales were installed in the tributary, to filter out contaminants, during Mr Caskey's inspection.

3.8 Photographs of the area were taken by Mr Caskey.

Photograph 3 – *Discharge appearing in a wax like form - 8 October 2010*

3.9 Mr Pope and Mr Payne inspected the lower reaches of the tributary and the Manawapou River. Booms and hay bales were installed in the unnamed stream to contain contaminants.

3.10 Samples and photographs were taken at the site.

3.11 Inspection Notice No.U210733410 was issued by Mr Payne.

Saturday 9 October – Day 2

3.12 Mr Pope called Scientific Officer Bart Jansma at 7.16am and arranged for Mr Jansma to carry out a biological survey of the affected unnamed stream.

3.13 Mr Payne arrived at the TRC office at 8.30am and logged samples into the laboratory with Laboratory Supervisor John Williams at 9.00am.

3.14 Mr Payne and Mr Jansma arrived at RPS at 10.00am, showed warrants and signed in. They inspected the containment points and Mr Payne assisted Mr Jansma with the biological survey.

3.15 Mr Payne took photographs and samples at the site.

3.16 Mr Pope arrived on-site at 1.30pm and inspected downstream of the discharge point to the culvert (Figure 1).

3.17 Mr Pope took photographs and videos of the area and then spoke with Anthony Joines on the phone.

3.18 Mr Pope and Mr Payne observed the stream clean-up by OENZ staff shovelling crude oil into manure bags, and then inspected the lower reaches of the tributary and the Manawapou River.

Photograph 4 – *Manual clean-up of oil spill - 9 October 2010*

3.19 Inspection Notice No.U210834069 was issued by Tim Payne.

Sunday 10 October 2010 – Day 3

3.20 Mr Payne at approximately 8.30am undertook an upstream survey from the Manawapou River mouth to the confluence with the affected unnamed tributary.

3.21 Mr Payne arrived at the RPS at approximately 10.00am, presented his warrant and inspected the clean-up operations and containment points. He undertook a sampling round at approximately 10.20am and took photographs.

3.22 Mr Joines phoned Mr Pope at approximately 11.00am to update him on the spill containment and recovery operation.

3.23 Mr Payne and Mr Pope arrived at Mr Hawken's property at approximately 12.00pm and inspected the clean-up operations and containment points. Mr Payne and Mr Pope also inspected the lower reaches of the unnamed tributary and the Manawapou River, leaving the site at approximately 3.00pm. Mr Pope's warrant was displayed at the commencement of the inspection.

3.24 Inspection Notice No.U210929414 was issued by Tim Payne.

Monday 11 October – Day 4

3.25 Tim Payne arrived at the RPS at approximately 9.00am and showed his warrant.

3.26 Mr Payne inspected the containment points and recovery operations undertaken. Mr Payne was accompanied at this inspection by Michael Oakes (OENZ), Mr Joines and other OENZ staff members.

3.27 No further activity by the clean-up team was being undertaken at this time.

3.28 Mr Payne left the site at 12.00pm.

3.29 Inspection Notice No.U211030622 was issued by Mr Payne.

3.30 Mr Pope and Mr Payne sorted photographs and reported to the Director - Resource Management Mr McLay and the Chief Executive Basil Chamberlain and updated Senior Information Officer Rusty Ritchie on the situation for any possible media liaison.

3.31 Mr Pope and Mr McLay arrived at the RPS at approximately 1.30pm, signed in and showed their warrants at the control room.

3.32 A meeting was held with Mr Pope, Mr McLay, Mr Joines and production staff. OENZ staff were updated on the progress of the clean-up and informed of future intended remediation works.

3.33 Mr Pope and Mr McLay advised that early observations had shown the discharge from the pipeline had solidified when it reached the ambient temperature in the environment. This caused it to settle on the bed of the stream, preventing the discharge from effecting more than 160m of stream down to the confluence with the Manawapou River.

3.34 It was agreed that initial quantity estimates were between 400-500 litres, however Mr Joines had explained that about 5 m^3 (5 tonnes) of oil and soil had already been removed from the stream bed.

3.35 OENZ discussed their intension to construct an earth bund downstream of the discharge with a culvert pipe which could be blocked off. The stream would then be diverted around the work area to allow machinery to work in the bed of the stream and remove all contaminants. Mr Pope suggested that the earth bund should include a skimmer (gooseneck) pipe which, in the event of the culvert being blocked off during a significant discharge at time of pipeline excavation, would allow water to flow through (keeping the stream flowing) but retain all hydrocarbons both on the surface and on the bed of the stream.

3.36 It was noted the TRC would need to be contacted before any earthworks took place and that the TRC needed to be present during the exposure of the pipeline and stream diversion.

3.37 An inspection was then undertaken by Mr McLay, Mr Pope and Mr Joines and it was observed that OENZ staff were in the stream undertaking further clean-up with shovels, recovering crude oil and placing it in plastic rubbish bags. This was then placed into fertilizer bags which were stored away from the stream and were to be removed when site access was safe. The area was slippery as a result of recent rain and was steep, limiting access.

3.38 A number of containment points were established below the discharge point with the primary containment point being at the culvert about 400 m below the discharge point (Figure 2). Photographs were taken.

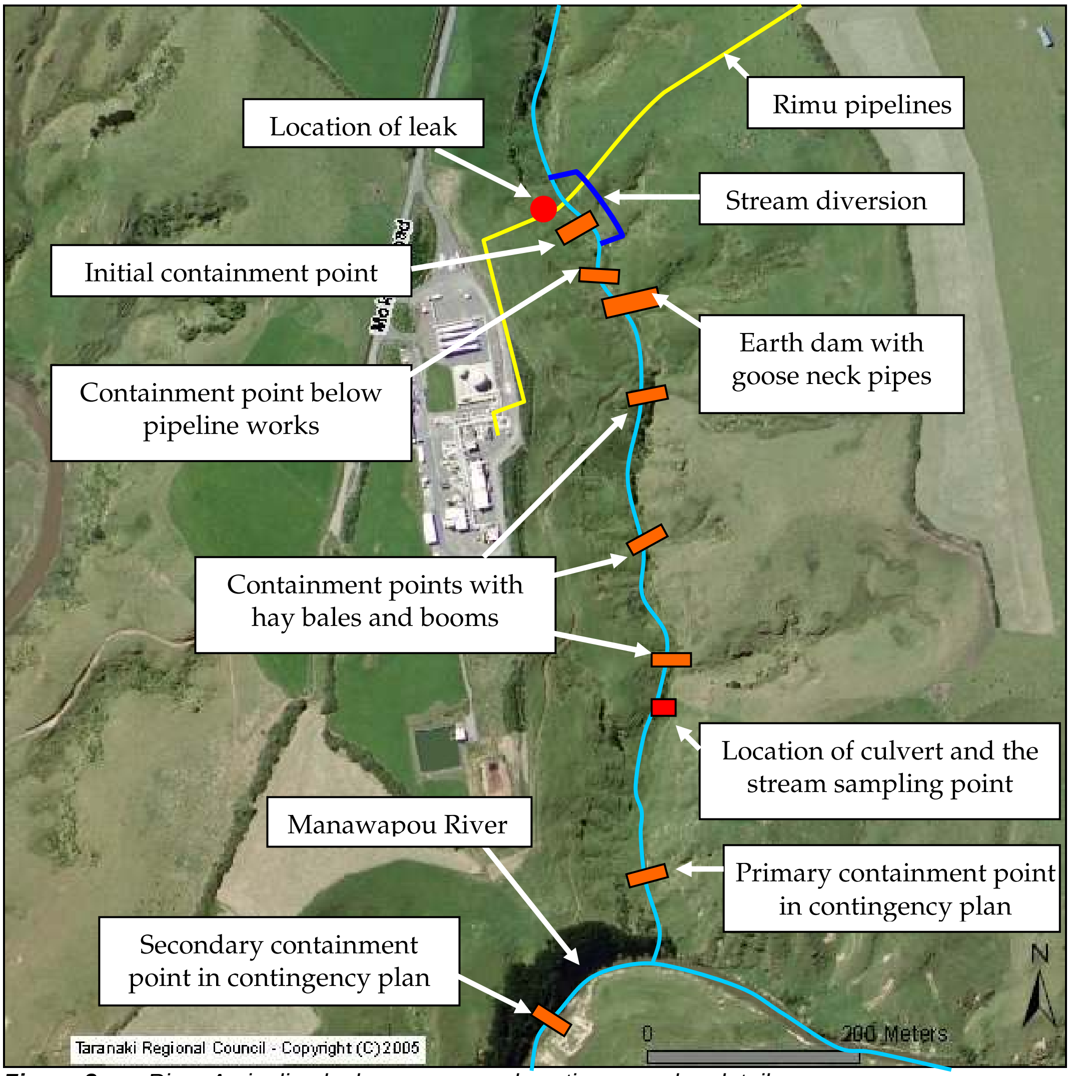


Figure 2 *Rimu A pipeline leak response and contingency plan details*

3.39 Observations and photographs show that floating hydrocarbons, caused by the disturbance of the streambed during recovery of the crude oil, were being contained in the absorbent booms placed in front of the hay bales. This provides evidence that this method of containment was effective.

3.40 Results from samples taken below the primary containment point show that up to 5 ppm of hydrocarbons were being found at this point, at least 10 ppm below the limit of OENZ's resource consent conditions for the discharge of stormwater from the RPS site.

3.41 Mr Pope questioned the amount of time taken to access the site with machinery. Mr Joines informed that health and safety reasons prevented them from doing so, given the wet land surface and steepness of the site.

3.42 Mr Pope and Mr McLay left the site at approximately 3.30pm.

Tuesday 12 October 2010 – Day 5

3.43 A briefing was held at the TRC between Mr Pope, Mr Payne and Mr Caskey.

3.44 Mr Caskey and Investigating Officer, Glen Candy arrived at RPS and showed their warrants.

3.45 A meeting was held with John Carthew (Core Group- engaged by OENZ to manage pipeline inspection and repair works), Jason Sole (BTW- site cleanup), John Chard and Rex Prestidge (OENZ RPS superintendents). During discussions they were informed that the Oil Spill Containment and Recovery (OSCAR) unit was now on site. The boom was on the hill above the Manawapou River ready for use, tracks were being established on the north side of the unnamed tributary to remove the recovered contaminated soil/oil and the absorbent booms in the tributary had been replaced. Discussions were also held about the possible further clean-up actions to be undertaken.

3.46 Mr Caskey and Mr Candy inspected the unnamed tributary from the discharge point to the confluence with the Manawapou River. Containment points had been set up in the tributary.

Photograph 5 *– Hay bales and absorbent booms at one of the containment points (Figure 2) - 12 October 2010*

3.47 Construction of a lined pit for contaminated soil was being undertaken at the time of inspection.

3.48 Photographs were taken.

3.49 Mr Caskey and Mr Candy left the site at approximately 2.15pm.

3.50 Inspection Notice No.M211131647 was issued by Mr Caskey.

3.51 Technical Officer/Administration Assistant Amy Cameron loaded the incident and prepared spill timeline report.

3.52 Mr Payne received a call from OENZ Environmental Advisor Josie Hannon at approximately 6.30pm who outlined the actions planned for the following day and forwarded the information by email to Mr Payne.

Wednesday 13 October 2010 – Day 6

3.53 A briefing was held at the TRC at 8.15am between Mr Pope, Mr Payne, Mr Caskey and Administrative Officer Flo Blyde.

3.54 Mr Payne issued Emergency Works No.U211127588 allowing works to be carried out to take preventative or remedial action to recover oil and mitigate any environmental effects.

3.55 Mr Payne arrived on site at approximately 9.30am and showed his warrant and handed the emergency works notice to Ray England.

3.56 Mr Payne spoke with Mr Carthew and showed him his warrant.

3.57 Mr Pope arrived on site at approximately 10.00am.

3.58 A meeting was held with Mr Pope, Mr Payne, Ms Hannon, Mr Carthew and other OENZ staff members. The purpose of this meeting was to meet with Mr Carthew who was going to manage the pipeline repair phase and clean-up operation.

3.59 Mr Carthew outlined the possible causes which may have contributed to the pipeline leak. This included earthquake, substandard installation, and/or corrosion.

3.60 Mr Carthew also outlined actions taken, which included the construction of a lined pit for contaminated soil and a second pit to be used for temporary storage of the recovered contaminants. A small temporary dam, with gooseneck pipes, was constructed in the unnamed tributary, above the stream diversion outlet, for the purpose of containing any discharges that may arise from pipeline works. The initial earth bund with goose neck pipes was removed.

3.61 Mr Carthew then outlined the planned action for the recovery and pipeline repair phase. This included constructing tracks, a water diversion around the affected area, containment ponds and the clean-up of the unnamed tributary.

3.62 Mr Pope explained that the TRC would be undertaking daily inspections to monitor progress and any environmental effects and would comply with OENZ's Health and Safety procedures.

3.63 The excavation of the pipeline was not planned for the immediate future. This would be undertaken once a safety plan and engineering plan were in place.

3.64 Mr Pope stressed the need for very good silt control measures, which included silt fences and silt traps, as well as hay bales when the tracks were to be constructed.

Containment points were to be retained within the stream at all times. It was also required that the downstream biological monitoring site would need to be preserved and the TRC agreed to tape off and identify the area. This was done after the meeting.

3.65 TRC were to arrange for long distance weather forecasting to be emailed to Josie Hannon.

3.66 Mr Payne and Mr Pope left the site at approximately 3.30pm.

3.67 Inspection Notice No.U211228771 was issued by Mr Payne.

Thursday 14 October 2010 – Day 7

3.68 Mr Payne arrived at the RPS site at 12.55pm. Mr Payne signed in and showed John Chard his warrant. Mr Payne took some photographs from the RPS site, then went to Hawkin's side of the stream and took more photographs. Silt controls (hay bales and containments) were in place as required. Mr Payne left the site at 1.30pm.

3.69 Inspection Notice No.U2113485053 was issued by Tim Payne.

3.70 Mr Payne received a phone call from Mr Carthew at 3.10pm regarding the inspection notices (querying 'serious non-compliance'). Mr Payne explained the situation was one of potentially serious non-compliance and requested that Mr Carthew email a list of the planned remedial actions, which was completed.

Friday 15 October 2010 – Day 8

3.71 Mr Payne phoned the RPS control room at 9.00am (spoke to Brent) and noted he was meeting Mr Carthew on-site.

3.72 Mr Payne went to the spill site via the Hawkin's property and met Mr Carthew, Paul Roberts, and Murray Phillips (contractor). Mr Payne offered to show Mr Carthew his warrant but he didn't need to see it.

3.73 Two pumps were put in place to divert the stream water around the affected (discharge/spill) area. Pumping began at 9.35am. Construction on the tracks was well underway but the swampy area needed further works.

3.74 The water level in the tributary was lowered and preliminary tests showed that the best course of action would be to use a digger to remove the containments in the area immediately below the discharge point for approximately 30 metres. Manual labour was to be used in the wetland area to remove pockets of contaminants.

3.75 At 10.30am a dam was constructed above the pumps to control the water level. A culvert pipe was installed on the top of the dam so that the water flow could resume once pumping had stopped.

3.76 It was decided that chemical sampling was not necessary throughout the weekend as there was going to be no activity over this period.

3.77 Photographs were taken of the site.

3.78 Mr Payne left the site at 10.50am and let the control room know by phone.

3.79 Inspection Notice No.U211348568 was issued.

Monday 18 October 2010 – Day 11

3.80 Mr Caskey arrived on site at 10.24am and met with Mr Chard, Mr Carthew, and showed them his warrant.

3.81 The digger and the clean-up crew were working on removing contaminated soil and all contaminated soil was being stored in the lined pit. Pumps were working at the time of inspection to bypass the contaminated area that was being cleaned up.

3.82 The TRC sent a letter to OENZ to provide an opportunity to write in, stating the circumstances relating to the oil spill discharge, the duration of the discharge, the quantity of oil discharged to the stream, the methods of pipeline integrity monitoring employed and the records of this monitoring, and giving sufficient reason why enforcement action under the Resource Management Act 1991 should not be considered in this instance.

Photograph 6 – Removing the contaminated soil from the pipeline route– 18 October 2010

3.83 OENZ staff had taken soil samples from exposed soil on each side of the tributary at the clean-up area and they had been taking water samples three times a day.

3.84 Mr Caskey discussed future planned works with Mr Sole.

3.85 Photographs were taken of the site.

3.86 Mr Caskey left the site at 12.07pm.

Tuesday 19 October 2010 – Day 12

3.87 Mr Caskey went to the mouth of the Manawapou River at 9.50am and spoke with a local whitebaiter who stated he had not noticed anything unusual about the river. Mr Caskey then went to the new project office (portacom) on the site at 10.47am and met Mr Sole and showed him his warrant.

3.88 Minor clean-up work was still being undertaken. The track was being constructed down to the discharge point and silt controls were being established where necessary.

3.89 The tributary had been left flowing through the site and no pumps were operating at the time of inspection.

3.90 There was no hydrocarbon sheen evident in the tributary or behind the earth bund.

3.91 Mr Caskey inspected the contaminated soil pits and they were nearly full. OENZ staff had taken samples from the pits. OENZ staff said the pits were going to be emptied prior to the opening up of the site over the suspected pipeline fracture area.

Photograph 7 – Contaminated soil storage pit – 19 October 2010

3.92 Photographs of the site were taken.

Photograph 8 – waste bags full of contaminated soil – 18 October 2010

3.93 Mr Caskey left the site at 11.30am.

Thursday 21 October 2010 – Day 14

3.94 Mr Caskey went to the project site and signed in and showed his warrant to Mr Sole and Mr Phillips.

3.95 The ring drain had been established and the access track to the leakage site was established. Works were underway to establish a retaining wall and a small amount of excavation had been undertaken over the pipe on the RPS side of the tributary.

3.96 No clean-up works were done over the past few days as there was nothing to clean-up.

3.97 small amount of silt had gone from the ring drain to the tributary, only as far down as the earth dam (Figure 2).

Friday 22 October 2010 – Day 15

3.98 Mr Pope and Mr Payne arrived at the project site and signed in. Nobody was present at the office.

3.99 Mr Pope and Mr Payne proceeded to the excavation site and met with Mr Carthew and showed him their warrants.

3.100 Manual clean-up in the stream continued and dirty tarpaulins were removed from the site for cleaning. Excavation continued from the downhill side of trench with the 4″ pipe exposed and section of insulation removed. No indication of oil or water was present so the leak was not coming from up slope. The section was rewrapped with industrial cling wrap to prevent any water entry into the Insapipe foam.

Photograph 9 – Exposed section of pipeline insulation – 22 October 2010

3.101. Staff had not found the leak.

Saturday 23 October 2010 – Day 16

3.102. Mr Payne observed the site from the neighbouring property and no works were being undertaken that day.

Tuesday 26 October 2010 – Day 19

3.103. Mr Pope and Mr Payne arrived at the project site and signed in. Nobody was present at the office.

3.104. Mr Pope and Mr Payne proceeded to the excavation site and met with Mr Carthew and showed him their warrants.

3.105. Manual clean-up in the stream continued with the contaminated soil transported to the holding pit.

3.106. Insulation from the area of pipeline where the leak was presumed to be was removed to inspect for oil or water presence. An abundance of oil and water was found but there was no obvious evidence of the leak point in the pipeline.

Photograph 10 – Exposed insulation section after wrap removal – 26 October 2010

3.107. The weld and external wall of the pipeline showed no obvious sign of defects, but the heat tracing equipment channel was full of contamination indicating that the leak point was possibly elsewhere on the line but only exited from this location. The exposed section was rewrapped with industrial cling wrap.

3.108. Staff had not found the leak.

Photograph 11 – Excavation of the pipeline – 27 October 2010

Wednesday 27 October 2010 – Day 20

3.109. Mr Carthew informed Mr Payne of the day's progress by email. Manual clean-up in the stream continued with the heat of the sun melting oil off the foliage of vegetation surrounding the stream. Contaminated soil was transported to the holding pit.

3.110. Excavation continued under the streambed with oil found on the outside of the pipe.

3.111. No obvious sign of the pipeline leak point was found and sections were rewrapped with industrial cling wrap.

Thursday 28 October 2010 – Day 21

3.112. Mr Payne visited the project site and signed in. He went to the excavation site and showed staff his warrant.

3.113. Manual clean-up of the stream continued with contaminated soil found along the outside of the pipe at the low point under stream transported to a holding pit.

3.114. Staff continued to excavate under the stream bed ending just past the second weld point. There was no obvious sign of the leak point and the weld showed no obvious defects.

3.115. The heat trace channel was found again to be filled with oil. Sections were rewrapped with industrial cling wrap to stop any water ingress into the Insapipe foam.

Friday 29 October 2010 – Day 22

3.116. Mr Carthew informed Mr Payne of the days progress by email. The contaminated soil found along outside the of the pipe at the low point under the stream bed was transported to the holding pit.

3.117. Excavation continued with the water pumped out and the brow of the east side hill section unearthed.

3.118. No evidence of oil was found in the heat tracing channel or foam insulation, indicating that the leak point was somewhere in between the hill on the east and the stream bed.

Tuesday 2 November 2010 – Day 26

3.119. Mr Carthew informed Mr Payne by of the day's progress by email. The contaminated soil found along the outside of the pipe at low point under the stream was transported to the holding pit and water pumped out of the excavation.

3.120. Stream diversion pipes were installed to divert was around the excavation site and a temporary pipe structure installed for pipe support.

3.121. A 20 tonne digger was used around the pipelines with a 30 tonne digger used at the same time to help remove the spoil.

Photograph 12 – Diggers removing the soil – 2 November 2010

3.122. Leak point was not found.

Wednesday 3 November 2010 – Day 27

3.123. Mr Caskey visited the project site and signed in. Nobody was at the office.

3.124. Mr Caskey inspected the site and found that a hole had been dug on the brow of the hill by the project office (portacom).

3.125. The pipe was found to be uncontaminated with oil.

3.126. Excavation was continuing from the tributary up the hill, exposing the pipe.

3.127. The tributary was being piped over the excavation work area.

3.128. Mr Carthew arrived on site and Mr Caskey showed him his warrant. They discussed the progress and procedures of excavating the pipeline area until the leak was exposed.

Thursday 4 November 2010 – Day 28

3.129. Mr Caskey visited the project site and signed in. Nobody was at the office.

3.130. A 55 tonne bulldozer was on site anchoring a digger above the tributary, this was excavating part of the pipeline area.

Photograph 13 – Tributary diversion above the oil pipe – 4 November 2010

3.131. Mr Caskey met Robert Rawles (Core Group) on site and showed him his warrant. They discussed the progress made in excavating the pipeline.

3.132. Staff were still finding oil in the heat tracing line at the base of the hill.

3.133. The tributary was still running clear with fresh bunds put in place.

3.134. The earth dam in the goose neck pipes were working well.

3.135. Silt fences were to be put in place at the end of each phase/day to prevent any silt entering the tributary given forecasted rain.

Friday 5 November 2010 – Day 29

3.136. Mr Pope and MS Blyde arrived at the project site and signed in. Nobody was present at the office.

3.137. Mr Pope and Ms Blyde proceeded to the excavation site and met with Mr Carthew. Mr Pope showed him his warrant.

3.138. OENZ staff had isolated an area where they thought the leak may be but had not found the leak.

Monday 8 November 2010 – Day 32

3.139. Mr Carthew informed Mr Payne of the days progress by email. The entire Insapipe coating was removed and the 100 NB pipeline was inspected, no leak point was found.

3.140. The third weld was ultrasonic (UT) and the magnetic particle was tested with no defects found.

3.141. Random UT thickness checks were completed along the pipeline with no anomalies found.

3.142. Further visual inspection found a wax like build up appearing at the 6 o'clock position at the start of the bend on the 100 NB pipeline on the west side. Upon removal of this build up a pipeline leak was discovered. The leak firstly dripped and then sprayed well fluids and then was temporarily sealed.

3.143. Leak point finally found.

Monday 15 November 2010 – Day 39

3.144. Mr Carthew informed Mr Payne by of the day's progress by email. Holding pits have been backfilled and all rubbish bags, discarded overalls and holding pit liners had been disposed of following the agreed procedure at the landfill.

3.145. The excavation was widened at the leak location to allow exposure of the 8" pipeline for inspection.

3.146. Videoscope inspection of both the 4" and 8" pipelines was scheduled to be completed from RPS to the Rimu A wellsite.

Thursday 18 November 2010 – Day 42

3.147. Mr Pope, Mr McLay and Bev Wisnewski (OENZ) met in Mr McLay's office at approximately 2.00pm and discussed progress to date and future actions.

Tuesday 23 November 2010 – Day 47

3.148. Mr Payne observed the site from Mokoia Road. No significant work was being undertaken and the dams were still in place.

Friday 26 November 2010 – Day 50

3.149. Mr Payne informed by email from Mr Carthew of progress to date. Video inspection was completed for the pipeline, 37.5m upstream and 37m downstream with no evidence of any internal wall loss identified. The likely cause of pipeline failure was corrosion in a specific pipeline section.

3.150. OENZ replied to the Council's please explain letter of 18 October and provided a full report.

Thursday 2 December 2010 – Day 56

3.151. Mr Pope, Mr McLay, Mr Joines and OENZ Production Manager Max Murray, met and discussed pipeline corrosion causes, remedies and the implications of the OENZ pipeline problem for the other pipelines and operators in the region.

Monday 13 December 2010 – Day 67

3.152. Mr Payne observed the site from Mokoia Road. No Significant work was being undertaken and the dams were still in place.

Monday 14 January 2011 – Day 98

3.153. Energyworks had started the new pipeline replacement with new equipment (welders, pipe benders, side booms) arriving on site. Pipe instatement was envisioned to take approximately two weeks.

Friday 21 January 2011 – Day 105

3.154. Mr Caskey visited the site and was pleased with how the stream had recovered from the clean-up operations.

Tuesday 25 January 2011 – Day 109

3.155. Mr Payne was informed by email of progress at the site by Mr Carthew. Non destructive pipeline testing was planned to be completed this week with hydrotesting to be completed by the following week. Exposed areas would then be sand blasted and paint/wrap coated with Insapipe and weld kits were to be installed. The excavated area would then be ready for reinstatement. It was planned to import sand to provide a compact foundation and clean cover for the pipeline. The excavation would then be backfilled with the clean fill previously removed.

4. Summary of oil spill response and clean-up

4.1. Following primary containment on 8th October 2010, which involved placing hay bales and absorbent booms at various places in the stream, OENZ set about cleaning up the stream (Figure 2). Through crews armed with shovels and rakes cleaning all obvious deposits of waxy oil from the stream environment occurred for about two weeks. The oil was contained in bags and stored in a containment facilities onsite (Photographs 7 and 8).

4.2. Once the primary clean-up was completed an earth bund was constructed downstream of the pipeline works area. Two 150 mm skimmer pipes (goosenecks) were installed to allow water to pass while retaining any hydrocarbons on the water surface where absorbent pads or suction could be used for oil collection. This provided additional containment during the pipeline excavation works.

4.3. The stream was also diverted to a point about 80m downstream to avoid the excavation area. Initially this occurred by using pumps then via an excavated drainage channel and then through pipes which crossed the excavation area. The area excavated was approximately 30m long by 10m wide to a depth of about 4m below the original streambed level.

4.4. The leaking pipe was repaired by Energyworks Ltd and completed by 15 April 2010. It was then inspected by M & I SGS for certification before use. The work area was reinstated shortly thereafter and the extent of re-grassing in May 2010 is shown in Photograph 17.

5. Chemical and Biological Environmental Monitoring

5.1. During the clean-up, containment and investigation process a chemical stream monitoring programme was implemented by OENZ. Testing was undertaken for hydrocarbons and chloride (possible contaminants), as well as conductivity.

5.2. The main sampling point was approximately 50m upstream from the confluence of the tributary with Manawapou River. While clean-up works were underway, hourly testing of the stream was undertaken. This was lessened to three times a day, then once a day and then once a week in agreement with the Council and due to monitoring showing compliant levels. The results of the monitoring from the first week (October 9-13) are summarised in Table 1.

Table 1 Results of OENZ in-stream monitoring (9-13 October 2010)

SAMPLING LOCATIONS	CONDUCTIVITY (us- ultrasiemen)	CHLORIDE (ppm)	HYDROCARBONS (ppm)
100m upstream leak point 9 Oct			0.9
20m upstream leak point 13 Oct	270	39.2	1.2
50m upstream of Manawapou River (below leak point and treatment system)	313 (maximum)	47 (maximum)	4.4 (maximum)
	257 (minimum)	21.5 (minimum)	1.4 (minimum)

5.3. Stream sampling did show a level of chloride and hydrocarbons above what was normal for the stream but these were not considered significant. They were also less than the general stormwater discharge consent maximum limit of 15 ppm hydrocarbons and 50 ppm chloride. However, there was a large quantity of solidified hydrocarbons in the 80m reach below the leak.

5.4. The TRC carried out a separate biological monitoring survey on October 9 2010 with the monitoring undertaken and results described in a separate detailed report by the Council's Scientific Officer - Freshwater Biology Bart Jansma, "Biomonitoring of an unnamed tributary of the Manawapou River in relation to an unauthorised discharge of crude oil and produced water, October 2010" (Document 815611). The survey involved 3 sites being 20m upstream of the leak (control site), and 130m and 250m downstream of the leak. The survey concluded, directly below the leak, that there was significant habitat smothering caused by the waxy crude oil solidifying over the substrate, and also coating the vegetation, which provided important invertebrate habitat. 130 metres downstream of the discharge it was apparent that much of the invertebrate community had been killed by the discharge, but that recovery was already underway. This was evident from the samples collected containing both live and dead invertebrates, but containing overall fewer individuals when compared with the control site. Although similar impacts were evident 250 metres downstream, they were not present to the same degree. While some dead invertebrates were recorded at this site, four live fish were observed in this reach of the stream, including a large eel.

5.5. A biological survey was conducted on 24 May 2011 by the Council's freshwater biologist- "Biomonitoring of an unnamed tributary of the Manawapou River in relation to an unauthorised discharge of crude oil and produced water, May 2011" (Document 902376). The survey showed that although there was a statistically significant drop in MCI score 130 metres downstream of the discharge, when compared with the upstream control site, overall the communities at all sites had much greater abundances of invertebrates when compared with the earlier survey. The sample collected 130 metres downstream of the discharge smelt of hydrocarbons, and this indicates that there is a lingering impact at this site. However, the effect of this lingering impact on the macroinvertebrate community is relatively subtle.

5.6. In summary, the monitoring results from both the TRC and OENZ showed:

- Hydrocarbon levels were below the maximum limit generally applied to discharge consents
- Chloride levels were below the maximum limit generally applied to discharge consents
- The impact on the macroinvertebrate community started to reduce approximately 250 m downstream of the discharge where live eels and kokopu (native fish) were discovered.
- The stream was showing signs of recovery 7 months after the incident. There were much higher abundances of invertebrates downstream of the discharge, when compared with the previous survey, although a subtle lingering impact was present 130 metres downstream.

5.7. To assist in the regeneration of the stream ecology, OENZ intend to put in place some stream mitigation. This includes:

- Reinstating the stream bed and environment close to its original dimensions as far as practicable.
- Provide a riparian planting programme for the stream, which includes the reach affected by the leak, and invite the TRC, local iwi and community to be involved in the project.
- Provide an opportunity in partnership with the TRC's environmental education unit for a curriculum based project to track the regeneration of the stream.

5.8. Ngati Ruanui Iwi representatives also visited the incident site on a number of occasions during the clean-up and remediation to monitor impacts and progress. The Council was aware through OENZ that the iwi was concerned about the environmental effects of the incident but were thankful for the rapid oil spill response to limit environmental impacts that were limited to the small tributary. The lack of impact on the Manawapou River was important to Ngati Ruanui.

6. Pipeline Failure Assessment

6.1. The 100 NB line transfers the entire well stream product (hydrocarbons, produced water and gas) from the wells to the Rimu Production Station. The typical operation of the pipeline is every 7-10 days as the Rimu A3 well stream is flowed under low pressure for approximately 24 hours. This equates to around 4 days of well stream flow per month. For the balance of the time, on a daily basis and under low pressure conditions, the line is used to transfer well stream product from the Rimu A1 well to the Rimu Production Station. This operation utilises lift gas to produce from the well. Pressure can vary between 13 and 28 bar as the Rimu A wells are flowed.

6.2. Installed in August 2001, the 100 NB pipeline is made out of steel, specification API 5L Grade X52, and has a total length of 1.8 km. The outside diameter is 114.3 mm with a nominal wall thickness of 6.02 mm and a design life of 50 years. It has an Insapipe covering and is heat traced for external protection, but is not cathodically or internally protected. The 200 NB pipeline has the same specifications except an outside diameter of 219.1 mm and nominal wall thickness of 8.18 mm.

6.3. Various tests for external corrosion were carried out by OENZ on the 100 NB line including magnetic particle inspection, angle phased array ultrasound testing and visual inspections but no indications of the leak point were found.

6.4. Wall thickness checks were conducted on site around the welds and at various points along the pipeline to test for internal corrosion. The first sign of wall loss was indicated on length 100 of the pipeline at the 6 o'clock position, being approximately 4.3 mm – 5.7 mm. Lengths 99, 101 and 102 were also discovered to have extensive internal wall loss spanning from the 4 – 8 o'clock position in the pipeline.

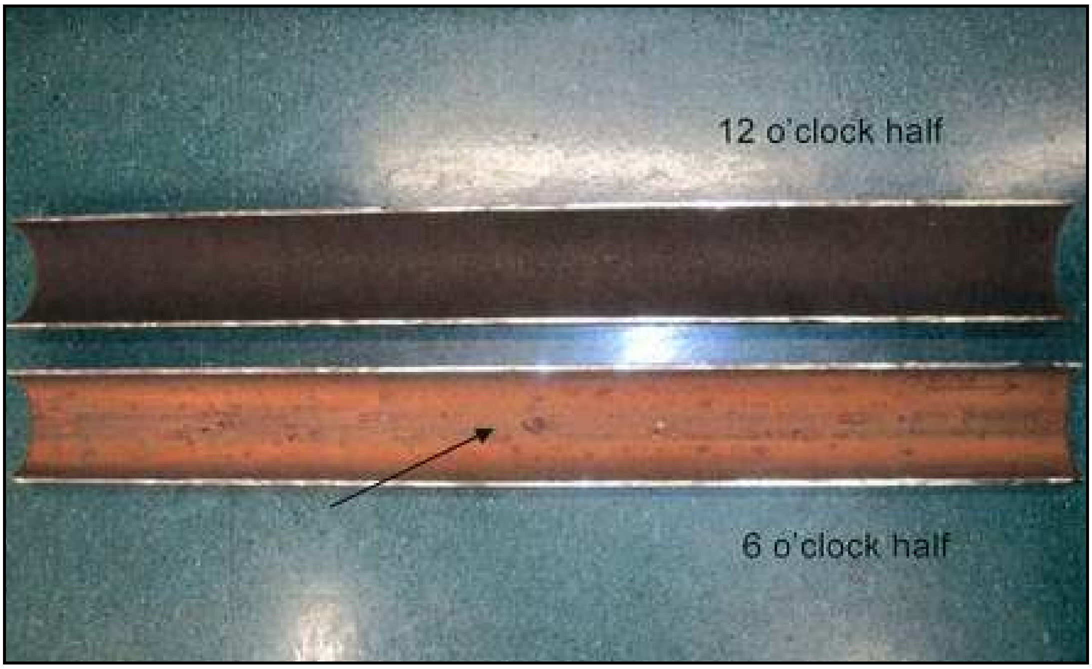
Photograph 14 *- Location of the pipeline leak point - 8 November 2010*

6.5. The leak point was discovered on Monday 8 November where a 4 mm x 1 mm slit was discovered at the 6 o'clock position in the pipeline (photographs 14 and 15). The section was cut from the pipeline and sent away for independent specialist metallurgy testing on Thursday 11 November to assist in investigating the pipeline failure.

6.6. Video inspection was completed 37.5 m upstream and 37 m downstream of the leak point with no evidence of any internal wall loss identified.

6.7. Results found the top half of the pipe to be covered in a black uniform layer consisting of siderite ($FeCO_3$) and magnetite ($Fe3O_4$), with the bottom layer exhibiting a light brown or red colour consisting of siderite. This layer exhibited a considerable number of large open pits (> 1 cm) scattered randomly between the 4 – 8 o'clock positions along the entire length of the pipe section, with pit depth and diameter decreasing as they moved away from the 6 o'clock position.

6.8. With the horizontal outline of the pipeline documented, final analysis of the pipe section indicated that the failure was located within the part of the pipe-work with lowest vertical position. At this specific location the pooling of well stream fluids would have occurred due to the irregular use of the pipe.



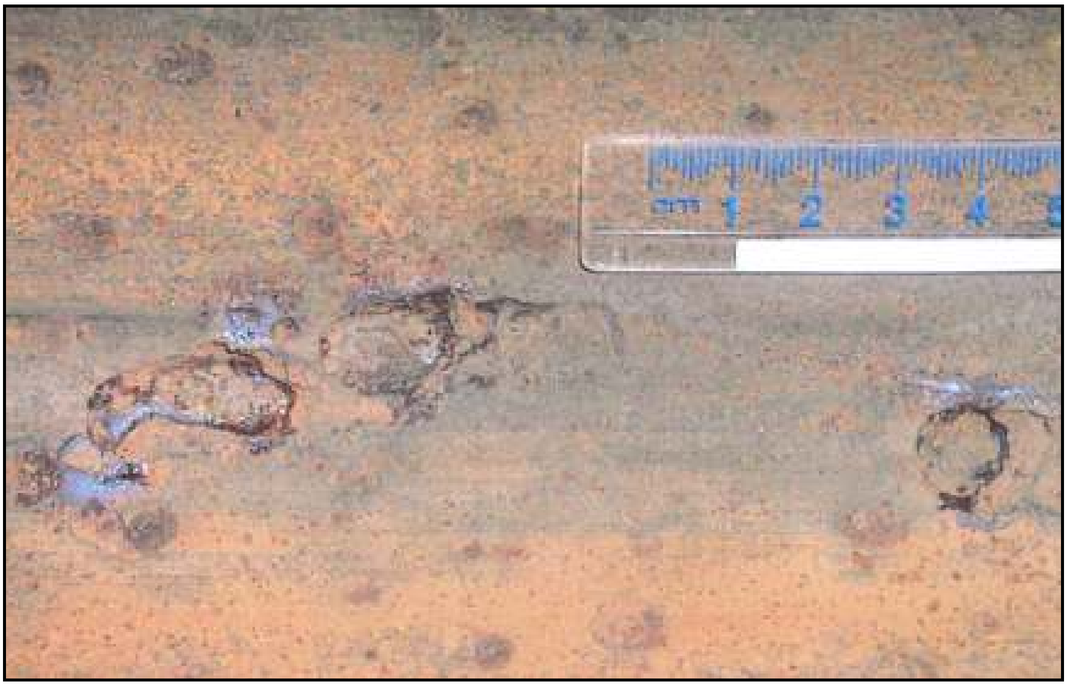
Photograph 15 *– Location of pipeline failure located by arrow*

6.9. The pipeline fluid was found to be corrosive and contained solids as well as chloride ions. There is a high possibility that the pipeline bottom would have accumulated sediment which in turn eliminates the effect of the corrosion inhibitor programme.

6.10. Larger pits were found to have an oval shape with some displaying a comet like appearance which is often associated with flow assisted pipeline erosion/corrosion (Photograph 16).

6.11. Two sections of the 200 NB gas line, which is adjacent to the 100 NB line, were also inspected, one opposite to the leak point and the other at the low point of the pipeline. Non destructive testing indicated random pitting at a maximum of 1.8

mm on a nominal wall thickness of 8.2 – 8.4 mm. However, when the pipe section was removed for inspection minimal wall loss was evident.



Photograph 16 – Appearance of pipeline pits in the 6 o'clock position

7. Regulatory Requirements

7.1. OENZ has nominated Australian Standard 'AS 2885 Pipeline-Gas and Liquid Petroleum' as the standard it will use for operation and maintenance to achieve compliance with the New Zealand Health and Safety in Employment (Pipelines) Regulations 1999. The AS 2885 standard comprises: Part 1- pipeline design and construction; Part-2 welding; and Part 3 operation and maintenance.

7.2. OENZ operates the Rimu pipelines under a Certificate of Fitness issued by SGS M&I as required by the 1999 Regulations. The current certificate was issued on 22 December 2009 and is valid to 31 May 2012.

7.3. The procedures and plans OENZ have in place to maintain and manage the pipelines include:

- Safety and Operating Plan Onshore Pipelines
- Integrity Management Strategy Onshore Pipelines
- Internal Corrosion Control Plan
- Pipelines Easement Surveillance and Maintenance Onshore Pipelines
- Pipelines Annual Operations and Maintenance Review.

7.4. The current Pipeline Easement Management Contractor for OENZ is Vector. Under this contract Vector are required to fulfil a number of duties and this includes monthly aerial and annual walkover pipeline surveillance.

7.5. Pipeline monitoring, testing and analysis are provided by Baker Petrolite Ltd, the corrosion management contractor for OENZ. They provide weekly testing, monitoring and dosage recommendation services.

7.6. For the Rimu pipelines a chemical monitoring and treatment management plan is developed in conjunction with Baker Petrolite Ltd. The plan for the pipeline is reviewed six monthly with OENZ staff and forms part of the overall pipeline management programme. Reports and recommendations are reviewed as part of the SGS M&I certifying audit process. SGS M&I provide independent inspection, testing, and certification services to various industries, including the oil and gas industry. The last audit was undertaken in late October 2009 and the next audit was scheduled for mid December 2010 and has occurred.

7.7. OENZ has currently contracted Core Group to review and update the Safety Management System for the pipelines to maintain compliance with recent and proposed changes to AS 2885.

7.8. The discharge from the pipeline leak was in contravention with Section 15(1)(b) of the Resource Management Act 1991 (RMA), which concerns the discharge of a contaminant onto or into land in circumstances which may result in that contaminant entering water.

7.9. In the event of a spill, the OENZ 'Production Station and Pipeline Spill Contingency Plan' is implemented. The plan's main priorities are to ensure the safety of people and to minimise impacts on the environment, should there be a pipeline malfunction or accidental unauthorised discharge. Special conditions under consents 5744-1 and 5748-1 (copies attached in the appendices) require the contingency plan to be prepared and approved prior to using the pipeline.

8. Incident Assessment

8.1. In the 'Onshore Pipelines Safety and Operating Plan', pipeline risk assessments are completed for all onshore pipelines with possible threats identified in accordance with AS 2885 and a risk rating assigned. This is reviewed at a minimum of 5 years. Internal pipeline corrosion is considered a low risk threat and to occur at an unlikely frequency. It was not identified by OENZ as a potential pipeline failure mechanism.

8.2. According to the Pipeline Easement Surveillance and Maintenance Onshore Pipelines procedure, OENZ has engaged Vector as the Pipeline Easements Management Contractor (PEMC) to manage all aspects of pipeline easements surveillance on a monthly schedule, with observations taken by helicopter. According to the Vector flyover report on the 14th September there were no observations to report for the pipeline corridor assessment flight. OENZ also did not notice anything unusual as the Wellhead Safety System not did pick up any major changes in operating pressure due to the small scale of the pipeline failure. If it had not been for the neighbour who had first noticed the leak, the environmental effects would have been a lot more severe with oil possibly reaching the Manawapou River and ultimately the beach. The leak started approximately between the 14th September and 8th October.

8.3. The well stream produced fluid that the Rimu A pipeline transfers is a combination of produced water, oil and gas. The well stream accumulated in the pipeline at its lowest point and given intermittent pipeline use, this contributed to corrosion. A metal surface wet with an oil and water emulsion where water is the continuous phase, is highly susceptible to corrosion. Even more so than the surface just being water wet because the oil layer above the water layer facilitates localisation.

8.4. The gas that is used to gas lift the well has a small amount of CO_2 present but it is not considered corrosive. Once the gas is injected into the well, it comes into contact with the reservoir fluids and becomes saturated. This increases the risk of corrosion in the Rimu A pipeline and a corrosion inhibitor has been injected to mitigate this risk. However, the presence of siderite ($FeCO_3$) in the pipe indicates that CO_2 corrosion also played a significant part in the corrosion mechanisms in the pipeline.

8.5. Pigging is the only physical treatment OENZ has in place to clean the fluid and solid build up that may lead to internal corrosion in the Rimu A pipeline. The pig is pushed through using well fluids. This does not remove all fluids from the line and in some cases some of the produced water remains. Once pitting has started then there is a void below the internal walls of the pipe that the pig will not come into contact with and sediment and fluids can settle in these voids enhancing corrosion.

8.6. The 100 NB pipeline is pigged intermittently and the decision to pig is made on the basis of the previous pigging and from the results of the corrosion monitoring programme. The pipeline was pigged most recently on 27 August 2010, 6 weeks prior to the leak being discovered. Preceding that, pigging occurred on 1 August 2010. OENZ supplied all the pigging records to the Council.

8.7. Intelligent pigging (inline inspection) was not considered a viable option for the Rimu pipelines, in particular the 100 NB pipeline because intelligent pigging for pipelines less than 200 mm in diameter is a relatively new technology. The pigging tools require a very clean interior as dirty pipelines hamper the collection of data so various pig providers have been reluctant to allow their pigs in pipelines that transport high pour point waxy material, the case for most of the gathering and oil transmission pipelines OENZ manages.

8.8. In 2005, Weight Loss Coupons installed showed a significant weight loss for the Rimu A pipeline. A corrosion inhibitor was recommended and further monitoring showed improved corrosion protection. A review in 2008 recommended the Weight Loss Coupons to be replaced by Electrical Resistance (ER) probes as they reduced the HS&E risk and allow for corrosion data to be collected at a greater frequency. The ER Probes installed in 2009 measured a low corrosion rate of 0.096 mm/year for the period August 2009 to October 2010 (Baker Petrolite Corporation 2010). Weight Loss Coupons are still present at the wellheads.

8.9. The corrosion monitoring devices that are implemented are usually able to prevent general corrosion. However, their effect on localised corrosion is limited. It is also important to note that corrosion coupons and ER probes indicate metal loss to the environment only at the point of exposure so the results may not be indicative of other areas of the pipeline which may have undergone more serious damage. ER probes also indicate more towards the process fluid's condition rather than the pipeline's condition (Nalli 2010).

8.10. Local corrosion is most commonly initiated at the inner bottom on pipelines, along horizontal straight line sections of the pipe work (Ahamed and Singh 2008), as there can be increased wetting on low lying points. It would seem that the area where the pipe failure was discovered was susceptible to pitting corrosion. However, the angle of pipe orientation alone doesn't increase or decrease the probability of pitting, but it does affect the flow pattern and deposition of possible sediment, thus indirectly affecting localised corrosion (Papavinasam et al 2010).

8.11. Sediment of solids can increase pitting corrosion rates in many ways. Under moderate flow conditions, the solids may remove the protective layer in localised areas while at higher flow rates, the presence of solids can lead to erosion, erosion/corrosion and abrasion.

8.12. Fortnightly, test samples of the well stream produced water and oil is taken to monitor irons and sulphur reducing bacteria levels which assist in determining the biocide and corrosion inhibitor dosing rates. Monitoring did show a spike in iron levels but this was assumed by OENZ and their consultants to be from metal loss along the entire length of the pipe, not from localised corrosion.

8.13. The iron count is only viable when the corrosion product is soluble (Dawson and Oliver 2010). Hence if there is a high bicarbonate content the process becomes saturated with siderite ($FeCO_3$). Once the process is saturated, any increase in the corrosion rate cannot add extra irons to the solution because insoluble iron carbonate scale forms instead. This can lead to misleading information if results show iron counts stabilising as it may not actually be the case.

8.14. The Rimu A pipeline is used irregularly, transferring well stream product from both the A1 and A3 well sites at different times. Studies have shown that sudden changes in operating conditions such as intermittent use can lead to a higher pit growth rate due to more aggressive conditions, and is a possible factor that facilitated the pitting corrosion.

8.15. The Council thoroughly assessed the incident, took legal advice, and decided not to take enforcement action. OENZ was deemed to have a defence under section 341 of the RMA. The incident was due to an event beyond their control and the event could not have reasonably been foreseen or provided against, and the effects of the event were adequately mitigated or remedied by OENZ afterwards. OENZ provided a comprehensive assessment of the incident (copy of letter in Appendices) and fully cooperated with the Council. OENZ provided daily reports to the Council whilst the cleanup was underway and during the location of the pipeline leak.

8.16. Photograph 17, taken seven months after the oil spill shows the pipeline excavation and stream area. The area has been recently re-grassed and the streambed area has had small cobbles added. A slight hydrocarbon odour was noticeable in the stream substrate at the site due to residual hydrocarbons and this is expected to shortly dissipate.

Photograph 17 - Reinstated pipeline excavation area and affected streambed (centre of photograph) on 24 May 2011. RPS perimeter fence on upper left side of the photograph.

9. Incident Learning Points for Industry Assessment and Application

Internal Pipeline Corrosion

9.1. While external pipeline corrosion is still considered by OENZ to be the greatest risk this incident has shown that internal corrosion can be higher than previously thought. Also OENZ consider that pitting corrosion is not the most common form of corrosion.

9.2. This incident has shown that internal pitting corrosion is a rapid process. The pipeline was only 9 years old and not expected to be subject to such corrosion given the OENZ management regime in place. Determining the location and rate of the corrosion is particularly difficult. However, precautions can be taken in the future to reduce risk of pipeline failure. Such precautions, based on this incident and overseas literature, are set out below:

- Detecting pitting corrosion and preventing its formation is a difficult and complex issue with much research currently going into this process. There are no available corrosion science models that address pitting corrosion but research is currently underway globally to find possible solutions to this issue and should be regularly accessed by industry.
- Internal corrosion should be recognised as more of a threat than external corrosion which can be effectively addressed by coatings and cathodic protection standards. The most common form of internal pipeline corrosion is

localised and not general, and it should be part of the industry risk assessment process, particularly given this incident.

- Iron level results may be misleading due to iron counts only being viable with soluble corrosion products. Therefore calculating realistic corrosion rates with this method is difficult.
- The driving force for pitting corrosion is the breakdown of the passive layer on the metal which is initiated by a series of factors, a combination which varies depending on the situation, so pipeline data needs to be interpreted on a case by case basis.
- Even if an area is predetermined as a high corrosion risk, the actual location of localised corrosion is still not readily identifiable as the preferred deposition of the localised corrosion can be random in nature making it unpredictable. Pipeline assessments need to recognise this phenomenon.
- The initial breakdown of the boundary layer on the metal surface may take months, but once the pit is formed it can develop rapidly. This is because pitting is an autocatalytic process so creates conditions that favour its further growth. Pipeline assessments need to recognise this phenomenon.
- Pitting corrosion is known to be more susceptible on horizontal positions at six o'clock due to water being heavier than crude oil, with pipe orientation indirectly affecting the localised corrosion rates. Extra attention should be taken by the industry to inspect these areas such as placing corrosion coupons/probes in positions where they will be immersed in any produced water. Many are placed in the sides of the pipelines rather than at the bottom which may make them easier to remove but may not provide the most accurate and reliable data.
- The management of change in pipeline operation from continuous to intermittent flow is important and in this incident was not judged significant at the time. Neither was a significant change in well stream product. In the future this will trigger reassessment of risks and the corrosion monitoring/dosing regimes.
- Pipelines that are used intermittently should be checked thoroughly for possible threats of corrosion as the irregular operating conditions can lead to more aggressive conditions prone to corrosion.

Pipeline Monitoring

9.3. Due to the small size of the leak hole (4 x 1 mm slit), pressure and temperature inside the pipeline would not have been noticeably different to cause concern or set off an alarm. Current monitoring methods appear to be insufficient to detect pipeline failures of this nature, so a review is considered necessary for pipelines used in this way. The visual inspection method used by Vector may be sufficient. However, as noted by the farmer who discovered the leak, visually at a distance it was difficult to differentiate from a spring and discolouration caused by a fresh in the tributary so the Vector survey may have the same limitation.

Contingency Planning and Spill Response

9.4. A significant learning from the incident is the usefulness of the contingency planning framework that is required by the Council in the resource consents that are issued. The industry staff responding first to the incident immediately referenced the site contingency plan to guide the incident response. Experienced Council staff were then able to provide assistance based on past oil spills. Contingency plans need to be updated after an incident to capture the learning points. Spill response exercises also need to be held regularly so staff are suitably prepared.

10. Conclusions

10.1. This type of pipeline failure occurred as a result of pitting corrosion resulting in a spill and an environmental incident. It is considered a rare occurrence in industry terms and not experienced before by OENZ. The pipeline was only 9 years old and the section should not have been corroded. External pipeline corrosion is still considered by OENZ to be the greatest risk. However, this incident has shown that internal corrosion can be higher than previously thought. Environmental effects were kept to a minimum through the application of contingency planning measures. This minimised the effected area and prevented the discharge from entering the Manawapou River and eventually the sea. Other conclusions are set out below:

- An estimated 200-500 litres of oil and produced water had leaked to the environment. This is, however, a rough estimate with the full quantities or percentage of oil and produced water were unable to be precisely determined.
- Oil was visibly deposited 80m from the discharge point in and around the stream bed and on surrounding grassy areas.
- Biological monitoring showed 250m of stream was adversely affected by the leak.
- The clean-up response was carried out quickly and effectively under the Type 2 oil spill provisions of the OENZ Production Station and Pipeline Spill Contingency Plan.
- The oil from the discharge had a melting point of 18°C, aiding in the clean-up as it solidified to a waxy form when it came into contact with the cooler stream and air temperatures.
- If it had not been for an outside source to first notice the leak, the leak could have likely continued to discharge until the next scheduled easement surveillance monitoring. However, with operation of the pipeline the pressure drop would have been more noticeable and the safety systems should have identified the leak.

10.2. The cause of the pipeline failure was found to be from internal localised corrosion that produced a pin sized slot/hole leaking crude oil and produced water under pressure into the environment. This and other conclusions from the corrosion investigation are set out below:

- The leak did not discharge directly where the pipeline hole was located making the leak point difficult to locate. Instead the product travelled down and through the soil and came out on the side of the bank approximately 2 m above the stream bed.
- The localised corrosion that caused the leak appeared to be triggered by a combination of CO_2 corrosion, pipeline orientation, pooling of the oil in water emulsion, accumulated sediment, and other possible factors that are yet to be determined.
- Internal localised corrosion was considered a low risk possible failure mechanism in the OENZ risk analysis, with internal corrosion deemed low risk and unlikely to occur.
- The corrosion monitoring in place had not suspected or detected noticeable signs that pitting corrosion was occurring in the pipeline, except for a slight increase in iron levels but this was assumed to be from general pipeline corrosion and was returned to acceptable levels through corrosion dosing.
- Localised internal corrosion was initiated in the 6 o'clock position in the pipeline with wall thickness losses measured around this position in the 100 NB and other pipelines in the vicinity.
- Pipeline orientation is considered a significant factor in internal pipeline corrosion.

10.3. Monthly easement surveillance and the Wellhead Safety Systems were not sufficient to detect the pipeline leak.

10.4. A review of the current OENZ Asset Integrity may be necessary for monitoring possible future leaks of this nature. Vehicle or foot patrol should be considered as viable options and carried out regularly on a more frequent basis.

10.5. In light of the leak, the pipeline spill has provided a good learning experience for OENZ staff with a number of significant learning points included in the recent review of the OENZ Production Station and Pipeline Spill Contingency Plan.

10.6. The mitigation measures offered by OENZ will result in an improved stream environment over time and experience with other similar incidents that damage a section of stream shows rejuvenation can be rapid and in the order of 12 to 18 months.

10.7. The Council considered the immediate effects of the spill were adequately mitigated and there is a further extended mitigation programme proposed.

10.8. OENZ agreed to record the learning points from the pipeline corrosion, leakage, and clean up response so that these could be shared with the oil and gas industry to develop best practice. These are identified in the section above.

10.9. The stream is showing signs of rejuvenation. The biological survey undertaken in May 2011 found much higher abundances of invertebrates downstream of the discharge, when compared with the previous survey, although a subtle lingering impact was present 130 metres downstream. This impact is likely to be related to a slight hydrocarbon odour, which was evident in the sample collected 130 metres downstream of the discharge point. This is expected to shortly dissipate as any residual hydrocarbons are broken down.

10.10. The outcome of this regrettable incident will be safer operations and protection for industry personnel, the public and the environment.

11. References

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Appendices

1. Correspondence from Origin Energy NZ Ltd to the Taranaki Regional Council dated26 November 2010.

2. Resource Consent 5748-1

3. Resource Consent 5744-1

origin

Taranaki Regional Council
Document No:

29 NOV 2010

Document No of Reply:

26 November 2010

Compliance Manager
Taranaki Regional Council
Private Bag 713
47 Cloten Rd
Stratford

Att: Mr Bruce Pope

Dear Mr Pope

Re: Unauthorised discharge from pipeline leak into an unnamed tributary of the Manawapou Stream.

The following information addresses issues raised in your correspondence (ref Document 817732) with regard to the Rimu A 100NB pipeline leak.

1. Background

Early afternoon on Friday 8th October Rimu Production Station (RPS) control room staff were notified by a neighbour to the site, Mr David Steele, that he suspected a small stream had oil in it.

The stream is an unnamed tributary of the Manawapou River located at the end of Mokoia Rd, beside the RPS and on the property owned by Mr Mark Hawken.

Mr Steele stated that he first noticed it around ten days beforehand but thought it was something to do with the heavy rainfall at the time and did not think anything more of it until viewing it again on the 8th October.

The stream location was immediately inspected and a leak was confirmed with the location ~~close to a pipeline easement route. The oil was not flowing from the exit locations that~~ were evident on the land beside the stream but evidence of waxy oil in the stream and stream margins was found.

The OERNZ Production Station and Pipeline Spill Contingency Plan (OEUP-NZ1000-PLN-SAF-007) was actioned and containment booms were deployed.

The location of the observed leak point is close to three pipelines in an easement. Two carbon steel 'insapipe' pipelines ; a 100 NB oil/produced water/gas line and an 200 NB gas line; and a polyethylene yellow jacket 50 NB fuel gas line. Immediately after the leak was discovered all of these lines were depressurised and flow stopped. (see Appendix G for Insapipe cross section)

The OERNZ Emergency Response plan was instigated and an emergency response team formed.

The key stakeholders; TRC (Mr Bruce Pope), landowner (Mr Mark Hawken) and Iwi (Ngati Ruanui- Simon Rangiwahia), were notified of the spill. All three parties visited the site that same afternoon.

A cleanup crew, machinery and equipment were organised. Spill booms and hay bales were immediately put in place to contain the spill and the Oscar Unit from Port Taranaki mobilised.

The emergency response team held discussions with TRC and a plan of action was agreed to for ongoing containment, cleanup and water monitoring, including sampling.

Over the remaining hours on the Friday further hay bales and oil containment sorbent booms were taken to the site and put in place.

These measures were effective in containing the spill.

2. Pipeline operation

The 100 NB line connects Rimu A wellsite to the Rimu Production station.

It was installed in 2001 as part of the Rimu field development.

This line transfers the entire well stream product (hydrocarbons, produced water and gas) from the wells to the production station.

The typical operation of the 100 NB pipeline is every 7-10 days the Rimu A 3 well stream is flowed under low pressure for approximately 24hrs. This equates to around 4 days of well stream flow per month.

For the balance of the time, on a daily basis and again under low pressure, this line is used to transfer well stream product from the Rimu A1 well to the production station. This operation utilises lift gas to produce from the well.

Pressure can vary between 13 and 28 bar as the Rimu A wells are flowed.

3. Site Cleanup

Following primary containment, cleanup of the stream environment was the next priority. This was somewhat aided by the characteristics of the oil which has a melting point of around 18 °C and therefore when it was exposed to the cooler open air and the stream waters, solidified to a waxy form.

The area affected by the visible physical waxy oil was approximately 80m downstream from the leak source location.

The cleanup began on site Saturday 9th October. This was first by hand with crews armed with shovels and rakes cleaning all obvious deposits of waxy oil from the stream environment. This waxy oil was shovelled into bags and the bags were stored in a containment facility on site.

The main cleanup continued primarily by hand for the next fortnight and during this time track excavation started on the east side of the valley to permit a digger and other equipment access to the area of the spill.

Once the primary cleanup was completed, further soil bunded walls and culverts were constructed. The soil bund downstream of the works area has two six 150mm skimmer pipes that permit water to pass whilst hydrocarbons are contained on the water surface and can be removed with absorbent pads or suction. This assured additional containment if any further fluid was exposed during the excavation works.

The stream was also diverted to a discharge point approximately 80 m downstream in agreement with the TRC to enable earth works in the affected area and to minimise further contamination of the stream. The stream was diverted initially by using pumps, then via an excavated drainage channel and then eventually the diversion was managed through pipes crossing the excavation area.

Once the stream diversion was in place, the excavation of the pipelines around the leak location began.

Due to the physical site constraints, the depth of the pipeline which is around 4m below the original stream level and the site safety requirements, the excavation eventually resulted in removal of all material from an approximately 30m long by 10m wide land area in the pipeline easement.

Once the pipeline was exposed examinations to identify the leak point were undertaken.

The leak point was eventually discovered on the 8th November 2010. This was a 4mm X 1mm slit at the 6 o'clock in the pipeline itself.

A section of pipeline containing the leak point was cut from the pipeline and sent away for independent specialist metallurgy testing on the 11th November 2010 to assist in identifying the cause of the pipeline failure.

Results of the testing and identification of the cause of the leak is discussed further below.

4. In-stream Monitoring

An in-stream sampling programme was implemented during the cleanup, containment and investigation process. Testing was undertaken for hydrocarbon, chloride and conductivity.

The main sampling point was beyond the last containment location upstream of the stormwater discharge point from the Rimu Production Station. This was approximately 50m upstream for the tributary's discharge point into the Manawapou Stream.

Whilst cleanup works were underway in and around the stream environment for the first week hourly testing was undertaken. Due to monitoring showing compliant levels of chloride and hydrocarbons and in agreement with the TRC this was lessened to three times a day, then once a day and then once weekly, on the basis that results showed no levels of contaminants that were of concern. The TRC also undertook stream sampling analysis over this period.

Full results of the testing are in Appendix H.

In-stream results from the first week (9th to 13th October) in summary:

	Conductivity	Chloride	Hydrocarbon
100m upstream of leak point 9 Oct			0.9ppm
20m upstream of leak point 13 Oct	270 us	39.2 ppm	1.2 ppm
Maximum at 50m upstream of Manawapou	313 us	47 ppm	4.4 ppm
Minimum at 50m upstream of Manawapou	257 us	21.5 ppm	1.4 ppm

In summary the stream sampling did show a level of chloride and hydrocarbons above what is normal for the stream but these levels were not significant and at all times complied with normal discharge consent maximum rates of 15ppm Hydrocarbons and 50ppm Chloride at the sampling point 50m upstream from the Manawapou River.

5. Investigation Process

5.1 Searching for the leak point

The following activities were undertaken on site specifically to identify the leak point in the 100NB pipeline;

- Three weld wraps, mid length injection points and wrap repairs were stripped off for visual inspection - no external corrosion was found.
- Magnetic particle inspection was performed on the three welds exposed to check for cracking - no indications found.
- Angle phased array ultrasound testing was undertaken on the welds to check for internal defects - no indications were found.
- The insapipe coating was stripped on the pipeline to visually inspect external pipe wall - no indications found.
- Wall thickness checks were conducted around the welds and at various points along the pipeline to check for internal corrosion. The first sign of any wall loss was indicated here, being 4.3mm - 5.7mm at the 6 o'clock position on length 100.
- Further visual inspection of the exposed pipeline found the leak point in the 6 o'clock position on length 100.

5.2 Further integrity inspection and testing.

The following activities were undertaken to ensure the remainder to the pipeline was not affected by corrosion:

- A 1 metre long piece of the pipeline, including the leak point, was sent to Quest Integrity metallurgists for analysis to determine the failure mechanism.
- A sample of the pipeline product along with detailed product flow records were also sent to Quest integrity to aide analysis.
- Video inspection of the pipeline was completed in each direction from leak point, upstream towards Rimu A (35.5 metres) and downstream towards RPS (31 metres). Extensive internal wall loss was discovered spanning the 4 - 8 o'clock position.

- Video inspection of this pipeline was conducted from the pig launcher at Rimu A (69 metres) and the pig receiver at RPS (80 metres). The internal condition was found to be good with no noted corrosion or damage.
- Affected lengths of pipe (99, 100, 101 and 102) have been cut out and further video scope inspection will now be conducted to ensure the remaining is clear of defects. Previous video inspection has shown that the remaining pipe is clear of defects.

5.3 Inspection conducted to date on the 200NB Rimu A to RPS pipeline

The following activities were undertaken or will be undertaken to ensure the remaining insapipe pipeline in the easement is not affected by corrosion:

- Two 800mm long sections of the 200NB pipeline were 100% inspected (with the exception of pipe under heat tracing) by ultrasound scanning. One opposite the leak point on the 100NB and one at the low point of the pipeline. Inspection found random pitting to a maximum of 1.8mm in these areas on a nominal wall thickness of 8.2 - 8.4 mm. This will be further investigated.
- The 200NB pipeline will be gas freed and video inspected 250 metres from the pig receiver at RPS to the low point in the stream to further evaluate the pipeline integrity.

5.4 Inspection conducted to date on the 2" Rimu A to RPS pipeline

The following activities were undertaken or will be undertaken to ensure the 50NB pipeline is not affected by corrosion:

- 300mm of the 2" pipeline was stripped at the low point and 100% inspected by ultrasound scanning. No internal wall loss was indicated.

6 Pipeline management and monitoring of the 100 NB pipeline.

6.1 Health and Safety in Employment (Pipelines) Regulations 1999

~~In November 1999, the Health and Safety in Employment (Pipelines) Regulations~~ 1999 [hereafter referred to as the HSE (Pipelines) Regulations 1999] were enacted to replace the existing Petroleum Pipelines Regulations 1984. The new regulations introduced a significant change in regulatory policy, requiring all pipelines to be operated with a current "Certificate of Fitness" issued by a recognised Certifying Authority.

Guidelines for a Certificate of Fitness for high pressure gas and liquid transmission pipelines were issued by the Department of Labour and OSH. The Guidelines are intended to assist both the pipeline owner/operators and the certifying authorities to achieve the minimum requirements necessary in order to obtain a Certificate of Fitness for a pipeline. In summary, in relation to a Certificate of Fitness for a pipeline, the HSE (Pipelines) Regulations 1999 require the *"employer" (owner/operator)* to ensure that:

- A pipeline is not to be operated unless there is a current Certificate of Fitness.
- The Certificate of Fitness is in respect of:

- the pipeline; and

- all equipment necessary for the safe operation of the pipeline.

- A copy of the Certificate of Fitness is to be provided to the Secretary before the pipeline is operated.

In respect of the *"Certifying Authority"*, the HSE (Pipelines) Regulations 1999 impose the following duties:

- Carry out such inspections or examinations of pipeline and equipment fixed to or associated with pipelines, as may be necessary to determine the safety of such pipelines and equipment.
- Issue Certificates of Fitness in respect of the safety of the structure of pipelines and other equipment necessary for the safe operation of the pipelines.
- Impose limitations or conditions if the pipeline or equipment no longer complies with the relevant Certificate of Fitness.
- Ensure that the certification is in accordance with a Code or Standard recognised by the Regulations, but as a minimum standard in accordance with the Code or Standard to which the pipeline was designed and built.
- Issue the Certificate of Fitness in accordance with Schedule 1.
- Specify the expiry date of the certificate, ensuring that the term shall be no longer than five (5) years.
- Consider the conditions of the "Pipeline Authorisation" (if any).

Origin has nominated Australian Standard "AS 2885 Pipelines-Gas and Liquid Petroleum" as the standard it will use for operation and maintenance of its pipelines to achieve compliance with the HSE (Pipelines) Regulations 1999.

6.2 Certifying Authority - SGS M&I

SGS M&I in New Zealand provides independent inspection, testing and Certification services to various industries including the Petroleum Industry.

They are a Certifying Authority approved under the HSE (Pipelines) Regulations 1999.

Origin Energy Resources (NZ) Ltd operates the TAWN and Rimu pipelines under a Certificate of Fitness issued by SGS M&I as required by the HSE (Pipeline) Regulations 1999.

The current Certificate of Fitness was issued on 22 December 2009 and is valid through to the close of 31 May 2012.

SGS M&I audit our management systems and procedures as part of the certification process.

The procedures Origin has in place to manage our pipelines include:

- OEUP-NZ1000-PLN-MTC-002 Integrity Management Strategy Onshore Pipelines

- OEUP-NZ1000-PLN-MTC-003 Safety and Operating Plan Onshore Pipelines
- OEUP-NZ1000-PLN-MTC-008 Internal Corrosion Control Plan
- OEUP-NZ1000-PRO-MTC-004 Pipeline Easement Surveillance and Maintenance Onshore Pipelines
- OEUP-NZ1000-PRO-MTC-008 Pipelines Annual Operations and Maintenance Review

Referenced within these procedures are:

- Report 7762-R-023 Risk Analysis for Rimu A/B to Rimu Production Station 200/100 NB Flowlines
- Report 7762-R-025 Risk Analysis for Rimu Production Station to Rimu A/B 50 NB Gas line

A chemical monitoring and chemical treatment management plan is developed in conjunction with Baker Petrolite. This management plan for the pipeline is reviewed six monthly by Baker Petrolite and Origin Staff and forms part of the overall pipeline management programme. The reports and recommendations are reviewed as part of SGS M&I certifying audit process. (see section 5.4 and 5.5.5).

The last audit was undertaken on 29th and 30th October 2009. (Report 865J1/R1/Issue- 0).

A total of seventeen action items were identified and by 27th July 2010 thirteen had been completed, three were for SGS to action at the next audit and one remained in progress with the requested change related to H_2S monitoring being agreed and soon to be implemented.

The next Audit is scheduled for 14th and 15th December 2010 which is after the completion of the Kupe Shutdown.

All the documents quoted above and the current certificate of fitness can be found in Appendices A, B and C.

6.3 Easement Management - Vector

As specified in OEUP-NZ1000-PRO-MTC-004 Pipeline Easement Surveillance and Maintenance Onshore Pipelines procedure, Origin engages a Pipeline Easement Management Contractor (PEMC). This is currently Vector.

This continues with the arrangement that was in place for Swift Energy NZ the previous owners of the assets. Vector also provides similar services for other Taranaki based exploration and production companies.

Under the contract Vector are required to fulfil a number of duties that also specifically include pipeline surveillance and easement maintenance;

- Monthly aerial inspection by helicopter over the area containing gathering lines (included is the Rimu A 100 NB Pipeline easement)
- Annual walking of the pipeline easements route.

These inspections look for any conditions that could affect the safe operation of the pipelines and any signs of leakage.

Vector produces a monthly report which includes the Pipeline Easement Surveillance Report. A number of these reports are included in Appendix D.

The September 2008 and February 2010 reports provide specific evidence that the 789 (Rimu A 100NB) and other Rimu lines were viewed during regular Pipeline Surveillance by Vector.

The September 2008 report records observations that plastic markers were on the ground in two locations on Hawkins property well site end and Work Order 1450193 was raised to replace the signage.

The February 2010 report records observations on the 789 pipelines that plastic markers were on the ground at Hawkins property near Rimu A and Work Order 2023980 was raised to replace the signage.

The September 2010 report records that on 14th September 2010, after a fly over inspection, there were no observations on Origin Energy lines. This was approximately two weeks before the date the leak was identified.

The October 2010 report records two work permits issued relating to this leak. No 8716 on 789 Line to John Carthew for clean up spillage from pipeline leak and soil test to 1200 mm and No 8833 on 788,789,790 lines to John Carthew for the excavation to find the leak.

In summary there was no indication from the Vector monitoring programme identifying the leak.

6.4 Monitoring and Analysis - Baker Petrolite

As specified in OEUP-NZ1000-PLN-MTC-008 Internal Corrosion Control Plan, Origin engages a Corrosion Management Contractor (CMC) and this is currently Baker Petrolite.

This continues with the arrangement that was in place for Swift Energy NZ and they offer similar services for many other local petroleum based companies.

Baker Petrolite provides weekly testing and monitoring and dosage recommendation services as described in section 6.5.5.

They also provide bi-annual reports that are reviewed by Baker Petrolite and Origin, and are part of the SGS M&I audit process.

As part of the leak investigation a recent report on the Corrosion Monitoring History for Rimu Production Station was produced at the end of October 2010. It is a summary of relevant information from the reports Origin receives from Baker Petrolite (see Appendix E).

It includes the implementation of corrosion inhibitor dosing after weight loss was observed from coupons in 2005. This matter was not significant and was satisfactorily addressed by the corrosion inhibitor dosing.

As part of the continual improvement process the coupons were subsequently replaced over a three year programme with ER (CK4) probes to improve data collection on a more frequent basis.

6.5. Updating of Systems and Procedures

Core Group is a specialist pipeline integrity management company that provides services to the petroleum industry. Origin has currently contracted Core Group to review and update the Safety Management System for our pipelines to maintain compliance with recent and proposed changes to AS 2885, our nominated Operations and Maintenance standard.

Changes to the standard include:

AS2885.1 - 2007 Design & Construction,

AS 2885.1/Amdt No.1 - 2009 Design & Construction and the new requirements of AS2885.3 - 2001 Operation & Maintenance which is currently being revised and is due for reissue in 2010.

We have completed two stages of a five stage plan and have recently commenced work on the remaining three phases of the plan which is expected to be completed within the next six months. (see Appendix I)

6.6 Methodology

The following processes and practices are undertaken to prevent, identify and treat corrosion of the 100 NB pipeline.

6.6.1 Pigging

Pigging is an industry accepted practise and forms part of the management programme for our pipelines. It involves the pushing of a cup "pig" through a line to clean the inside of the pipe and push water, hydrocarbons and debris through the line. This helps prevent the build-up of fluids and solids in the pipeline that may lead to internal corrosion.

The wellstream products in the pipeline are used to push it along down the pipe until it reaches the receiving trap, the 'pig receiver. For the 100 NB pipeline the pig launcher is at the Rimu A wellsite and the receiver at the Rimu Production Station'

The 100 NB pipeline is pigged intermittently and this is governed by the material that has been through the pipeline and results from the monitoring program. For example if the line has been used for gas and corrosion monitoring showed everything was within normal parameters, there would be no need for it to be pigged.

Most recently the 100 NB line was pigged on the 27th August 2010 and prior to that the 1st August 2010.

Results from pigging data have not indicated any significant issues with the pipeline.

A full record of pigging dates and observation is included in Appendix J.

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6.6.2 *CK4 corrosion probes and corrosion coupons*

These are two methods for measuring corrosion rates based on the corrosion of an in-stream metal probe. Until 2009 corrosion coupons were used and subsequently replaced by CK 4 probes.

The main differences in the methodology is the coupons have to be physically removed from the pipelines and well stream separators to be analysed, whilst CK 4 probes can be electronically analysed without having to remove them from each location.

For the 100 NB line CK 4 probes are located in the pipeline as it enters the RPS and in the well stream separators also at the RPS.

The CK 4 probes are measured weekly. The corrosion data from the probes provides guidance for the pipeline monitoring and treatment programme.

6.6.3 *Pressure controls and monitoring*

The pressure in the 100 NB line is governed by the suction pressure maintained by the RPS compressors.

The compressors run at two levels:

High pressure: 29 bar (420 psi)

Low Pressure: 14 bar (203 psi)

For the Rimu A well site lower pressure levels are preferred as this assists with production rates from the wells.

The integrity of the 100 NB pipeline is protected by two systems.

The first system is duplicate barber (shut off) valves. These are located on the well head and are set to shut the flow in the pipeline if the flow reaches below 5bar (72 psi) possibly due to a loss of pressure in the line from a leak or rupture, or above 55bar (798 psi) possibly due to a line blockage.

The leak in the line was so small that the pressure in the line was around normal low pressure levels of 14bar (see Appendix F).

The 100 NB pipeline has the following design pressure characteristics:

Maximum operating pressure:	93 bar (1349 psi)
Design pressure:	93.5 bar (1356 psi)
Test pressure	153 bar (2219)

The second system is a series of alarms that indicate changes in pressure within set limits. These alarms are constantly monitored 24/7 by the duty operations staff located at the RPS control room.

The alarms are set to activate if there is a change in pressure of more than 6 bar (87 psi).

With regard to the 100 NB pipeline there were no unusual changes in pressure that have triggered either of the above systems.

The data showing pressure trends can be found in Appendix F.

6.6.4 Fluid sampling

Sampling is undertaken off the well stream produced water and oil that flows through the lines. The purpose of this is to monitor for irons and SRB's (sulphur reducing bacteria).

Every two weeks test samples are taken from the separators at the RPS.

The analysis of these samples assists in determining dosing rates for biocide and corrosion inhibitors to manage corrosion and SRB issues.

6.6.5 Chemical treatment

Pipelines are dosed with chemicals to assist in controlling internal corrosion.

Dosing is undertaken at the wellsite and at the production station to minimise corrosion in the pipeline and at the production station.

Testing of the pipeline fluids and corrosion probes as discussed above in sections 6.6.2 and 6.6.4 help determine the dosing requirements.

The main chemicals used are corrosion inhibitors and biocides. The 100 NB pipeline is currently dosed with Corrosion Inhibitor CRW29820 and Biocide XC29393.

Both are according to the dosage instructions from Baker Petrolite and both are injected at the wellsite at the start of the pipeline.

CRW29820 is used for internal corrosion inhibition. It is made up in water and contains the following chemicals:

- 2-(2-butoxyethoxy)ethanol : 203-961-6 112-34-5 10-30% Xi;R36
- Imidazoline salt: 1-5% Xn;R22. Xi;R36/37/38.
- ~~Phosphate ester salt: 5-10% Xi;R36/38.~~

XC29393 is a Biocide used to control SRB"s (Sulphur reducing bacteria) to assist in minimising internal corrosion. This is dosed in batches, is made up in water and contains the following chemicals:

- Alkyl propylene diamine salt: 263-195-3 61791-63-7 10-30% Xn;R22. C;R35. N;R50.
- Benzyl alkyl dimethyl ammonium chloride 8001-54-5 1-5% Xn;R22. C;R34. Xi;R41.

The corrosion probe monitoring and water sampling is undertaken on Origins behalf by Baker Petrolite Ltd.

From the monitoring and testing, Baker Petrolite produces dosing instructions for volume and frequency.

Dosing of the corrosion inhibitor is on a continual injection basis from the wellsite and the biocide is on a batched as required basis. Attached in Appendix K are the dosing records for the biocide batches.

7. Leak Discussion

7.1 Period of discharge

Before we were notified on the 8th October we were not aware of the pipeline leak and our monitoring showed no indications the leak was occurring.

Inspection of the line revealed that there had been a leak of fluid. The fluid would most likely have included produced water and hydrocarbons.

The neighbour who advised us of the leak, Mr Steele stated that he first noticed it around ten days beforehand but thought it was something to do with the heavy rainfall at the time and did not think anything more of it until viewing it again on the 8th October.

The Vector flyover inspection on the 14th September did not notice anything of concern along the easement.

The combination of the small leak slit and low line pressure means there was no significant leakage at any one specific time, rather a small leak occurred over a period of time.

We therefore cannot accurately determine how long the pipeline had been leaking.

However based only on the visual evidence on the surface as noted by the neighbour approximately around the 29th September , and the Vector fly over on the 14th September, we can estimate that the leak started to appear on the surface somewhere between the 14th and 29th September 2010.

7.2 Volumes of discharge

The volume of material discharged to the environment is not able to be accurately identified. This is due to the leak occurring overtime at levels that were not detectable by our monitoring systems.

The actual content of the discharge is also not able to be accurately determined. Although we know that the pipeline contained well stream product and the well stream contains hydrocarbon, produced water and gas, there is no consistent ratio between them so we are unable to estimate the percentages of each well stream component.

What we do know is from visual and chemical analysis it is evident that hydrocarbons and produced water leaked from the pipeline.

However based on the physical evidence in the affected environment when the spill was discovered, we can estimate that the volume of well stream fluid discharge. This could be somewhere in the vicinity of 200-500 litres.

7.3 Analysis of the cause of the leak of 100NB Rimu Pipeline

The pipeline was cut and a corroded section where the leak was located was sent to Quest Integrity NZL Limited (Quest).

Quest Integrity Group is an international company focused on asset integrity and reliability management solutions. They offer technology-enabled advanced inspection and engineering assessment services and products.

As part of their services Quest provides Metallurgy analysis and we sought their help in analyzing the pipeline corrosion to determine its root cause.

The following is a summary of their process and conclusions;

7.3.1 Visual examination (refer to Appendix G for photos)

The pipe was cut in longitudinal direction (cut conducted at 3 and 9 o'clock positions) and subjected to visual examination and the following was observed:

- Top half (12 o'clock) was found covered by a black and uniform layer.
- Bottom half (6 o'clock) was of light brown/red colour and exhibited considerable number of large open pits (> 1 cm). These were scattered in random between 4 to 8 o'clock positions along the entire length of the section. Amongst them was also the failure located around 6 o'clock position, close to the longitudinal weld, but evidently not at the weld.
- The size (depth and diameter) of pits decreased as they moved away from the 6 o'clock position.
- Large and deep pits had circular/oval shape, and some of them have an appearance of a comet.
- Small pits were rather circular.

7.3.2 X-Ray Diffraction Spectroscopy:

The surface layers on both halves of the pipe and the corrosion product from the bottom of the pit associated with the failure were examined. It was established that:

- Dark layer on the Top Half consists of siderite ($FeCO_3$) and magnetite (Fe_3O_4).
- Light brown/red layer on the Bottom half is siderite.
- Corrosion product found at the bottom of the failure consists of siderite.

7.3.3 Water analysis:

The saturation index of water was established at -1.76, which indicates that the water is corrosive. Concentration of chloride ions was established at about 0.07 g/dm^3, which is relatively low.

7.3.4 Analysis Conclusion

Based on the results from the visual inspection, X-Ray diffraction spectroscopy and the water analysis, the following is a preliminary statement from Quest on the possible cause of the failure:

- Failure and the observed pitting are not associated with longitudinal weld.

- From the supplied documentation that outlined the horizontal profile of the pipeline, it is evident that the failure is located within the part of the pipe-work with lowest vertical position. Considering that the pipeline has been used intermittently, this would allow for pooling of water at this specific location.

- The supplied water was found corrosive, and contained solids (visible upon receipt) and chloride ions.

- The presence of siderite in the analysed corrosion product and the surface layers indicates that CO_2 corrosion plays a significant part in the corrosion mechanisms.

- The operating temperature (60°C) would allow for condensation of water vapours on the top half of the pipe and CO_2 present in the environment would ultimately lead to formation of siderite; magnetite being the natural product of uniform corrosion. This explains the composition of the analysed surface layer on the top half.

- It is highly possible that the bottom of the pipeline at the investigated location would accumulate sediment. Presence of sediment eliminates effect of the corrosion inhibitor in the produced water and allows for the formation of more severe environment that would promote localised corrosion.

- Some corrosion pits carry comet-like features, which is often associated with flow-assisted corrosion.

8. Why did we not prevent the leak?

8.1 Integrity Management

As discussed in section 5 of this report Origin has an extensive pipeline management and monitoring programmes in place. This includes:

- Integrity Management and Compliance Systems to meet requirements of Health and Safety in Employment (Pipelines) Regulations 1999
- Pipeline certification and independent audit by SGS M&I.
- Pipeline integrity procedures
    - Integrity Management Strategy Onshore Pipelines
    - OEUP-NZ1000-PLN-MTC-003 Safety and Operating Plan Onshore Pipelines
    - OEUP-NZ1000-PLN-MTC-008 Internal Corrosion Control Plan
    - OEUP-NZ1000-PRO-MTC-004 Pipeline Easement Surveillance and Maintenance Onshore Pipelines
    - OEUP-NZ1000-PRO-MTC-008 Pipelines Annual Operations and Maintenance Review
    - Risk Analysis for Rimu A/B to Rimu Production Station 200/100 NB Flowlines
- Easement Management by Vector
- Monitoring and analysis provided by Baker Petrolite Ltd

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- Pipeline Integrity Management processes
  - Pigging
  - Corrosion inhibitor and biocide dosing
  - Corrosion probes and coupons
  - Fluid sampling and corrosion analysis
  - Line pressure controls and monitoring

Origin takes a risk based approach to all areas of health safety and environmental care.

Risk analysis of Rimu A pipelines identified internal corrosion with an unlikely frequency of occurrence and low risk class. Pitting corrosion was not identified as a risk

This is the first failure associated with our pipeline assets and very rare across the industry.

Monitoring records do show a spike in iron levels and it was reasonable for us and our consultants to assume that iron was coming from metal loss through the entire length of the pipeline rather than localised pitting. The iron levels recorded did not give cause for concern against this assumption and the pipeline was dosed with corrosion inhibitor and biocide and the iron levels then returned to normal.

The risk of a leak through internal corrosion was determined as being low due to the integrity management discussed above. These measures are considered as "best industry practise".

The analysis by Quest notes the cause of the corrosion is linked to CO_2 corrosion and the presence of sediment at the pipeline low point and the pooling of water at this specific location.

Pigging is the only physical treatment for the cleaning of material in the pipeline. The pig is pushed through using well fluids. This does not remove all fluids from the line and in some cases some of the produced water remains. Once the pitting has started then there is a void below the internal walls of the pipe that the pig will not come into contact with and sediment and fluids may settle in these voids.

The gas that is used to gas lift the well is supplied from the RPS and is treated to export gas quality. While it has a small amount of CO_2 present it is not corrosive. This is not normally a problem due to the monitoring and treatment programme that is in place.

Once this gas is injected into the well and used as gas lift, it comes in contact with the reservoir fluids and becomes saturated and would increase the risk of corrosion in the 100 NB pipeline. To mitigate against this risk, continuous corrosion inhibitor is injected into the pipeline at the Rimu A site.

Questions have been raised over whether intelligent pigging could have assisted in identifying the leak potential.

Historically intelligent pigs have not been available for 100mm (four inch) pipelines as the design of the pigs is such that they would not be able to travel around the tight radius bends.

Intelligent pigging is commonly used for 200mm (8 Inch) gas lines.

Intelligent pigging of suitably sized wellstream lines is still relatively uncommon in the industry as they require a very clean interior pipe environment. This involves extensive preparation of the line prior to introduction of the intelligent pig usually involving toxic cleaning fluids.

In recent times we have been advised by the technology vendors that intelligent pigs have now been developed for 4" lines. However they also advise there is still a question around the reliability of data from pigs of this size.

Origin has not considered the use of the new pigs to date because the risk assessments for the pipelines did not justify it.

9. Environmental Effects of Leak

The unnamed tributary of the Manawapou River has been affected by the leak. Hydrocarbons and produced water have entered the stream and have affected the ecology downstream from the spill.

Analysis of the stream has shown that the levels of hydrocarbons and chlorides as measured at the sample point 50m upstream from the discharge to the Manawapou River were at acceptable levels.

The main visible area affected by the leak was 80m downstream from the leak point. Although nothing physical was seen beyond this point the benthic macro-invertebrate community can be particularly sensitive to such events but these communities are also known to recolonise and recover reasonably quickly.

The quick response to contain the effects when the leak was discovered has aided the prevention of downstream contamination. The solidification of the waxy oil and the removal of this material was the first priority of the cleanup.

This was assisted by the stream diversion during the site cleanup and excavation works which restricted further downstream contamination from these activities.

Some of the effects of the leak contamination to the stream environment were short lived and during the clean up process eels and koura were discovered surviving in the effected stream area. They were relocated upstream of the spill.

Looking forward there is some mitigation that will assist in the regeneration of the stream ecology.

Stream Mitigation

a. Reinstate the stream bed and environment close to its original dimensions as far as practicable.

b. Provide a riparian planting programme from the water fall up the stream valley to the point of the large dam which is located upstream of the spill area.

c. Invite the TRC, Iwi and community to be involved in the riparian project.

d. Work in partnership with the TRC education unit, providing an opportunity for a curriculum based project to track the regeneration of the stream.

10. Management Review

The work that was in progress with Core Group before this event includes updating of our Safety Management Process and includes a Qualitative Risk Assessment.

The results from this 100 NB failure analysis will now be fed into this and used to generate an updated and more accurate Risk Assessment.

From this we will review the work programmes we have in place and make the necessary adjustments to our current operation and management processes to cover the new risks that have been identified and incorporate the lessons learnt as a result of the leak.

It is expected that the revised version of AS 2885 Part 3 - Operation & Maintenance scheduled for release this year will reflect the requirements of AS 2885 Part 1 - 2007 which requires a Safety Management Study (risk assessment) to be carried out, as a minimum, every 5 years and reviewed, as a minimum, every year.

This work will enable us to comply with these requirements going forward.

We also intend to share the lessons learnt from this event with other industry representatives to alert them to any issues arising from the review.

In summary

This leak occurred as a result of a very small failure of the Rimu A 100 NB pipeline. We consider we had undertaken all necessary precautions to minimise the probability of this leak event. The management, audit, operations and maintenance programmes have been undertaken according to "best industry practise".

Given our operations and maintenance regime, including extensive input for external advisors and the fact that this type of occurrence is rare in industry terms and has never ~~previously been experienced by us, we do not consider the event could reasonably have~~ been foreseen or provided against by us.

Our staff reacted well to the leak event and their prompt action and the action of the cleanup and investigation team that followed has minimised any ongoing effects on the environment. The effects have been mitigated and remedied and this work is ongoing.

We also worked well with the key stakeholders the TRC, Iwi and the landowner in addressing all concerns regarding the leak and environmental effects.

We undertake to take remedial works to return the stream to a healthy environment including a new extensive riparian planting programme.

Our current Safety Management Process review will now take into further account the findings from the leak investigation to ensure the likelihood of this type of event occurring again in the future is minimal.

origin

We would like the opportunity to discuss this report with the TRC and in the meantime invite you to contact Anthony Joines (06 7592503 - anthony.joines@origenenergy.com.au) if you have any questions or require further information.

Yours faithfully

[signature]

Max Murray
New Zealand Production Services Manager

Ph 06 759 2518 mob 027 226 3153
email max.murray@originenergy.com.au

Note: Appendices provided [illegible]

Land Use Consent

Pursuant to the Resource Management Act 1991
a resource consent is hereby granted by the
Taranaki Regional Council

Name of Consent Holder:	Origin Energy Resources NZ [Rimu] Limited Private Bag 2022 NEW PLYMOUTH 4342
Consent Granted Date:	24 January 2001

Conditions of Consent

Consent Granted:	To lay a pipeline under the bed of the Manawapou River for conveying hydrocarbons for the Rimu Production Station at or about (NZTM) 1715952E-5609771N
Expiry Date:	1 June 2016
Review Date(s):	June 2004, June 2010
Site Location:	Rimu Production Station, Mokoia Road, Mokoia [Property owner: Geoffrey Hawken Limited]
Legal Description:	Sec 586 Patea Dist Blk XIV Hawera SD
Catchment:	Manawapou

For General, Standard and Special conditions
pertaining to this consent please see reverse side of this document

General conditions

a) That on receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.

b) that unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.

c) That the consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:

   i) the administration, monitoring and supervision of this consent; and
   ii) charges authorised by regulations.

Special conditions

1. The consent holder shall notify the Chief Executive, Taranaki Regional Council, at least 48 hours prior to commencement and upon completion of the installation of the pipeline, and again prior to and upon completion of any subsequent maintenance works which would involve disturbance of, or discharge to, the stream channel.

2. The pipeline licensed by this consent shall be constructed pursuant to the documentation submitted in support of application 1231.

3. During construction and any subsequent maintenance, the consent holder shall observe every practical measure to prevent the discharge or placement of silt and/or organics and/or any other contaminants into the stream and to minimise the disturbance of the stream channel and stream banks.

4. The consent holder shall ensure that disturbance of the stream channel will be restricted to a practicable minimum and that areas disturbed from the exercise of this consent are to be reinstated to the satisfaction of the Chief Executive, Taranaki Regional Council.

5. The consent holder shall prepare a contingency plan to be approved by the Chief Executive, Taranaki Regional Council, prior to the exercise of this consent, to show the effect of pipeline malfunction, and measures to avoid, remedy and mitigate the environmental effects of such malfunctions. This plan shall be approved prior to using the pipeline.

6. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2004 and/or June 2010, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Transferred at Stratford on 1 December 2008

For and on behalf of
Taranaki Regional Council

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Director-Resource Management

Discharge Permit

Pursuant to the Resource Management Act 1991
a resource consent is hereby granted by the
Taranaki Regional Council

Name of Consent Holder:	Origin Energy Resources NZ [Rimu] Limited Private Bag 2022 NEW PLYMOUTH 4342
Change To Conditions Date:	2 February 2001 [Granted: 24 January 2001]

Conditions of Consent

Consent Granted:	To discharge treated stormwater from the Rimu Production Station onto and into land and into an unnamed tributary of the Manawapou River at or about (NZTM) 1715752E-5610471N
Expiry Date:	1 June 2016
Review Date(s):	June 2004, June 2010
Site Location:	Rimu Production Station, Mokoia Road, Mokoia [Property owner: Geoffrey Hawken Limited]
Legal Description:	Sec 586 Patea Dist Blk XIV Hawera SD
Catchment:	Manawapou

For General, Standard and Special conditions
pertaining to this consent please see reverse side of this document

General conditions

a) That on receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.

b) That unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.

c) That the consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:

   i) the administration, monitoring and supervision of this consent; and
   ii) charges authorised by regulations.

Special conditions

1. The consent holder shall at all times adopt the best practicable option, as defined in the Resource Management Act 1991, to prevent or minimise any adverse effects of the discharge on the receiving environment.

2. The maximum stormwater catchment area shall be no more than 15.53 hectares.

3. Prior to the exercise of this consent, the consent holder shall prepare a contingency plan to be approved by the Chief Executive, Taranaki Regional Council, outlining measures and procedures to be undertaken to prevent spillage or accidental discharge of contaminants not licensed by this consent and measures to avoid, remedy or mitigate the environmental effects of such a spillage or discharge.

4. The design, management and maintenance of the stormwater system shall be generally undertaken in accordance with the information submitted in support of the application.

5. Any above ground hazardous substances storage areas shall be bunded with drainage to appropriate recovery systems and discharged only after testing to ensure the conditions of the consent can be met.

6. The following concentrations shall not be exceeded in the discharge:

Component	**Concentration**
pH (range)	6.5-8.5
suspended solids	100 gm^{-3}
total recoverable hydrocarbons [infrared spectroscopic technique]	15 gm^{-3}

This condition shall apply prior to the discharge of the treated stormwater into the receiving environment, at a designated sampling point approved by the Chief Executive, Taranaki Regional Council.

7. After allowing for reasonable mixing, within a mixing zone extending 80 metres downstream of the discharge point, the discharge shall not give rise to any of the following effects in the receiving waters of the Manawapou River:

    a) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
    b) any conspicuous change in the colour or visual clarity;
    c) any emission of objectionable odour;
    d) the rendering of fresh water unsuitable for consumption by farm animals;
    e) any significant adverse effects on aquatic life.

8. The Chief Executive, Taranaki Regional Council, shall be advised 48 hours prior to the reinstatement of the site and the reinstatement shall be carried out so as to minimise effects on stormwater quality.

9. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2004 and/or June 2010, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Transferred at Stratford on 1 December 2008

For and on behalf of
Taranaki Regional Council

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Director-Resource Management