1 INTRODUCTION

BMT WBM is a leading international multi-disciplinary engineering, science and technology consultancy offering a broad range of services, particularly in the defence, energy, environment, shipping and general transportation sectors. Customers are served by a network that currently comprises 26 international subsidiary companies. Further details can be found at www.bmt.org.

BMT WBM is an Australian subsidiary that was established in 1969 to provide specialist engineering and environmental consultancy services to a broad range of industries from offices in Melbourne, Brisbane, Newcastle, Sydney, Perth, Mackay, Vancouver (Canada) and Denver (USA). Our web site can be found at www.bmtwbm.com.au for more detailed information.

BMT WBM’s team of engineers, scientists and technicians are highly qualified and collectively have vast experience in a broad range of fields. An open-minded approach enables BMT WBM to characterise root causes of problems and provide definitive solutions. The benefits of these services are improved quality, robustness, reliability and availability of machinery, greater safety, avoidance of unexpected operational problems, extended life and lower life cycle operating and maintenance costs.

One of BMT WBM’s particular specializations is the engineering associated with large materials handling equipment including bucketwheel excavators, stackers, reclaimers, ship loaders, ship unloaders, conveyors and conveying systems, mills, crushers, screens, draglines and mining shovels. As a highly experienced designer, BMT WBM has the technical expertise and experience to provide engineering services for projects involving this type of machinery. Some of the services offered by BMT WBM include:

- Investigation services including design auditing, concept design study, feasibility studies, due diligence studies, machine life extension, risk and hazard assessment.
- Project management for construction and overhaul, including complete refurbishment projects.
- Design of machinery and associated peripherals from concept through to the detailed design of individual components for manufacture. Our design engineering methodology involves finding a solution based on innovative thinking, knowledge and engineering expertise.
- Specialist electrical services including power reticulation design, control systems design and PLC programming.
- Procurement services including supply contract management, quality assurance in manufacture, etc.
- Technical support for projects including test and measurement services, commissioning, mine development technical services.

BMT WBM has particular expertise in using specialist design tools for analysis and design, including finite element analysis, computational fluid dynamics, discrete particle modelling, fatigue analysis, conveyor static analysis, conveyor dynamic modelling and analysis, etc. BMT WBM has experienced analysts to provide efficient and reliable analysis of problems and has developed in house software for complex state of the art analysis work in conveyor dynamics, free piston dynamics and hypersonic flows.
BMT WBM has full third party Quality Assurance accreditation to AS/NZS ISO 9001:2000. The QA system utilised by BMT WBM includes specific procedures for design, design review, project management, site troubleshooting, post-processing, analysis and reporting.
2 **MINING MACHINERY CAPABILITY**

BMT WBM provide specialist engineering and technical support services for the owners, operators and constructors of bulk materials handling plant such as stackers, reclaimers, conveyor systems, excavators, mining machinery, crushers, screens, trucks and shovels; transport systems such as train locomotives, carriages, wagons etc; port facilities such as cranes, grab unloaders, ship loaders etc; aerospace and defence systems; and many other engineering areas.

BMT WBM has also recently been involved in projects as the prime design and construction contractor. These recent projects add to many where BMT WBM has had very significant involvement throughout the complete project from concept design to finally commissioning the plant at site.

2.1 **Design Audit & Life Extension**

BMT WBM has carried out numerous design audits and re-design analysis to improve or rectify existing machinery. BMT WBM has also been involved in several life extension projects that involve a review of the overall design and fatigue life of machine structures.

Typical projects have included:

- Design and Condition Audit for 20 year life extension for major coal conveyor system, (CLP).
- Design and condition audit for 20 year life extension for 2 grab unloaders, (CLP).
- Design investigation on various Marion and Bucyrus Eyre shovels including fatigue crack investigations and detailed site testing and measurement.
- Longwall Roof supports - design audit of 870 tonne, 2 leg design.
- Ore Grinding Mill - re-design of manhole covers to avoid fatigue cracking.
- Coal trainer - fatigue design and FE analysis.
- Bucket wheel excavators - design audit and slew bearing failure analyses.
- Concrete pump - performance assessment for different pump speeds and pipeline lengths.
- Underground coal shearer ranging arms - re-design analysis including strain gauging and fatigue analysis.
- Design Audits of Bulk Material Handling Systems - conveyors, ship loaders, reclaimers, screens, etc.

2.2 **Detailed Design**

BMT WBM provides mechanical, electrical and structural design services across a broad range of industries, from conceptual design and feasibility study to final design, FE analysis and material selection, fabrication and commissioning specifications to life cycle maintenance procedures. Most of the design projects undertaken by BMT WBM involve the integration of mechanical, structural, electrical, electronic and fluid power hydraulic systems together with associated controls. These services are inherently linked with both manual and computational design techniques, several of which have been developed in house.
Examples of projects were BMT WBM has undertaken detailed design include:

- Detailed structural, mechanical, electrical, hydraulic and automatic control design for the bucket-wheel reclaimer and discharge system on the M. V. Wunma transfer vessel for Pasminco.
- Detailed structural, mechanical, hydraulic and control system design for port passenger gantries for Sydney Ports.
- Detailed mechanical, electrical and structural design of large conveyor systems for coal, overburden and rock (copper ore), including dynamic analysis using in house developed software, for Minera Escondida Limitada in Chile.
- Materials handling machine component design and redesign maintaining regulatory requirements.
- Ship loader and reclaimer skew control systems - design, manufacture, installation and commissioning of several systems to avoid skew problems.
- Self propelled elevating work platform - 24 m three piece telescoping boom able to support its 300 kg safe working load from full horizontal to full vertical reach.

BMT WBM has designed many ‘special purpose machines’ for customers with specific requirements. Typical projects include:

- Design of (robotic) wagon vibrator for releasing coal from coal wagons as they move through a discharge shed.
- Design of self propelled, remotely controlled vehicles for transporting and locating pipe line segments.
- Design, building and use of portable numerically controlled grinding machinery for dragline slew bearings and for rotary breakers, (Figure 4).
- Design of throttle and steering controls for radio controlled target boats.
- Design of wave and tide generating machines for hydraulic model basins. These machines incorporate electro-hydraulic servo controlled actuators, analogue and digital control electronics.
- Design of electro-mechanical servo systems for automatic positioning of articulated landing platform for a ship to shore access facility.
- Design, installation and commissioning of PLC and microprocessor based skew control systems for reclaimers.
- Custom Test Rig Design - fatigue of components, unusual loading configurations.
- Design of an automated rotary press for the manufacture of building panels. (Figure 5).

Over the past twenty years BMT WBM have carried out a large number of detailed design, machine modification and life extension projects on bulk handling and mining equipment worldwide. The most recent of these projects have been design audits, maintenance audits, redesign, refurbishment and life extension of the coal handling plant at the CLP – Castle Peak Power Station in Hong Kong.

The following pages give summaries of just a few of the significant projects that BMT WBM has completed.
2.3 Loy Yang Mine L310 Conveyor Design

Loy Yang Mine in Victoria engaged BMT WBM to design the L310 conveyor. This conveyor handles both coal and interseam at a nominal rate of 8500 tonne per hour. In future this conveyor will allow coal winning to extend to a new area and was designed to extend to approximately 6km in length. It was the first time that 6.6kV VVVF drives were used in the mine. The structural design accommodates the issues of future relocation and severe ground movements by using a flexible modular structure concept.
2.4 Loy Yang Mine Dredger 16 Bucketwheel Design

BMT WBM provided the design for the new double cone bucket wheel for dredger 16 at Loy Yang. BMT WBM utilised experience in bucketwheel design combined with special expertise in finite element analysis to provide the wheel design.

The double cone design provides savings in mass, efficient structural design, fatigue life and reduced spill accumulation. BMT WBM was able to simultaneously improve the bucket design of Dredger 14 at Loy Yang and apply this in the D16 wheel design to minimise spares holdings and maximise the efficiency of maintenance of the machines.

BMT WBM’s involvement in the project also included complete management of quality assurance for the manufacture of the wheel and buckets. Forging, casting and welding quality was closely monitored through ITP’s and inspections by BMT WBM’s experienced engineers and technical officers to ensure the final performance of the wheel.

Performance measurement for the new wheel indicates that a significant increase in digging efficiency has been achieved with the new design.
2.5 Loy Yang Mine Proposed Internal Overburden Conveyor System

Loy Yang Mine engaged BMT WBM to produce concepts to transfer overburden dumping into the mine. BMT WBM developed design concepts that minimised the changeover outage period, maintained critical road access throughout the construction period, and provided flexibility for other possible future plant upgrades and additions.
2.6 Loy Yang Mine Head Chute Modifications

These drawings show typical chute upgrades designed by BMT WBM, where the speed and ease of construction is critical to the success of the projects.

In this example, the original chute was wearing and developing cracks and was replaced.

In this example the belt line through an existing tail end boot was straightened and the skirts redesigned to overcome maintenance problems.
2.7 Loy Yang Bunker Controls System

BMT WBM have been involved in three control systems upgrades at the Loy Yang Mine in Victoria, the raw coal storage bunker, the control system for the bunker discharge wagons and the overall mine control and monitoring system redevelopment.

The projects have involved detailed design of control system, PLC programming, systems investigations, integration with existing systems, remote operation design and development of SCADA systems.
2.8 Yallourn Energy Mine Planning

BMT WBM personnel undertook the concept and detailed design for the Yallourn Eastfield project, which involved 15 conveyors being relocated to a new mining area with minimal disruption to mine operation.

BMT WBM can work with mine planners and geotechnical specialists to plan the layout in the mine. This involves looking at long term objectives in order to create specifications that accommodate future developments and as a result lower capital costs for the short and long term.
2.9  Yallourn Energy E415 Conveyor Design

BMT WBM were contracted to carry out the concept and detailed structural, mechanical, electrical and controls design for conveyor E415, as well as the design related activities for the refurbishment of two other conveyors – E410 and E400.

The conveyor system forms a strategic part of the coal transport infrastructure supplying the Yallourn W Power station.

E415 conveyor was designed with a moving shuttle head, capable of loading the four rising conveyors that supply coal to the 60,000 tonne storage bunker, at a nominal rate of 3,500 tonnes per hour.
2.10 Latrobe Valley Mines Bucketwheel Dredger Projects

BMT WBM has been involved with various projects regarding bucketwheel dredgers and other large mining machinery in the Latrobe Valley mines (Maryvale, Morwell and Loy Yang). Some of these projects include:

- Dredger 15 bucketwheel investigation and development of a repair strategy
- Dredger 13 bucketwheel shaft assessment
- Dredger 13 control system upgrade
- Dredger 25 stability assessment
- Dredger 14 slew torque device
- Dredger 11 stability assessment
2.11 Escondida Copper Mine Conveyor Design

BHP’s Escondida mine (MEL), in Chile is one of the world’s largest and richest copper mines, with an annual production rate in excess of 800,000 tonnes.

BMT WBM was contracted to manage the complete design project for the Stage 4 Conveyor development for MEL. This involved the design of 4 new conveyors as well as the substantial modifications and extensions to existing conveyors.

As the conveyors were crucial in maintaining the entire copper production of Escondida, it was important for the machinery to be designed to allow extremely short outages for integration of the new conveyors into the existing systems. BMT WBM used expertise gained in other mines to provide innovative design solutions to minimise outage risks and simplify erection.

The project involved providing sufficient mechanical, structural, civil and electrical documentation for the design, supply and erection of four new conveyors, the head end extension of two existing conveyors and a tail end extension of another conveyor.

BMT WBM also carried out detailed dynamic conveyor modelling for all of the conveyors to ensure that the 7000 tph handling rate could be achieved and that starting and stopping the conveyors could be achieved without unfavourable dynamic behaviour.

Challenges in the design for the project included the design of transfers to handle the hard rock ore where the transfer height in some cases was up to 13m. The

Following the completion of the design phase, BMT WBM personnel returned to Chile to provide technical support for the erection phase, critical outages and commissioning.
2.12 Dalrymple Bay Stacker/Reclaimer Failure Analysis

BMT WBM was involved in the investigation of a catastrophic collapse of the Dalrymple Bay Coal Terminal RL1 stacker/reclaimer.

The investigation found that sections within the support arms at the base of the machine were not installed appropriately and that the failure was caused by fatigue in one of the support arms.

Finite element models were produced to estimate the dynamic loading on the machine and to assess its fatigue in operation. The finite element models correlated well with the real problem and the failure mechanism was successfully modelled.
2.13 China Light & Power Audit, Design & Refurbishment

BMT WBM was commissioned by China Light and Power (CLP) – Hong Kong, to carry out a detailed audit of the complete coal handling conveyor system. The project was broken down into several stages, including:

• Detailed inspection and testing of conveyors (around 42 off) with audit report recommending actions required to extend the operating life for a further 20 years.

• Detailed design of all conveyor transfers, (over 80), incorporating improved transfer, sealing, new impact arrangements, anti-corrosion materials etc.

• Rationalisation study for pulleys and detailed design of new pulleys for each conveyor.

• Selection and nomination of appropriate belt and pulley cleaning equipment.

• Review and design of dust suppression spray systems for conveyor transfers.

• Preparation of detailed technical specifications for the refurbishment of all the conveyors, transfer houses and supporting structures.

• Review of tenders for the refurbishment work.

• Staged audits of the refurbishment work, preparation of audit reports including detailed outstanding works lists.
BMT WBM was commissioned by China Light and Power (CLP) to carry out two significant design and construction projects associated with their stacker reclaimer.

The first project involved replacement of the machine’s main slew race and suspension ropes. The second project involved the complete refurbishment of the machine including:

- Design, supply and replacement of all chutes.
- Design, supply and erect new automatic lubrication systems.
- Repair of mechanical and structural damage and modification of belt profiles.
- Overhaul of the bucketwheel including redesign and replacement of the buckets and shaft.
- Design and installation of a complete new electrical and control system including new PLC and VVVF drive systems.
- Design, supply and installation of new travel drives, wheels and rail clamps.
- Overhaul of all other drives including the bucketwheel drive.
- Design, supply and installation of new conveyor components including idlers, pulleys, belt cleaners, pull wires, etc.
- Painting of the entire machine.
- Finite element analysis for life extension evaluation.
- Training of CLP Personnel.

BMT WBM as prime contractor utilised local contractors in Hong Kong under the supervision of a BMT WBM site project manager to complete the project works on time and within budget.
2.14 PASMINCO Bulk Transfer Vessel

The Pasminco Century Zinc project has commissioned a 5,100 dwt self loading / self unloading transfer vessel, the M. V. WUNMA, to transport lead and zinc concentrates from Karumba, Queensland, to export vessels anchored in deep water in the Gulf of Carpentaria.
BMT WBM were responsible for all of the materials handling plant design, including the mechanical, structural, electrical and controls details for 7 conveyors, a bucket wheel reclaimer, a load distribution gantry, a slewing, luffing discharge boom, the cargo hold enclosure and the ventilation and dust control systems. The mechanical and structural design was progressed in detail, producing fabrication and machine shop drawings.

BMT WBM supervised the fabrication and construction of the materials handling plant in China and commissioned the plant. The controls system PLC software was written, installed and commissioned by BMT WBM personnel.

BMT WBM currently is contracted to Intercontinental Ship Management (ISM) to provide on-going engineering and technical support for the plant.
2.15 BT Marine Spur Barge

BMT WBM was commissioned to provide concept design and detailed design services of the materials handling plant mounted atop a barge for BT Marine through PTINDOSTRAITS.

The design incorporated a moving bridge structure, transfer conveyors, hoppers and a discharge boom with both slewing and luffing controls. BMT WBM provided all the mechanical, structural, electrical and controls design. Finite element analysis was conducted that assessed many different load cases provided by the barge design and its response to wave data and also for hopper design.
2.16 OneSteel Whyalla Shiploader Life Extension

BMT WBM was engaged by Thiess to provide design services for the refurbishment of the OneSteel shiploader located in Whyalla, South Australia. The existing 40-year-old shiploader with inherent constraints and limitations was refurbished to achieve an operable and maintainable asset to current standards and expectations. BMT WBM provided both mechanical and electrical design services to increase performance of the plant whilst simultaneously addressing environmental issues.
2.17 Esperance Port Authority Shiploader

BMT WBM has been retained by Esperance Port Authority (EPA) Western Australia, to conduct the mandatory shiploader annual structural inspections. Areas inspected include primary and secondary structures and all critical mechanical connections effecting the strength and stability of the plant.

BMT WBM has also been retained by EPA as their prime consultants regarding all technical advice for their shiploaders and also for other general plant. Recent design work includes an additional braking system for a shiploader boom shuttle drive, pivoting spill plate beneath a shiploader boom to address environmental concerns, lifting devices for their workshop and general ad-hoc technical advice such as welding procedures.
2.18 Lyttelton Port of Christchurch Coal Handling Facility Review

Lyttelton Port Company and Solid Energy engaged BMT WBM to provide an independent review of the coal handling system and associated plant. Coal is delivered by train and is then distributed to ships via mobile plant, a bucket wheel reclaimer, conveyors and a shiploader. Improvements were sought in the following areas:

- Operational efficiencies.
- Ability to achieve required load-in and load-out rates.
- Maximise stockpile capacity.
- Minimise use of mobile plant, and
- Reduce the cost per tonne handling rate.

BMT WBM provided a review which detailed equipment related inefficiencies, product handling characteristics and associated inefficiencies, and the inefficiencies in the facility layout. Recommendations to rectify the issues were provided to the client.
2.19 Cargill Salt Twin Boom Stacker & Tripper

BMT WBM was responsible for the complete detailed design of a new tripper section in the twin boom stacker arrangement for Cargill Salt.

The design needed to be compatible with the existing connecting boom structure, and had to incorporate a soft loading directional transfer chute.

The design was tailored to accommodate an extremely short system outage window to minimise plant downtime. BMT WBM was also involved in the supervision of manufacture, installation and commissioning of the project.
2.20 Blackwater Mine Shovel

A recently completed project involved the assessment of structural cracking problems with a large shovel carbody at Blackwater mine, Central Queensland. BMT WBM redesigned a totally new carbody structure, which was subsequently fabricated and retrofitted to this shovel.
2.21 NRG Dravo Reclaimers

BMT WBM has completed a major remnant life assessment, life extension project for NRG, Gladstone, on two of their three Dravo reclaimers. NRG were seeking advice on how to appropriately upgrade and/or manage these machines to enable them to operate at increased capacity for an additional 20 years.

The project involved analysis and assessment of all of the structure and machinery and resulted in decisions to implement the following:

- new bucketwheel shaft, bearings and new hydraulic drive;
- refurbished bucketwheel.
- new luff cylinders and revised hydraulic luff circuit.
- new upgraded capacity slew bearing.
- structural reinforcement of boom, rotating cone, operator’s cab support, undercarriage and lower cone.
- upgraded load equalisation system for undercarriage.
2.22 BELSIM Bulk Materials Conveyor Analysis Software

Long conveyors may have dynamic behaviour, which contributes to spill, plant damage and/or belt failure. Dynamic events such as aborted starts and emergency stops result in a sudden change in the belt tensions in a conveyor. In long conveyors the time taken for the belt tensions to settle down is significant and so dynamic events can result in tension ‘waves’ that overload the structure, cause excessive belt sag and spill etc.

BMT WBM’s BELSIM program models the dynamic behaviour of conveyors and their control systems.

Recent projects where BELSIM has been used include:

- A take-up failure in an underground mine.
- Optimising tripper locations for an underground mine development.
- Reviewing the control settings for a CST controlled conveyor with a tripper to avoid excessive spill during stops.
- Assessing the consequences of brake timing and partial loading on an underground trunk conveyor with uphill and downhill sections.

BELSIM includes full modelling capabilities for fluid couplings, VVVF drives, CST drives, wound rotor motors etc.

Recent enhancements to the program have substantially reduced the time required to analyse a conveyor and made it practical to check any suspect conveyor.

BMT WBM provides clients with movie files showing how the belt tension, belt sag, belt load and belt speed vary with time for various operating and control system scenarios.
2.23 Integrated Modelling of Draglines

The fatigue life of dragline booms is significantly affected by accelerations which are determined, at least in part, by the control system, as well as other factors such as increased bucket capacity. WBM has developed a novel technique whereby nonlinear dynamic finite element analysis software such as LS-Dyna can be coupled with simulation software, to model the dynamic response of the structure as well as the functions and effects of the control system. This method allows development of tailored control system algorithms which enable the dragline to accommodate increased capacity buckets, with little effect on overall cycle time while minimising the stresses in the boom during operation. This allows the machine to operate efficiently while extending the life of the dragline as a result. In addition it is possible to adjust the operational suspended load while maintaining an acceptably low risk of collapse by the use of the model.
2.24 **Various Other Projects & Capability**

Other projects BMT WBM have been involved with include:

- Robe River iron ore stacker/reclaimer design audit
- Bucketwheel excavator design audit in Namibia
- Mobile conveyor bridge design audit in South Africa
- Underground coal trunk conveyor design for Anglo Coal in Kayuga, Australia
- Complete underground coal conveyor system design in Oaky Creek, Queensland
- Copper ore conveyor design to Tasmanian Copper
- Overburden conveyor system design in Mae Moh, Thailand
- Overland bauxite conveyor design for ALCOA, Western Australia
BMT WBM has the capability of modelling processes using Discrete Element Modelling (DEM) software. Bucketwheels, ball mills and chutes, just to name a few, can be studied to gauge their efficiency and efficacy. From there the control system can be altered or the design changed accordingly to achieve or increase performance. Finite element analysis can be conducted to assess the fatigue life of, and stresses induced on, structures, such as vibrating screens and slew arrangements.
3 CONTACT DETAILS

Machinery Group General Manager
Russell Smith 02 4940 8882
Russell.Smith@bmtwbm.com.au

Machinery Group Business Development Manager
David Proud 07 3831 6744
David.Proud@bmtwbm.com.au

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<th>Brisbane Office</th>
<th>Melbourne Office</th>
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<tr>
<td>Contact: Geoff Sokoll</td>
<td>Contact: Peter Essig</td>
<td>Contact: Neil Watson</td>
</tr>
<tr>
<td>Level 8, 200 Creek Street</td>
<td>Level 5, 99 King Street</td>
<td>Level 1, 256-258 Norton Street</td>
</tr>
<tr>
<td>Brisbane Qld 4000</td>
<td>Melbourne Vic 3000</td>
<td>Leichhardt NSW 2040</td>
</tr>
<tr>
<td>P.O. Box 203</td>
<td>P.O. Box 604</td>
<td>P.O. Box 194</td>
</tr>
<tr>
<td>Spring Hill Qld 4004</td>
<td>Collins Street West Vic 8007</td>
<td>Leichhardt NSW 2040</td>
</tr>
<tr>
<td>Tel: 07 3831 6744</td>
<td>Tel: 03 8620 6100</td>
<td>Tel: 02 8987 2900</td>
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<td>Contact: Francois Coetsee</td>
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<td>Contact: Andrew Hunter</td>
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<td><a href="mailto:Brad.Stevenson@bmtwbm.com.au">Brad.Stevenson@bmtwbm.com.au</a></td>
<td><a href="mailto:Andrew.Hunter@bmtwbm.com.au">Andrew.Hunter@bmtwbm.com.au</a></td>
</tr>
<tr>
<td>Unit 6, 29 Hood Street</td>
<td>Suite 1, 138 Wood Street</td>
<td>126 Belford Street</td>
</tr>
<tr>
<td>Subiaco WA 6008</td>
<td>Mackay South Qld 4740</td>
<td>Broadmeadow NSW 2292</td>
</tr>
<tr>
<td>Tel: 08 9328 2029</td>
<td>PO Box 4447</td>
<td>PO Box 266</td>
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<tr>
<td>Fax: 08 9484 7588</td>
<td>Mackay South Qld 4740</td>
<td>Broadmeadow NSW 2292</td>
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<td>Contact: Charles Constancon</td>
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<td><a href="mailto:rjsharp@wbmdenver.com">rjsharp@wbmdenver.com</a></td>
<td><a href="mailto:cconstancon@wbmengineering.com">cconstancon@wbmengineering.com</a></td>
</tr>
<tr>
<td>8200S. Akron Street, Unit 120</td>
<td>401-611 Alexander Street</td>
</tr>
<tr>
<td>Centennial, CO 80112</td>
<td>Vancouver, BC V6E 1A1</td>
</tr>
<tr>
<td>USA</td>
<td>Canada</td>
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<tr>
<td>Tel: +1 303 792 9814</td>
<td>Tel: +1 604 683 5777</td>
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