

FINAL STRATEGIC RESEARCH PLAN V2.0

Landry Hemp Research Platform

*A Multidisciplinary Hemp Science, Technology, and Innovation
Ecosystem*

Transform hemp from an agricultural commodity into a high-value renewable materials platform. The objective is not simply to create hemp products. The objective is to build a complete scientific and industrial ecosystem around hemp-derived innovation.

LANDRY INDUSTRIES HEMPOXIES DIVISION MONCTON, NB JULY 2026

Contents

- 00 Vision, Mission & Core Philosophy
- 01 Executive Summary & Strategic Framework
- 02 Research Architecture Overview
- 03 Division 1 — Hemp Biology & Genetics Institute
- 04 Division 2 — Hemp Carbon Materials Laboratory
- 05 Division 3 — Hempoxies Advanced Composite Platform
- 06 Division 4 — Hemp Energy Materials Institute
- 07 Division 5 — Hemp Construction Technologies
- 08 Division 6 — Hemp Manufacturing Technologies
- 09 Division 7 — Hemp Biotechnology Division
- 10 Division 8 — Hemp Food & Nutritional Science
- 11 Division 9 — Hemp Environmental Solutions
- 12 Division 10 — Hemp AI Research Platform
- 13 Division 11 — Testing, Standards & Certification
- 14 Division 12 — Commercialization & Partnerships
- 15 Core Research Database & ID System
- 16 AI-Driven Materials Discovery
- 17 Commercial Strategy
- 18 Ultimate Goal & Long-Term Vision

Front Matter

Document Title

Landry Hemp Research Platform (LHRP) v2.0

Final Strategic Research Plan

Subtitle

A Multidisciplinary Hemp Science, Technology, and Innovation Ecosystem

Authoring Organization

Organization:	Landry Industries
Division:	Hempoxies Division
Location:	Moncton, New Brunswick, Canada
Territory:	Mikmaki / Wabanaki Territory

Document Control

Version:	2.0
Status:	Final Strategic Research Plan
Date:	July 2026
Classification:	Open Research — CC BY-SA 4.0
Review Cycle:	Annual external peer review

Authorship & Governance

ROLE	RESPONSIBILITY	REPORTING STRUCTURE
Chief Executive Officer	Strategic direction, investor relations, partnership negotiations	Board of Directors
Scientific Director	Materials science research oversight, publication strategy, IP portfolio	CEO

Agricultural Director	Biology and agronomy research, grower network, field trial coordination	CEO
Division Leads (12)	Day-to-day research execution, budget management, milestone delivery	Scientific / Agricultural Director
Commercialization Board	Stage-gate evaluation, market assessment, investment decisions	CEO (Chair)
External Peer Review Panel	Annual scientific integrity review, emerging opportunity identification	Independent

Intended Audience

- **Internal:** Division Leads, research staff, manufacturing personnel, commercialization team
- **Investors:** Venture capital, impact investors, government funding agencies
- **Partners:** Academic institutions, industry collaborators, supply chain partners
- **Regulators:** Health Canada, CFIA, NB Department of Environment, building code authorities
- **Public:** Open research community, hemp growers, sustainability advocates

Document Conventions

- **TRL:** Technology Readiness Level (NASA scale, 1-9)
- **SSA:** Specific Surface Area (BET method, m²/g)
- **LCA:** Life Cycle Assessment (ISO 14040/14044)
- **FAIR:** Findable, Accessible, Interoperable, Reusable (data principles)
- **All temperatures:** Degrees Celsius unless otherwise noted
- **All chemical concentrations:** Weight/weight percent unless noted

Revision History

VERSION	DATE	AUTHOR	DESCRIPTION
0.1	June 2026	LHRP Core Team	Initial concept document — 12 divisions outlined
0.5	July 2026	LHRP Core Team	Expanded with scientific detail, literature citations, evaluation framework
1.0	July 2026	LHRP Core Team	First complete draft — all divisions fully developed
2.0	July	LHRP	Final Strategic Research Plan — integrated Hempoxies platform

Related Documents

- LHRP Division Charter Templates (12 documents, one per division)
- LHRP Standard Operating Procedures (SOP) Library
- LHRP Intellectual Property Management Policy
- LHRP Data Management Plan (FAIR principles implementation)
- LHRP Health, Safety, and Environment (HSE) Manual
- SearchForOrganics.com Platform Architecture Specification
- Hempoxies Formulation Development Protocol (Hempoxies 43, 44, 71)
- Universal Organic Rights Framework (Landry Industries policy document)

Disclaimer

This document represents a strategic research plan and does not constitute a guarantee of technical performance, regulatory approval, or commercial success. All performance targets are aspirational and subject to experimental validation. Financial projections are based on market analysis and modeling, not historical performance. The document is provided under Creative Commons Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) unless proprietary sections are explicitly marked.

Vision, Mission & Core Philosophy

Vision

Create a global research platform for developing hemp-derived technologies that contribute to renewable manufacturing, circular economy systems, carbon reduction, sustainable energy, regenerative agriculture, and advanced materials innovation.

Mission

To discover, characterize, validate, and commercialize hemp-derived materials and technologies through scientific experimentation, materials engineering, artificial intelligence, industrial partnerships, and open research collaboration.

Core Philosophy

Transform hemp from an agricultural commodity into a high-value renewable materials platform. Rather than focusing on a single application such as vehicles, the LHRP develops a complete ecosystem spanning advanced materials science, carbon engineering, bio-composites, energy storage, biotechnology, agriculture, construction, environmental restoration, artificial intelligence, and commercialization.

The objective is not simply to create hemp products. The objective is to build a complete scientific and industrial ecosystem around hemp-derived innovation — one that treats hemp as a biomass feedstock platform capable of producing thousands of materials and products, not as a niche agricultural commodity.

PROGRAM OVERVIEW

Executive Summary

The Landry Hemp Research Platform (LHRP) is a twelve-division multidisciplinary initiative designed to position hemp as a foundational biomass feedstock platform capable of producing advanced materials, energy technologies, sustainable products, agricultural solutions, and next-generation industrial systems.

Hemp (*Cannabis sativa* L.) is among the most versatile lignocellulosic biomass sources known. With cellulose content exceeding 70% in bast fibers, lignin concentrations of 3-5% (among the lowest of structural fibers), and a rapid growth cycle of 90-120 days, hemp offers a unique combination of high yield, low input requirements, and exceptional carbon sequestration potential. The global industrial hemp market, valued at approximately \$6.8 billion in 2024, is projected to exceed \$25 billion by 2030.

Strategic Pillars

SCIENTIFIC RIGOR

Every experiment receives a unique identifier and enters the Core Research Database. Full scientific method: hypothesis, design, characterization, analysis, publication.

OPEN ARCHITECTURE

Research outputs published openly unless proprietary commercialization pathways are activated. Knowledge graph accessible to partners.

SCALABLE PIPELINE

From cultivar selection to commercial product, each division feeds into a unified innovation pipeline with defined stage-gates and TRL milestones.

CARBON-NEGATIVE MISSION

All research prioritizes lifecycle carbon negativity. Target: net sequestration across the full value chain from farm to finished product.

INDIGENOUS KNOWLEDGE

Traditional ecological knowledge from Mikmaq and other First Nations informs agricultural and materials practices on Mikmaki territory.

100% BIO-DERIVED TARGET

All formulated materials target >=98% bio-derived content, with a stretch goal of 100% for flagship Hempoxies products.

Evaluation Framework

The hardest part of hemp innovation is not generating ideas — hemp already has thousands of documented applications. The challenge is building a rigorous pipeline that identifies which applications have the strongest scientific evidence, economic value, and scalability.

CRITERION	WEIGHT	ASSESSMENT METHOD
Scientific Readiness	30%	TRL assessment, peer-reviewed evidence, reproducibility verification
Economic Viability	25%	Feedstock cost modeling, CAPEX/OPEX, market price elasticity

Scalability Potential	20%	Agricultural yield projections, manufacturing scale-up pathways
Carbon Impact	15%	LCA cradle-to-gate, carbon sequestration quantification, recyclability
Regulatory Alignment	10%	Standards compliance, certification clarity, freedom-to-operate

KEY LITERATURE FOUNDATION

Wang, H., et al. (2013). "Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy." ACS Nano, 7(6), 5131-5141. DOI: 10.1021/nn400731g — Hemp bast fiber conversion to partially graphitic carbon nanosheets (10-30 nm thickness, SSA up to 2287 m2/g) with power-energy characteristics competitive with graphene-based electrodes.

Ukkakimapan, P., et al. (2025). "Hemp-Derived Hierarchical Porous Carbon with Optimized Pore Structure by NaOH Activation." PMC12612924 — NaOH-activated hemp hurd achieved 3033 m2/g SSA and 725 F/g specific capacitance, establishing hurd as a high-performance precursor surpassing commercial activated carbon.

STRUCTURE

Research Architecture Overview

The platform consists of twelve interconnected divisions, each with defined objectives, research programs, and outputs. Divisions are not silos — they exchange materials, data, and personnel through the Core Research Database and the Hemp Knowledge Graph.

DIVISION	NAME	CORE OBJECTIVE	PRIMARY OUTPUTS
D1	Hemp Biology & Genetics Institute	Understand hemp as a biological resource	Cultivar database, agricultural protocols
D2	Hemp Carbon Materials Laboratory	Convert biomass to engineered carbon materials	Biochar, activated carbon, nanosheets, fibers
D3	Hempoxies Advanced Composite Platform	Develop hemp-based composite materials	Structural, lightweight, fire-resistant, conductive composites
D4	Hemp Energy Materials Institute	Develop sustainable energy materials	Battery anodes, supercapacitors, structural energy systems
D5	Hemp Construction Technologies	Create sustainable building systems	Hempcrete, panels, insulation, modular structures
D6	Hemp Manufacturing Technologies	Develop industrial production methods	Compression molding, additive manufacturing, recycling
D7	Hemp Biotechnology Division	Explore hemp as a biochemical resource	Cellulose, nanocellulose, biopolymers, enzymes
D8	Hemp Food & Nutritional Science	Develop sustainable nutrition systems	Protein, oils, functional foods, animal feed
D9	Hemp Environmental Solutions	Use hemp for ecological restoration	Carbon sequestration, phytoremediation, water purification

D10	Hemp AI Research Platform	Create AI-powered discovery engine	Knowledge graph, predictive models, optimization tools
D11	Testing, Standards & Certification	Create reliable scientific benchmarks	Test protocols, material specs, sustainability metrics
D12	Commercialization & Partnerships	Move discoveries from lab to market	Products, licenses, joint ventures, spin-offs



Division 1 establishes the biological substrate upon which all other divisions depend. Without optimized germplasm, no amount of processing innovation can overcome feedstock limitations. This division operates at the intersection of quantitative genetics, molecular biology, and agronomic field trials.

Research Programs

Hemp Genome & Trait Database

> CULTIVAR CHARACTERIZATION

- Comprehensive phenotyping of 500+ global accessions
- Quantitative trait locus (QTL) mapping for fiber quality
- Genome-wide association studies (GWAS) for materials-relevant traits
- Reference genome assembly for elite Canadian cultivars
- Transcriptomic profiling under abiotic stress

> FIBER PRODUCTION & BIOMASS YIELD

- Bast fiber percentage vs. total biomass yield tradeoffs
- Retting optimization (dew, water, enzymatic)
- Harvest timing effects on fiber mechanical properties
- Dual-purpose (grain + fiber) cultivar development
- Field density and row spacing optimization

> ENVIRONMENTAL ADAPTATION

- Photoperiod sensitivity mapping for latitude-adapted cultivars
- Cold-hardiness for Canadian Maritimes expansion
- Drought and flood tolerance mechanisms
- Salinity tolerance for marginal land utilization
- Climate change adaptation modeling

> DISEASE RESISTANCE

- Botrytis cinerea and Sclerotinia sclerotiorum resistance screening

- Pest resistance (hemp borer, aphids, spider mites)
- Root rot pathogen identification and management
- Biocontrol agent efficacy trials
- Marker-assisted selection for resistance traits

Agricultural Optimization

> REGENERATIVE FARMING METHODS

- No-till establishment protocols for soil carbon preservation
- Cover crop integration (clover, vetch) for nitrogen fixation
- Companion planting for pest management and biodiversity
- Reduced-input systems minimizing synthetic fertilizers

> SOIL IMPROVEMENT

- Soil organic carbon accumulation under continuous hemp
- Mycorrhizal inoculation for phosphorus uptake
- Biochar amendment from Division 2 residues
- Soil microbiome profiling under hemp vs. rotation systems

> WATER EFFICIENCY

- Drip irrigation optimization for Atlantic Canada climate
- Deficit irrigation protocols for fiber hemp
- Rainwater harvesting integration
- Water footprint analysis vs. cotton and synthetics

> ORGANIC CULTIVATION & CLIMATE RESILIENCE

- Organic certification pathways and transition support
- Drought-resistant cultivar screening
- Flood tolerance and recovery protocols
- Early-season establishment for short growing seasons

DIVISION OUTPUTS

- > Hemp biological database (500+ accessions, genomic + phenotypic data)
- > Cultivar performance models (multi-site, multi-year trials)
- > Agricultural protocols (regenerative, organic, climate-adaptive)
- > Genetic marker panels for marker-assisted selection

> Elite breeding lines with materials-science-optimized traits

Key Performance Indicators

KPI	YEAR 1	YEAR 3	YEAR 5
Cultivars in database	50	150	300+
Fiber yield (tonnes/ha)	5.0	6.5	8.0
Bast fiber cellulose (%)	70	73	75
Carbon sequestered (t CO2/ha/yr)	8.0	10.0	12.0

Division 2 is the materials science core of LHRP, transforming hemp biomass into a spectrum of carbon materials with tailorable properties. This division builds directly on the groundbreaking work of Mitlin et al. (2013) demonstrating hemp bast fiber-derived interconnected carbon nanosheets with specific surface areas exceeding 2200 m²/g and power-energy characteristics competitive with graphene electrodes.

Hemp-Derived Carbon Materials

Biochar

Slow pyrolysis (350-700 degrees C) under controlled atmosphere. Applications: soil amendment (Division 6, 9), water filtration (Division 9), carbon sequestration certification. Target: stable carbon content >80%, surface area 200-500 m²/g.

Activated Carbon

Chemical activation (KOH, NaOH, H₃PO₄, ZnCl₂) and physical activation (CO₂, steam). Recent breakthrough: Ukkakimapan et al. (2025) achieved 3033 m²/g SSA and 725 F/g from NaOH-activated hemp hurd — surpassing commercial activated carbon. LHRP extends this to systematic comparison of activation agents on hemp hurd vs. bast vs. whole stalk, with surface functionalization for catalytic and electrochemical applications.

Hard Carbon

High-temperature pyrolysis (1200-1600 degrees C) of lignin-rich precursors for sodium-ion battery anodes. Target: >300 mAh/g reversible capacity, >85% initial Coulombic efficiency, interlayer spacing 0.37-0.40 nm optimized for Na⁺ intercalation.

Graphitic Carbon

Catalytic graphitization of hemp carbon at 2000-3000 degrees C. Target: electrical conductivity >500 S/m, for conductive composites, EMI shielding, and thermal management applications.

Carbon Nanosheets

Hydrothermal carbonization (HTC) + KOH activation from hemp bast fiber. Literature benchmarks: 10-30 nm thickness, SSA 2287 m²/g, mesoporosity 58%, energy density 19-40 Wh/kg at power densities up to 20 kW/kg, 78% capacitance retention after 10,000 cycles. LHRP focuses on roll-to-roll continuous processing and hybrid structures with metal oxides.

Carbon Fibers

Lignin-based carbon fiber from hemp lignin via melt-spinning and carbonization. Target: tensile strength >1.5 GPa, modulus >150 GPa, at cost <\$15/kg (vs. \$20-30/kg for PAN-based CF). Critical for Division 3 high-performance composites and Division 4 structural batteries.

Carbon Aerogels

Supercritical drying of hemp-derived hydrogels for ultra-low-density materials. Applications: thermal insulation, oil spill remediation (>50 g oil/g sorbent), acoustic damping, and catalyst supports.

Applications

Li/Na-ion Batteries
Supercapacitors
Water Filtration
Catalysts
Electronics
Conductive Materials
EMI Shielding
Thermal Management

DIVISION OUTPUTS

- > Standardized carbon material synthesis protocols (SOPs) for each material class
- > Materials characterization database (XRD, Raman, BET, TEM, XPS, electrochemical)
- > Patent portfolio for novel synthesis methods and composite structures
- > Pilot-scale production capability (kg batches) for external validation
- > Cost models for each material at commercial scale

CRITICAL LITERATURE

Wang, H., et al. (2013). "Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy." ACS Nano, 7(6), 5131-5141. DOI: 10.1021/nn400731g

Ukkakimapan, P., et al. (2025). "Hemp-Derived Hierarchical Porous Carbon with Optimized Pore Structure by NaOH Activation for Supercapacitor Applications." PMC12612924.

03

Hempoxies Advanced Composite Platform

Develop a family of hemp-based composite materials

Division 3 is the flagship product development division of LHRP. Hempoxies becomes a materials platform containing multiple formulations, each optimized for specific performance requirements. The central challenge is replacing petrochemical epoxy systems — which dominate aerospace, automotive, marine, and wind energy composite markets — with 100% bio-derived alternatives that meet or exceed performance specifications while enabling end-of-life recyclability through vitrimer chemistry.

The Hempoxies Family

Rather than a single product, Hempoxies is a platform of formulations, each targeting distinct market verticals:

STRUCTURAL HEMPOXY

High stiffness, high strength composites for load-bearing applications. Glass transition temperature >120 degrees C, tensile strength >60 MPa.

Construction, Transportation, Industrial Components

LIGHTWEIGHT HEMPOXY

Low-density formulations with optimized strength-to-weight ratios. Density <1.2 g/cm³, specific strength >50 MPa/(g/cm³).

Aerospace, Drones, Robotics, Sports Equipment

FIRE-RESISTANT HEMPOXY

Intumescent and char-forming formulations meeting FAR 25.853 and UL94 V-0. Smoke toxicity reduction vs. phenolic resins.

Buildings, Transportation, Electronics

CONDUCTIVE HEMPOXY

Hemp biochar and carbon nanofiber-loaded matrices with tunable electrical conductivity (10⁻⁴ to 10⁻² S/m).

Sensors, Electronics, Energy Systems

THERMAL HEMPOXY

High thermal conductivity formulations for heat dissipation and thermal management. Thermal conductivity >2 W/mK.

Battery Systems, Heat Management, LED Housings

RECYCLABLE HEMPOXY

Vitrimer-based dynamic covalent networks enabling thermal reprocessing and chemical depolymerization. >90% property retention after 5 cycles.

Research Architecture

Bio-Based Resin Chemistry

RESIN PLATFORM	FEEDSTOCK	CHEMISTRY	KEY ADVANTAGE	TARGET TG
Epoxidized Hemp Oil (EHO)	Hemp seed oil	Peracid epoxidation of unsaturated fatty acids	Low viscosity, high flexibility	40-80 degrees C
Vanillic Acid Epoxy	Hemp lignin / biomass	Glycidylation of phenolic hydroxyls	Aromatic backbone, high Tg	120-180 degrees C
Furan-Based Epoxy	Hemicellulose-derived furfural	Furfuryl alcohol glycidyl ether	Self-healing potential, low toxicity	80-140 degrees C
Itaconic Acid Epoxy	Fermentation-derived itaconic acid	Epoxidation of unsaturated dicarboxylic acid	Rapid UV cure capability	60-100 degrees C
Lignin-Derived Epoxy	Organosolv hemp lignin	Demethylation + glycidylation	High aromatic content, UV stability	100-160 degrees C

Vitrimer Chemistry for Recyclability

Traditional thermoset epoxies cannot be remelted or reprocessed, creating massive end-of-life waste streams (wind turbine blades alone will generate 43 million tonnes of waste by 2050). Vitrimer chemistry introduces dynamic covalent bonds that enable thermoset-like properties at service temperature with thermoplastic-like reprocessability at elevated temperature.

- Transesterification exchange using zinc acetate catalyst at 180-200 degrees C
- Topology freezing transition (Tv) tunable between 50-150 degrees C
- Stress relaxation times <100s at Tv+30 degrees C for rapid reprocessing
- Tensile strength retention >90% after 5 reprocessing cycles
- Chemical recyclability via selective acid hydrolysis and aminolysis

Natural Fiber Reinforcement

- **Short hemp fiber (<6mm):** Injection molding compounds, 3D printing feedstock, bulk molding
- **Long hemp fiber (woven/non-woven):** Hand layup, vacuum infusion, RTM for structural panels
- **Hemp carbon fiber (Division 2 output):** High-performance aerospace and automotive composites
- **Nanocellulose (Division 7 output):** Nanocomposite films, barrier layers, interlaminar toughening
- **Hemp biochar:** Conductive filler for EMI shielding and thermal management

Processing Science

- Resin transfer molding (RTM) with bio-epoxy viscosity optimization
- Autoclave curing cycles for aerospace-grade laminates
- Pultrusion for continuous structural profiles
- Filament winding for pressure vessels and pipes

- Additive manufacturing (fused filament fabrication, vat photopolymerization)
- Compression molding for automotive body panels (SMC/BMC)

DIVISION OUTPUTS

- > Hempoxies formulation library (50+ validated formulations with full characterization)
- > Vitrimer reprocessing protocols with mechanical property retention data
- > Composite design guides for each market vertical
- > Processing parameter databases (viscosity, cure kinetics, gel time, exotherm)
- > End-of-life recycling pathways (thermal reprocessing, chemical depolymerization)
- > Material Safety Data Sheets (MSDS) for all formulations

04 Hemp Energy Materials Institute

Develop sustainable energy materials

Division 4 translates Division 2 carbon materials into functional energy systems. The global energy storage market exceeds \$120 billion and is growing at 15% CAGR. Hemp-derived materials offer renewable feedstock advantages, structural composites that double as energy storage devices, and bio-based components that reduce lifecycle environmental impact.

Hemp Battery Materials

Lithium-Ion Anodes

Hemp hard carbon as graphite alternative or silicon/carbon composite buffer matrix. Target: >350 mAh/g reversible capacity, >500 cycles at 1C, <10% capacity fade.

Sodium-Ion Anodes

Hard carbon is the only commercially viable SIB anode material. Hemp-derived hard carbon targets >300 mAh/g, >85% initial Coulombic efficiency, interlayer spacing 0.37-0.40 nm. Cost advantage: <\$5/kg vs. \$8-12/kg for petroleum pitch hard carbon.

Potassium-Ion Systems

Emerging chemistry for grid-scale storage. Hemp carbon materials with expanded interlayer spacing (>0.40 nm) for K⁺ intercalation. Target: >200 mAh/g, stable cycling >1000 cycles.

Zinc-Ion Systems

Aqueous electrolyte systems for safe, low-cost stationary storage. Hemp-derived cathode materials with high surface area and oxygen functional groups for Zn²⁺ adsorption/intercalation.

Hemp Supercapacitors

- **EDLC:** Hemp activated carbon (3033 m²/g SSA) achieving 725 F/g in 1M H₂SO₄, 78% retention after 10,000 cycles
- **Asymmetric Hybrid:** Hemp carbon cathode + battery-type anode (MnO₂, Fe₃O₄) targeting >50 Wh/kg
- **Ionic Liquid Systems:** Hemp nanosheets operating 0-100 degrees C, energy density 19-40 Wh/kg at 20 kW/kg
- **Flexible/Stretchable:** Hemp carbon on textile substrates for wearable electronics

Structural Energy Systems

Multifunctional composites combining load-bearing and energy storage. By replacing passive structural mass with active energy-storing mass, structural batteries can reduce overall system weight by 15-30%:

- Carbon fiber electrodes: 50-100 mAh/g specific capacity
- Structural electrolyte: ionically conductive polymer with >100 MPa modulus
- Separator: nanocellulose membranes with optimized porosity

- Target: >15 Wh/kg energy density, >50 MPa flexural strength, >10,000 cycles

DIVISION OUTPUTS

- > Coin-cell and pouch-cell prototypes with full electrochemical characterization
- > Ragone plots for all energy storage systems
- > Structural battery composite demonstrators
- > Cost models comparing hemp-derived vs. conventional electrode materials
- > LCA reports for energy system carbon footprint

05 Hemp Construction Technologies

Create sustainable building systems

The construction sector accounts for 39% of global energy-related CO₂ emissions. Hemp-based construction materials offer a unique decarbonization pathway: bio-sequestration during growth (8-12 t CO₂/ha/year), carbon-negative building products (hempcrete sequesters 165-250 kg CO₂/m³), and superior thermal performance reducing operational energy demand.

Research Areas

Hempcrete & Lime-Based Systems

- Binder optimization: hydraulic lime vs. natural air lime vs. magnesium oxide (MgO) cement. Target: compressive strength >2 MPa, thermal conductivity <0.08 W/mK
- Shiv characterization: particle size, bulk density, water absorption effects on workability and hardened properties
- Carbonation kinetics: CO₂ uptake quantification during curing. Target: >25% mass gain via carbonation within 90 days
- Pre-cast manufacturing: steam-cured blocks, spray-applied systems, 3D-printable mixes
- Moisture buffering: hygrothermal performance modeling for indoor humidity regulation

Composite Panels & Insulation

- Hemp fiber-reinforced cement boards for cladding and roofing
- Hemp-lime insulation batts with density <100 kg/m³ and thermal conductivity <0.045 W/mK
- Cross-laminated hemp fiber mats bonded with bio-based adhesives for wall and floor panels
- 3D-printed hemp bio-composite for modular construction elements

Modular Structures & Disaster Response

- Prefabricated hemp composite panels for rapid housing deployment
- Seismic-resistant hemp-lime wall systems with ductile behavior
- Flood-resistant foundations using hemp-based geopolymer binders
- Cold-climate performance validation at Moncton, NB test site

Carbon-Negative Buildings

- Whole-building LCA per ISO 14040/14044 and EN 15804
- Carbon sequestration certification per ISO 14064
- Integration with LEED v5, Passive House, and Living Building Challenge
- Canadian federal and provincial carbon offset program integration

Applications

Housing

Infrastructure
Disaster Response
Climate Adaptation

DIVISION OUTPUTS

- > Hempcrete mix design library (climate-specific for 6 Canadian climate zones)
- > Pre-cast block manufacturing SOPs with quality control
- > Structural testing reports (compression, flexure, fire, acoustic, durability)
- > Building code submission packages for NB and National Building Code
- > LHRP Pilot Facility: demonstration building in Moncton, NB
- > Carbon-negative building certification protocol and calculator

Division 6 develops the manufacturing processes that transform hemp-derived materials into finished products at industrial scale. This division bridges the gap between laboratory formulations and commercial production, ensuring that bio-based materials can be processed using existing infrastructure where possible and developing new methods where necessary.

Research Areas

Compression Molding

- Sheet Molding Compound (SMC) and Bulk Molding Compound (BMC) with hemp fiber and bio-resin
- Process parameter optimization: temperature, pressure, cure time for cycle time minimization
- Tooling design for hemp fiber flow and orientation control
- Target: cycle times <5 minutes for automotive body panel production

Resin Systems & Processing

- Vacuum-assisted resin transfer molding (VARTM) for large marine and wind energy structures
- Resin transfer molding (RTM) for automotive structural components
- Filament winding for pressure vessels, pipes, and tanks
- Pultrusion for continuous structural profiles (beams, channels, rods)
- Autoclave curing for aerospace-grade prepregs

Additive Manufacturing

- Fused Filament Fabrication (FFF) with hemp fiber-reinforced bioplastic filaments
- Vat photopolymerization with bio-based photocurable resins
- Material extrusion with short fiber-reinforced thermoplastic compounds
- Large-scale additive manufacturing for construction elements

Composite Manufacturing

- Hand layup and spray-up for marine and construction applications
- Automated fiber placement (AFP) and automated tape laying (ATL) for aerospace
- Thermoforming of hemp fiber-reinforced thermoplastic sheets
- Injection molding of short fiber compounds for consumer goods

Recycling Methods

- Thermal reprocessing of vitrimer-based composites (Division 3)
- Chemical depolymerization via selective bond cleavage
- Mechanical recycling of thermoplastic hemp composites
- Pyrolysis of end-of-life composites for carbon and energy recovery
- Closed-loop manufacturing: waste fiber and resin recovery and reuse

Applications

Consumer Products
Industrial Parts
Machinery Components
Automotive Panels

DIVISION OUTPUTS

- > Manufacturing process SOPs for each technique
- > Process parameter databases (temperature, pressure, time, fiber loading)
- > Tooling design guidelines for hemp fiber composites
- > Quality control protocols (dimensional accuracy, void content, fiber volume fraction)
- > Recycling process flow diagrams and economic analysis
- > Training manuals for manufacturing personnel

07

Hemp Biotechnology Division

Explore hemp as a biochemical resource

Division 7 applies industrial biotechnology to hemp biomass, extracting high-value components and converting them into biopolymers, platform chemicals, and pharmaceutical precursors. This division bridges the gap between agricultural feedstock and high-value industrial products.

Research Areas

Cellulose Extraction & Refinement

- Organosolv pulping for high-purity cellulose (>95% alpha-cellulose)
- Ionic liquid dissolution and regeneration for cellulose film and fiber spinning
- Cellulose nanocrystal (CNC) extraction via sulfuric acid hydrolysis
- Cellulose nanofibril (CNF) production via TEMPO oxidation + high-pressure homogenization
- Aspect ratio control for specific reinforcement applications

Nanocellulose Applications

- Transparent films for flexible electronics and food packaging
- Barrier coatings with oxygen transmission rate <1 cc/m2/day
- Pickering emulsions for food and cosmetic applications
- Nanocomposite reinforcement in Division 3 Hempoxies matrices
- Membrane filtration supports for Division 9 water treatment

Biopolymers

BIOPOLYMER	FEEDSTOCK ROUTE	PRODUCTION METHOD	TARGET PROPERTIES
Polyhydroxyalkanoates (PHA)	Hemp cellulose -> glucose	Bacterial fermentation (Cupriavidus necator)	Tensile strength 20-40 MPa, biodegradable
Polylactic Acid (PLA)	Hemp cellulose -> glucose -> lactic acid	Fermentation + ring-opening polymerization	Tg 55-60 degrees C, compostable
Polyethylene Furanoate (PEF)	Hemicellulose -> furfural -> FDCA	Condensation polymerization	Barrier properties superior to PET
Cellulose Acetate	Hemp cellulose	Acetylation (acetic anhydride)	Film, fiber, filter applications
Lignin-Based Thermosets	Hemp lignin	Crosslinking with epoxies or isocyanates	High Tg, UV stability, antioxidant

Enzymatic Processing

- Cellulase cocktail optimization for hemp biomass saccharification

- Laccase-mediated lignin modification for adhesive and resin applications
- Pectinase retting as water/dew retting alternative (>90% water reduction)
- Enzyme immobilization on hemp-derived biochar for process intensification
- Consolidated bioprocessing with engineered microbial strains

Bio-Based Chemicals

- Levulinic acid from hemp cellulose via acid hydrolysis
- Furfural and 5-HMF from hemp hemicellulose
- Vanillin and syringaldehyde from hemp lignin oxidation
- Platform chemicals for Division 3 resin synthesis

Applications

Packaging
Materials
Industrial Biotechnology
Pharmaceuticals

DIVISION OUTPUTS

- > Cellulose purity grading system (technical, pharmaceutical, food-grade)
- > Biopolymer material datasheets (mechanical, thermal, barrier, biodegradation)
- > Enzyme process optimization reports (yield, titer, productivity)
- > Biodegradability certification results (ASTM D6400, EN 13432, ISO 14855)
- > Platform chemical production protocols and purity specifications

Hemp seed is a nutritional powerhouse: 30-35% protein by weight with a complete amino acid profile (PDCAAS 0.66), an optimal 3:1 omega-6 to omega-3 fatty acid ratio, and rich in gamma-linolenic acid (GLA), vitamin E, and minerals. Division 8 leverages this density to develop food security solutions, functional nutrition products, and animal feed alternatives.

Research Areas

Hemp Protein

- Protein isolate extraction: alkaline solubilization (pH 9-11) + isoelectric precipitation (pH 4.5-5.5). Target: >90% purity, >80% yield
- Functional properties: emulsification, foaming, gelation, water and oil holding capacity
- DIAAS assessment for protein quality certification
- Allergenicity screening: 2S albumin characterization and cross-reactivity testing
- Textured hemp protein via extrusion for meat analogue applications

Hemp Seed Oil

- Extraction comparison: cold-press vs. supercritical CO2 vs. enzymatic aqueous
- Oxidative stability enhancement via natural antioxidants (rosemary extract, tocopherols)
- Microencapsulation via spray-drying and complex coacervation for shelf-stable omega-3
- Cosmetic-grade refinement for topical applications (links to Division 7)
- Structured lipids via enzymatic interesterification

Functional Foods

- Bioactive peptides: enzymatic hydrolysis for ACE-inhibitory and antioxidant activity
- Fermented products: hemp-based yogurt alternatives with probiotic strains
- Protein-fortified staples: bread, pasta, beverages with >20% hemp protein
- Senior nutrition: high-protein, easy-digest formulations addressing sarcopenia
- Sports nutrition: complete amino acid profile for athletic recovery

Animal Feed & Agricultural Nutrition

- Hemp seed cake as poultry and aquaculture feed (5-15% inclusion)
- Hemp hull inclusion for ruminant digestibility and omega-3 enrichment of meat/milk
- Pet food formulations with hemp protein and oil
- CFIA regulatory approval pathway for hemp in animal feed
- Whole-plant silage for dairy and beef cattle nutrition

Applications

Animal Feed
Food Security
Functional Foods

DIVISION OUTPUTS

- > Hemp protein technical datasheets (isolates, concentrates, textured)
- > Nutritional analysis database (amino acids, fatty acids, minerals)
- > Food product prototypes and sensory evaluation reports
- > Shelf-life stability studies (oxidation, microbial, texture)
- > Animal feed trial results (growth, product quality, health markers)
- > CFIA novel food submission packages

Division 9 deploys hemp and hemp-derived materials for environmental remediation, pollution control, and waste valorization. This division closes the loop between agricultural production, industrial processing, and ecological restoration, embodying LHRP's commitment to circular economy principles.

Research Areas

Carbon Sequestration

- Soil organic carbon accumulation under hemp cultivation: target +0.3% SOC/year
- Root biomass quantification and rhizodeposition carbon accounting
- Biochar for long-term carbon storage (>100 year stability assessment)
- Direct air capture (DAC) sorbents: amine-functionalized hemp activated carbon
- Carbon credit quantification and verification for voluntary and compliance markets

Soil Regeneration

- Phytoremediation of heavy metals (Cd, Pb, Ni, Zn, Cu): target >50% reduction in bioavailable soil metals within 3 seasons
- Soil microbiome restoration under continuous hemp vs. degraded soils
- Mycorrhizal inoculation for soil structure improvement and nutrient cycling
- Biochar amendment for water retention, nutrient holding, and pH buffering

Phytoremediation

- Heavy metal hyperaccumulation capacity across 50+ cultivars
- Phytoextraction vs. phytostabilization strategy selection
- Post-remediation biomass processing: safe disposal or metal recovery
- Field trials at contaminated sites in Atlantic Canada (mining, urban brownfields)

Water Purification

- PFAS removal from drinking water: hemp activated carbon targeting >99% removal of PFOA/PFOS to <4 ng/L
- Agricultural runoff nutrient recovery (N, P) using hemp biochar
- Membrane filtration using hemp cellulose nanofiber supports (>95% bacterial rejection)
- Point-of-use water treatment for remote and Indigenous communities
- Oil spill remediation: hydrophobic hemp carbon aerogels (>50 g oil/g sorbent)

Biochar Systems

- Pyrolysis parameter optimization for target biochar properties (surface area, pH, nutrient content)
- Biochar amendment protocols for specific soil types and crops
- Combined biochar-compost systems for synergistic soil improvement
- Biochar in constructed wetlands for wastewater treatment

Applications

Climate Mitigation
Environmental Cleanup
Sustainable Agriculture
Water Treatment

DIVISION OUTPUTS

- > Phytoremediation protocol library (contaminant-specific, cultivar-specific)
- > Water treatment system designs and performance validation
- > Carbon capture material characterization and stability data
- > Soil carbon sequestration quantification methodology
- > Zero-waste processing facility feasibility study
- > Community partnership agreements for remediation projects

10 Hemp AI Research Platform

Create an AI-powered hemp knowledge and discovery engine

Division 10 builds the digital infrastructure that connects all LHRP divisions into a unified intelligence system. The Hemp Knowledge Graph aggregates scientific literature, experimental data, formulation records, and market intelligence into an AI-augmented research platform that accelerates discovery, prevents duplication, and identifies white-space opportunities.

Hemp Knowledge Graph

A comprehensive semantic network representing the full hemp innovation landscape:

> DATABASE CONTENTS

- Scientific publications (automated ingestion from PubMed, WoS, arXiv, Google Scholar)
- Experiments and test results from all 12 divisions
- Materials formulations with processing parameters
- Manufacturing data and quality control records
- Agricultural data (yield, weather, soil, cultivar performance)
- Patent databases (USPTO, EPO, WIPO, CIPO)
- Market intelligence and supply chain data

> TECHNICAL INFRASTRUCTURE

- Ontology: entities (cultivars, compounds, materials, methods, applications) + relationships
- Graph database: Neo4j with Cypher query interface and REST API
- NLP pipelines: entity extraction, relationship inference, topic modeling
- Automated literature ingestion: daily scraping and indexing
- FAIR data principles: Findable, Accessible, Interoperable, Reusable

AI Applications

Literature Discovery

Automated systematic reviews, emerging trend detection, and research gap identification. Natural language queries return synthesized answers with source attribution. Quarterly "State of Hemp Science" reports generated automatically.

Experimental Design

AI-assisted Design of Experiments (DoE) recommendation based on historical data, statistical power analysis, and resource constraints. Integration with Division 3 formulation development to suggest optimal parameter combinations for target properties.

Material Prediction

Surrogate modeling (Gaussian Processes, Neural Networks, Random Forests) predicting material properties from formulation and processing parameters. Target: >90% prediction accuracy for mechanical and thermal properties of Hemproxies formulations.

Process Optimization

Real-time parameter adjustment recommendations for pyrolysis, extraction, and composite manufacturing based on feedstock variability and quality feedback. Reinforcement learning for continuous process improvement.

Market Intelligence

Global hemp production monitoring, price forecasting, demand prediction across construction, automotive, food, and energy sectors. Supply chain risk assessment and alternative sourcing recommendations.

SearchForOrganics Integration

- Organic certification verification API for real-time claim validation
- Hemp product marketplace: B2B platform connecting growers, processors, manufacturers
- Supply chain transparency: blockchain-optional traceability from farm to product
- Consumer search enhancement: AI-powered organic search with hemp-specific filtering
- SEO intelligence: automated content generation and keyword optimization

DIVISION OUTPUTS

- > Hemp Knowledge Graph (public API, SPARQL and REST query interfaces)
- > AI Research Assistant (natural language interface for literature and experiment queries)
- > Material Optimization Dashboard (interactive DoE, prediction, uncertainty quantification)
- > Quarterly Patent Landscape Reports (division-specific, with freedom-to-operate assessment)
- > SearchForOrganics.com platform enhancement specifications and implementation
- > Open-source tools: knowledge graph schema, NLP pipelines, prediction models

Without rigorous standards, innovative materials cannot achieve market adoption regardless of technical merit. Division 11 ensures that all LHRP outputs meet or exceed industry standards for safety, performance, and sustainability. This division operates as the quality assurance backbone of the entire platform.

Research Protocols

Mechanical Testing

- Tensile: ASTM D3039, ISO 527
- Flexural: ASTM D790, ISO 178
- Impact: ASTM D256 (Izod), ASTM D6110 (Charpy)
- Interlaminar shear: ASTM D2344
- Compression: ASTM D695, ISO 604

Thermal Testing

- TGA: thermal stability and decomposition kinetics
- DSC: cure kinetics, T_g, melting/crystallization behavior
- DMA: viscoelastic properties across temperature and frequency
- TMA: coefficient of thermal expansion
- Thermal conductivity: ASTM E1461 (laser flash)

Chemical Testing

- FTIR: functional group identification and cure monitoring
- XPS: surface chemistry and elemental composition
- NMR: molecular structure confirmation
- GC-MS: volatile organic compound analysis
- HPLC: purity and composition quantification

Electrical Testing

- Four-point probe: electrical conductivity and resistivity
- Dielectric spectroscopy: permittivity and loss tangent
- Electrochemical impedance spectroscopy (EIS): for battery and supercapacitor materials
- EMI shielding effectiveness: ASTM D4935

Environmental Testing

- UV aging: ASTM G154 (QUV), ASTM G155 (xenon arc)
- Moisture absorption: ASTM D570
- Salt spray: ASTM B117
- Freeze-thaw cycling for construction materials
- Biodegradation: ASTM D6400, EN 13432, ISO 14855

Lifecycle Analysis

- Cradle-to-gate and cradle-to-grave LCA per ISO 14040/14044
- Carbon footprint quantification per GHG Protocol
- Renewable content certification via ASTM D6866 radiocarbon analysis
- End-of-life recyclability assessment

Developed Standards

Material Specifications

- Hemp fiber grading system: length, fineness (dtex), strength, color, impurity
- Bio-based resin quality standards: viscosity, epoxide equivalent, purity, shelf-life
- Carbon material specifications: SSA, pore volume, pore size, ash, conductivity
- Composite qualification test matrices: statistical sampling and acceptance criteria

Quality Standards

- ISO 9001:2015 quality management system (program-wide)
- ISO/IEC 17025 laboratory accreditation
- Good Manufacturing Practice (GMP) for food and pharmaceutical products
- Good Laboratory Practice (GLP) for regulatory studies
- Electronic QMS for SOPs, batch records, and deviation management

Sustainability Metrics

- Life Cycle Assessment methodology and reporting templates
- Carbon footprint verification with third-party auditing
- Biodegradability certification protocols
- Renewable content verification procedures
- Cradle to Cradle certification pathway

DIVISION OUTPUTS

- > LHRP Standard Test Methods Manual (comprehensive protocols for all material categories)
- > Material Specification Sheets (grade definitions, acceptance criteria, test frequencies)
- > LCA Reports for all flagship products (cradle-to-gate and cradle-to-grave)
- > Carbon Footprint Verification Certificates (third-party audited)
- > ISO 9001:2015 Certification (program-wide quality management)
- > Building Code Submission Packages (NB, NBC, international)

12

Commercialization & Industry Partnerships

Move discoveries from laboratory to market

Division 12 is the interface between LHRP research and market reality. It operates the stage-gate process that moves discoveries through prototype, testing, certification, and manufacturing scale-up. This division is where scientific potential becomes economic value.

The Innovation Pipeline

RESEARCH	PROTOTYPE	VALIDATION	CERTIFICATION	MANUFACTURING	COMMERCIALIZATION
----------	-----------	------------	---------------	---------------	-------------------

Stage-Gate Framework

STAGE	TRL	KEY ACTIVITIES	GATE CRITERIA	TIMELINE
Research	1-3	Literature review, hypothesis, proof-of-concept	Reproducible effect; IP landscape clear	0-12 months
Prototype	3-5	Parameter study, characterization, optimization	Performance defined; cost estimate	6-18 months
Validation	5-6	Full characterization, aging, field trials	Specs met; failure modes understood	12-24 months
Certification	6-7	Third-party testing, regulatory submissions	Certifications obtained; approvals secured	18-30 months
Manufacturing	7-8	Pilot production, supply chain, quality system	Cost within target; yield >80%	24-42 months
Commercialization	8-9	Market launch, customer support, improvement	Revenue targets; satisfaction >85%	30-60 months

Potential Companies & Product Families

Tier 1: Near-Term (2026-2028)

- Hempoxies:** Bio-based epoxy resin systems for general composite applications. Target: marine, consumer goods. Revenue: \$2M/year by 2028
- Hemp Carbon Materials:** Supercapacitor electrodes and water filtration media. Revenue: \$5M/year by 2028
- Hemp Energy Systems:** Hard carbon anodes for sodium-ion batteries. Revenue: \$3M/year by 2028

- **Hemp Construction Systems:** Pre-cast hempcrete blocks and insulation. Revenue: \$1M/year by 2028

Tier 2: Medium-Term (2028-2031)

- **Hemp Carbon Nanosheet Electrodes:** High-performance energy storage for EVs and grid
- **Hemp Carbon Fiber:** Low-cost structural reinforcement for automotive and wind
- **Hemp Filtration Technologies:** PFAS removal, air purification, oil spill remediation
- **Hemp Industrial Materials:** Biopolymers, nanocellulose films, platform chemicals

Tier 3: Long-Term (2031+)

- **Structural Battery Composites:** Multifunctional materials for EVs and aircraft
- **Pharmaceutical-Grade Cannabinoids:** API production for therapeutic applications
- **Carbon Capture Systems:** DAC sorbents and point-source capture units
- **Hemp AI Platform:** Licensed knowledge graph and prediction tools

Business Models

- **Direct Sales:** LHRP-branded products via SearchForOrganics.com and B2B channels
- **Licensing:** Patent and know-how licensing (e.g., ZILA BioWorks partnership for Hempoxy)
- **Joint Ventures:** Co-development with industry for capital-intensive scale-up
- **Spin-Off Companies:** Independent entities for high-growth product lines
- **Contract Research:** Fee-for-service materials development for external clients

DIVISION OUTPUTS

- > Product development roadmaps (tiered by commercialization timeline)
- > Business plans and financial models for each product line
- > Intellectual property portfolio (patents, trade secrets, trademarks)
- > Customer validation reports (pilot feedback, LOIs, purchase orders)
- > Manufacturing scale-up plans (equipment, facility, supply chain)
- > Revenue projections and investment requirements (5-year forecasts)

INFRASTRUCTURE

Core Research Database & ID System

Every experiment, sample, formulation, and test result within LHRP receives a unique identifier and enters the Core Research Database. This creates a long-term intellectual property and knowledge asset that ensures reproducibility, traceability, and continuous improvement across all twelve divisions.

Unique Identifier System

IDENTIFIER FORMAT

LHRP- [DIVISION] - [CATEGORY] - [YYYY] - [NNNN]

Example: LHRP-MATERIAL-2026-0001 = First materials experiment in 2026

FIELD	DESCRIPTION	EXAMPLE VALUES
LHRP	Platform prefix	LHRP (fixed)
DIVISION	Division code	BIO, CARBON, HEMPOXY, ENERGY, CONST, MFG, BIOTECH, FOOD, ENV, AI, TEST, COMM
CATEGORY	Experiment type	MATERIAL, FORMULA, TEST, FIELD, PROCESS, ANALYSIS, PATENT, PUBLICATION
YYYY	Year of initiation	2026, 2027, etc.
NNNN	Sequential number	0001-9999

Database Records

Each record in the Core Research Database contains:

- **Hemp Source:** Cultivar, growing location, harvest date, retting method, storage conditions
- **Cultivar:** Genetic identity, breeder, generation, trait profile reference
- **Processing Method:** Equipment, parameters (temperature, pressure, time, atmosphere), operator
- **Chemical Composition:** Elemental analysis, functional group identification, purity assessment
- **Manufacturing Parameters:** Formulation ratios, mixing conditions, cure schedules, post-processing
- **Testing Results:** Raw data, statistical analysis, instrument calibration records, operator
- **Performance Metrics:** Application-specific benchmarks, comparison to targets, failure analysis
- **Metadata:** Date, location, personnel, equipment IDs, environmental conditions, deviations

Database Architecture

>RELATIONAL DATABASE

- PostgreSQL for structured experimental data
- Normalized schema for samples, tests, results, personnel
- Version control for formulation changes
- Audit trails for regulatory compliance

>DOCUMENT STORE

- MongoDB for unstructured data (images, spectra, reports)
- Raw instrument files (XRD, FTIR, TGA, etc.)

- Lab notebooks and observation logs
- Photographic documentation

> TIME-SERIES DATABASE

- InfluxDB for process monitoring data
- Temperature, pressure, pH, flow rates
- Environmental sensors (greenhouse, field)
- Real-time manufacturing parameters

> GRAPH DATABASE

- Neo4j for knowledge graph (Division 10)
- Relationships between experiments, materials, publications
- Citation networks and collaboration maps
- Patent landscape connections

Data Governance

- **FAIR Principles:** All data Findable, Accessible, Interoperable, Reusable
- **Open by Default:** Research data published openly unless proprietary commercialization activated
- **Data Quality:** Standardized protocols, instrument calibration schedules, inter-laboratory validation
- **Security:** Role-based access control, encrypted storage, backup redundancy
- **Retention:** Permanent archival for published research, 10-year minimum for all experimental data

DATABASE OUTPUTS

- > Searchable web interface for all experimental records
- > API for programmatic access by Division 10 AI systems
- > Automated report generation for regulatory submissions
- > Data export in standard formats (CSV, JSON, NetCDF, HDF5)
- > Integration with electronic lab notebooks (ELN)

FUTURE CAPABILITY

AI-Driven Materials Discovery

The future objective of Division 10 is to build an AI system capable of recommending optimal hemp feedstock, processing conditions, composite formulations, battery applications, and industrial uses. The platform becomes a continuously improving scientific discovery engine that accelerates innovation beyond human-only research capacity.

AI Capabilities Roadmap

Phase 1: Data Integration (2026-2027)

- Automated ingestion of all LHRP experimental data into structured databases
- Literature mining and knowledge extraction from 50,000+ hemp-related publications
- Patent landscape mapping with freedom-to-operate analysis
- Basic statistical models correlating processing parameters with material properties

Phase 2: Predictive Modeling (2027-2028)

- Machine learning models (Random Forest, XGBoost, Neural Networks) for property prediction
- Gaussian Process surrogate models for optimization with uncertainty quantification
- Bayesian optimization for experimental design recommendation
- Natural language interface for querying the knowledge graph

Phase 3: Generative Discovery (2028-2030)

- Generative models for novel formulation design (VAE, GAN, diffusion models)
- Molecular dynamics simulations for resin-curing kinetics prediction
- Multi-objective optimization balancing performance, cost, and sustainability
- Autonomous experimental loops: AI designs -> robot executes -> AI analyzes -> AI iterates

Phase 4: Ecosystem Intelligence (2030+)

- Real-time global hemp market monitoring and price forecasting
- Climate-adaptive cultivation recommendations based on weather predictions
- Supply chain optimization with disruption prediction and mitigation
- Cross-domain innovation: identifying unexpected applications by connecting distant research areas

Target AI Recommendations

Domain	AI Recommendation	Input Data	Expected Benefit
Feedstock	Optimal cultivar for target application	Genetics, climate, soil, desired properties	30% reduction in trial-and-error
Processing	Optimal carbonization/activation conditions	Precursor properties, target SSA, pore structure	50% reduction in optimization time
Formulation	Composite recipe for target properties	Property targets, constraints, available materials	5x acceleration in formulation development
Battery	Electrode design for target energy/power	Cell chemistry, electrolyte, operating conditions	20% improvement in energy density
Industrial	Novel application identification	Material properties, market needs, competitive landscape	White-space discovery for new markets

AI PLATFORM OUTPUTS

- > Trained prediction models for each material class (open-source release)
- > Automated experimental design recommendations with uncertainty bounds
- > Novel formulation proposals with predicted properties and synthesis routes
- > Market opportunity reports generated from literature and patent trends
- > Real-time dashboard for global hemp innovation monitoring

BUSINESS

Commercial Strategy

Short Term (2026-2027)

> RESEARCH DOCUMENTATION

- Core Research Database establishment and population
- Standard operating procedures for all divisions
- Intellectual property landscape mapping
- Peer-reviewed publication strategy

> PARTNERSHIPS

- University partnerships (UNB, Dalhousie, UAlberta)
- Industry partnerships (ZILA BioWorks, automotive OEMs)
- Government partnerships (NRC-IRAP, AAFC, NRCan)
- Indigenous partnerships (Mi'kmaq First Nations)

> PROOF-OF-CONCEPT

- Hempoxies 71 formulation validation
- First carbon material batches
- Initial field trials (Moncton test site)
- Customer sample distribution

> SCIENTIFIC VALIDATION

- Third-party testing initiation
- Standard method development
- Reproducibility verification
- Peer review submission

Medium Term (2027-2029)

> PROTOTYPE MATERIALS

- Hempoxies family (6 formulations) fully characterized
- Pilot-scale carbon material production
- Construction material prototypes
- Energy storage device prototypes

> LICENSING OPPORTUNITIES

- Hempoxy resin technology licensing
- Carbon material synthesis patents
- Processing method licenses
- Software/knowledge graph licensing

> PILOT MANUFACTURING

- Small-batch production facility
- Quality system implementation
- Supply chain establishment
- Customer pilot programs

> MARKET ENTRY

- First commercial product launches
- Direct sales via SearchForOrganics.com
- B2B channel development
- Revenue target: \$5M/year by 2029

Long Term (2029-2032)

> INDUSTRY ECOSYSTEM

- Hemp materials industry cluster in Atlantic Canada
- Supplier network across all divisions
- Farmer cooperative for feedstock supply

- Processing facility network

>INTERNATIONAL PARTNERSHIPS

- European hemp research networks (Fraunhofer, Wageningen)
- Asian battery and electronics manufacturers
- Global carbon credit platforms
- International standards bodies

>COMMERCIAL PORTFOLIO

- 10+ product lines across all divisions
- Spin-off companies for high-growth areas
- Joint ventures for capital-intensive scale-up
- Revenue target: \$50M/year by 2032

>GLOBAL RECOGNITION

- 100+ peer-reviewed publications
- 50+ granted patents
- Industry awards and certifications
- Thought leadership in sustainable materials

Ultimate Goal & Long-Term Vision

The Landry Hemp Research Platform aims to establish hemp as a foundational renewable resource for the next generation of materials, energy systems, manufacturing, construction, and environmental technologies. The objective is not simply to create hemp products. The objective is to build a complete scientific and industrial ecosystem around hemp-derived innovation.

The Hemp Institute Model

The ultimate aspiration is to evolve LHRP into a globally recognized "Hemp Institute" — a center of excellence combining:

MATERIALS SCIENCE LABORATORY Full characterization suite (XRD, TEM, SEM, BET, Raman, FTIR, DMA, TGA/DSC) plus pilot-scale processing for carbonization, activation, composite manufacturing, and polymer synthesis.
AGRICULTURAL RESEARCH CENTER Greenhouse and field trial facilities across multiple agro-climatic zones. Breeding nursery, pathology lab, and soil science laboratory. Partnerships with UNB and Dalhousie.
BIOTECHNOLOGY INCUBATOR Fermentation suite for biopolymer and enzyme production. Extraction and purification for high-value compounds. GMP-compliant clean rooms for pharmaceutical products.
INDUSTRIAL DESIGN STUDIO Product design and prototyping for consumer goods, automotive, and architectural elements. 3D printing, CNC machining, and composite fabrication.
AI RESEARCH PLATFORM HPC cluster for molecular modeling, materials informatics, and knowledge graph. NLP pipelines and machine learning model development.

COMMERCIALIZATION HUB

Pilot production facility (tonne-scale) for carbon materials, resins, and composites. Customer demonstration center. Supply chain coordination.

Strategic Milestones

YEAR	MILESTONE	KEY DELIVERABLES	INVESTMENT
2026	Platform Launch	Division charters, governance, initial funding, first research contracts	\$500K
2027	Pilot Operations	First hemp crop, initial carbon batches, Hempoxies 71 launch	\$1.5M
2028	Product Validation	Certifications, customer pilots, 3+ products in market	\$3M
2029	Scale-Up	Pilot facility operational, supply chain established, revenue >\$5M/yr	\$5M
2030	Institute Formation	Physical institute, academic partnerships, international collaborations	\$10M
2032	Global Recognition	100+ publications, 20+ patents, \$20M+ revenue, 50+ employees	Self-sustaining

Impact Metrics (2032 Targets)

IMPACT CATEGORY	2032 TARGET	MEASUREMENT
Carbon Sequestration	100,000 t CO2/year	Biomass + soil + product carbon (LCA)
Petrochemical Displacement	50,000 t/year	Bio-based content vs. petroleum alternatives
Hemp Cultivation	10,000 ha (Atlantic Canada)	Contracts + satellite monitoring
Employment	500 direct + 2,000 indirect	FTE across research, production, agriculture
Publications	100+ peer-reviewed	Web of Science / Scopus
Patents	50+ granted	USPTO, EPO, CIPO
Revenue	\$50M/year	Audited financials

The Core Strategic Insight

Hemp is not one industry. It is a biomass feedstock platform capable of producing thousands of materials and products. The hardest part of hemp innovation is not generating ideas — hemp already has thousands of documented applications spanning 50,000 years of human use. The challenge is building a rigorous pipeline that identifies which applications have the strongest scientific evidence, economic value, and scalability, then prioritizing those first.

This requires a systems-level approach that no single company, university, or government agency can achieve alone. The Hemp Institute model brings together:

- **Academic Partners:** UNB (materials science), Dalhousie (agriculture), UAlberta (carbon materials, per Mitlin collaboration)
- **Industry Partners:** ZILA BioWorks (composite commercialization), automotive OEMs, construction firms
- **Government Partners:** NRC-IRAP, AAFC, NRCan, NB Economic Development
- **Indigenous Partners:** Mi'kmaq First Nations (traditional knowledge, land stewardship)
- **International Partners:** European hemp networks (Fraunhofer, Wageningen), Asian manufacturers, global carbon platforms

Closing Statement

The Landry Hemp Research Platform represents a bet on the future of materials: that biological feedstocks, processed with scientific rigor and commercial discipline, can replace petroleum-derived materials across the full spectrum of industrial applications. This is not a return to pre-industrial naturalism. It is a forward-looking integration of biotechnology, materials science, artificial intelligence, and systems thinking to create a regenerative materials economy.

The platform is built on the recognition that hemp — a plant cultivated by human societies for 10,000+ years — contains within its cellular structure the blueprint for carbon-negative materials that can decarbonize construction, electrify transportation, clean our water, and feed our populations. The challenge is not the plant. The challenge is the pipeline. LHRP builds that pipeline.

"The goal is not a hemp product. The goal is a complete hemp innovation ecosystem."

— Landry Hemp Research Platform Mission Statement

Back Matter

Appendix A — Glossary of Terms

TERM	DEFINITION
Activated Carbon	Carbon material with high specific surface area (typically >500 m ² /g) produced by chemical or physical activation of carbonaceous precursors. Used for adsorption, filtration, and electrochemical applications.
Bast Fiber	Long, strong fibers extracted from the phloem or inner bark of plants. In hemp, bast fibers contain 70-77% cellulose and provide the primary structural reinforcement for composites.
BET Surface Area	Specific surface area measured by Brunauer-Emmett-Teller nitrogen adsorption method. Expressed in m ² /g. Key metric for carbon materials used in energy storage and catalysis.
Biochar	Carbon-rich solid produced by pyrolysis of biomass in oxygen-limited conditions. Used for soil amendment, carbon sequestration, and as a precursor for activated carbon.
Carbon Nanosheet	Two-dimensional carbon material with nanoscale thickness (typically 10-30 nm) and high aspect ratio. Hemp-derived carbon nanosheets exhibit partial graphitization and high specific surface area.
Cellulose Nanocrystal (CNC)	Rod-like cellulose nanoparticles (100-300 nm length, 5-20 nm width) produced by acid hydrolysis of cellulose fibers. Exceptional mechanical properties (tensile strength >1 GPa).
Cellulose Nanofibril (CNF)	Entangled network of cellulose microfibrils with nanoscale diameters. Produced by mechanical fibrillation, often with TEMPO-mediated oxidation pretreatment.
Coulombic Efficiency	Ratio of discharge capacity to charge capacity in a battery. Initial Coulombic efficiency (ICE) measures first-cycle reversibility. Target >85% for commercial viability.
DIAAS	Digestible Indispensable Amino Acid Score. Protein quality metric endorsed by FAO/WHO, replacing PDCAAS. Accounts for ileal digestibility of individual amino acids.
EDLC	Electric Double-Layer Capacitor. Energy storage device based on electrostatic charge separation at the electrode-electrolyte interface. No Faradaic reactions.
Epoxidized Hemp Oil (EHO)	Hemp seed oil reacted with peracid to convert carbon-carbon double bonds to epoxide (oxirane) groups. Bio-based epoxy resin precursor with low viscosity and high flexibility.

FAIR Data	Findable, Accessible, Interoperable, Reusable. Principles for scientific data management ensuring long-term value and machine-actionability.
GHG Protocol	Greenhouse Gas Protocol. International standard for quantifying and reporting greenhouse gas emissions. Developed by WRI and WBCSD.
Hard Carbon	Non-graphitizable carbon with disordered turbostratic structure. Produced by pyrolysis of precursors at 1000-1600 degrees C. Primary anode material for sodium-ion batteries.
Hempcrete	Building material composed of hemp shiv (hurds), lime-based binder, and water. Carbon-negative due to biogenic carbon sequestration and binder carbonation.
Hemp Hurd / Shiv	The woody inner core of the hemp stalk, separated from bast fibers during decortication. High lignin content makes it suitable for biochar and construction applications.
Hempoxies	Proprietary family of bio-based composite materials developed by Landry Industries Hempoxies Division. Platform includes structural, lightweight, fire-resistant, conductive, thermal, and recyclable formulations.
HTC	Hydrothermal Carbonization. Wet process converting biomass to carbon-rich solids (hydrochar) in aqueous medium at 180-250 degrees C under autogenous pressure.
Interlayer Spacing	Distance between adjacent graphene layers in carbon materials. Critical for ion intercalation in batteries. Target 0.37-0.40 nm for Na ⁺ in hard carbon anodes.
LCA	Life Cycle Assessment. Systematic analysis of environmental impacts across a product's entire life cycle (cradle-to-grave) per ISO 14040/14044.
Organosolv Pulping	Delignification process using organic solvents (ethanol, methanol) to separate cellulose from lignin and hemicellulose. Produces high-purity cellulose for advanced materials.
PAN	Polyacrylonitrile. Synthetic polymer precursor for >90% of commercial carbon fibers. Petroleum-derived. LHRP targets lignin-based alternatives to reduce cost and carbon footprint.
PHA	Polyhydroxyalkanoate. Family of biodegradable polyesters produced by bacterial fermentation of sugars. Target: tensile strength 20-40 MPa, fully biodegradable.
Phytoremediation	Use of plants to remove, stabilize, or degrade environmental contaminants. Hemp's deep roots and high biomass make it effective for heavy metal uptake.
PLA	Polylactic Acid. Biodegradable polyester produced by ring-opening polymerization of lactide. Derived from fermentation of plant sugars (corn, hemp cellulose).
Retting	Process of separating bast fibers from hemp stalk through microbial decomposition of pectin. Methods: dew retting, water retting, enzymatic retting.
SIB	Sodium-Ion Battery. Electrochemical energy storage using Na ⁺ ions instead of Li ⁺ . Advantages: abundant sodium, lower cost, safer chemistry. Hard carbon anode required.
Specific Surface	Total surface area per unit mass of a material. Critical for catalysis, adsorption, and

Area (SSA)	electrochemical applications. Measured by BET nitrogen adsorption.
Supercapacitor	Electrochemical energy storage device with high power density and long cycle life. Types: EDLC (electric double-layer) and pseudocapacitor (Faradaic).
Technology Readiness Level (TRL)	NASA-developed scale (1-9) measuring maturity of a technology. TRL 1 = basic principles observed; TRL 9 = system proven in operational environment.
TEMPO Oxidation	2,2,6,6-Tetramethylpiperidine-1-oxyl radical-mediated oxidation. Selective oxidation of cellulose C6 hydroxyls to carboxylates, facilitating mechanical fibrillation to CNF.
Tg	Glass Transition Temperature. Temperature range where amorphous polymer transitions from glassy to rubbery state. Critical for composite service temperature limits.
Topology Freezing Transition (Tv)	Temperature in vitrimer materials below which dynamic covalent bond exchange is kinetically arrested. Above Tv, material flows and can be reprocessed.
Vitrimer	Polymer network containing dynamic covalent bonds that enable reprocessability without losing network integrity. Combines thermoset performance with thermoplastic processability.
XRD	X-Ray Diffraction. Technique for determining crystalline structure, phase composition, and interlayer spacing in materials.

Appendix B — Reference Standards & Methods

STANDARD	TITLE	APPLICATION
ASTM D256	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics	Impact testing
ASTM D570	Standard Test Method for Water Absorption of Plastics	Moisture absorption
ASTM D638	Standard Test Method for Tensile Properties of Plastics	Tensile testing
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics	Compression testing
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics	Flexural testing
ASTM D1652	Standard Test Method for Epoxy Content of Epoxy Resins	Resin quality
ASTM D2344	Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials	Interlaminar shear

ASTM D3039	Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials	Composite tensile
ASTM D3822	Standard Test Method for Tensile Properties of Single Textile Fibers	Fiber testing
ASTM D6400	Standard Specification for Labeling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities	Biodegradability
ASTM D6556	Standard Test Method for Carbon Black — Total and External Surface Area by Nitrogen Adsorption	Surface area
ASTM D6866	Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis	Bio-based content
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials	Fire performance
ASTM E119	Standard Test Methods for Fire Tests of Building Construction and Materials	Fire resistance
ASTM G154	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials	UV aging
EN 13432	Packaging — Requirements for packaging recoverable through composting and biodegradation	Compostability (EU)
EN 15804	Sustainability of construction works — Environmental product declarations	Construction LCA
ISO 14040	Environmental management — Life cycle assessment — Principles and framework	LCA framework
ISO 14044	Environmental management — Life cycle assessment — Requirements and guidelines	LCA requirements
ISO 14855	Determination of the ultimate aerobic biodegradability of plastic materials	Biodegradation
ISO 17025	General requirements for the competence of testing and calibration laboratories	Lab accreditation
ISO 5079	Textile fibres — Determination of breaking force and elongation at break of individual fibres	Fiber testing

Appendix C — Literature Cited

- c1.** Wang, H., et al. (2013). "Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy." *ACS Nano*, 7(6), 5131-5141. DOI: 10.1021/nn400731g
- c2.** Ukkakimapan, P., et al. (2025). "Hemp-Derived Hierarchical Porous Carbon with Optimized Pore

Structure by NaOH Activation for Supercapacitor Applications." *PMC*, 12612924.

C3. Muniandy, L., et al. (2014). "The synthesis and characterization of high purity mixed microporous/mesoporous activated carbon from rice husk using chemical activation with NaOH and KOH." *Microporous and Mesoporous Materials*, 197, 316-323.

C4. Peelman, N., et al. (2013). "Application of bioplastics for food packaging." *Trends in Food Science & Technology*, 32(2), 128-141.

C5. Shahzad, A. (2012). "Hemp fiber and its composites — a review." *Journal of Composite Materials*, 46(8), 973-986.

C6. Shah, D.U. (2013). "Developing plant fibre composites for structural applications by optimising composite parameters: a critical review." *Journal of Materials Science*, 48(18), 6083-6107.

C7. Sawpan, M.A. (2018). "Hemp fibers: Old fibers — new applications." In: *Handbook of Natural Fibres* (2nd ed.), Woodhead Publishing, 213-248.

C8. Kostic, M., et al. (2008). "Effect of hemp fibers on properties of hemp fiber reinforced polypropylene composites." *Fibers and Polymers*, 9(5), 551-557.

C9. Le Troedec, M., et al. (2008). "Influence of various chemical treatments on the composition and structure of hemp fibres." *Composites Part A*, 39(10), 1643-1652.

C10. Callister, W.D. & Rethwisch, D.G. (2018). *Materials Science and Engineering: An Introduction* (10th ed.). Wiley.

C11. ISO 14040:2006. "Environmental management — Life cycle assessment — Principles and framework." International Organization for Standardization.

C12. Denkena, B., et al. (2021). "Machining of hemp fiber reinforced composites: A review." *Composites Part B*, 207, 108588.

C13. Faruk, O., et al. (2012). "Biocomposites reinforced with natural fibers: 2000-2010." *Progress in Polymer Science*, 37(11), 1552-1596.

C14. Raquez, J.M., et al. (2010). "Thermosetting (bio)materials derived from renewable resources: A critical review." *Progress in Polymer Science*, 35(4), 487-509.

C15. Gandini, A. (2011). "The irruption of polymers from renewable resources on the scene of macromolecular science and technology." *Green Chemistry*, 13(5), 1061-1083.

C16. Llevot, A., et al. (2016). "From lignin-derived aromatic compounds to novel biobased polymers." *Macromolecular Rapid Communications*, 37(1), 9-28.

C17. Zheng, N., et al. (2021). "Peptide-mediated synthesis of functional nanomaterials." *Angewandte Chemie International Edition*, 60(11), 5702-5712.

C18. Zhang, C., et al. (2018). "Covalent adaptable networks: smart, reconfigurable and responsive network polymers." *Chemical Society Reviews*, 47(24), 8994-9006.

C19. Denissen, W., et al. (2016). "Chemical recycling of thermosetting polymers and composites through dynamic exchange of covalent bonds: A review." *Journal of Materials Science*, 51(24), 10939-10960.

C20. Rahimi, A. & García, J.M. (2017). "Chemical recycling of waste plastics for new materials production." *Nature Reviews Chemistry*, 1, 0046.

Appendix D — Acronyms & Abbreviations

ACRONYM	FULL FORM
AAFC	Agriculture and Agri-Food Canada
AMF	Arbuscular Mycorrhizal Fungi

API	Active Pharmaceutical Ingredient
BET	Brunauer-Emmett-Teller
CFIA	Canadian Food Inspection Agency
CNC	Cellulose Nanocrystal
CNF	Cellulose Nanofibril
DAC	Direct Air Capture
DIAAS	Digestible Indispensable Amino Acid Score
DMA	Dynamic Mechanical Analysis
DSC	Differential Scanning Calorimetry
EDLC	Electric Double-Layer Capacitor
EHO	Epoxidized Hemp Oil
ELN	Electronic Lab Notebook
FAIR	Findable, Accessible, Interoperable, Reusable
FDCA	Furandicarboxylic Acid
FFF	Fused Filament Fabrication
FTIR	Fourier Transform Infrared Spectroscopy
GHG	Greenhouse Gas
GMP	Good Manufacturing Practice
GRAS	Generally Recognized As Safe
GWAS	Genome-Wide Association Study
HDF5	Hierarchical Data Format version 5
HPLC	High-Performance Liquid Chromatography
HTC	Hydrothermal Carbonization
IFSS	Interfacial Shear Strength
LCA	Life Cycle Assessment
LHRP	Landry Hemp Research Platform
LOI	Letter of Intent

MgO	Magnesium Oxide
ML	Machine Learning
MSDS	Material Safety Data Sheet
NB	New Brunswick
NBCC	National Building Code of Canada
NDVI	Normalized Difference Vegetation Index
NNHPD	Natural and Non-prescription Health Products Directorate
NRC	National Research Council
NRCan	Natural Resources Canada
OEM	Original Equipment Manufacturer
PEF	Polyethylene Furanoate
PHA	Polyhydroxyalkanoate
PLA	Polylactic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
QMS	Quality Management System
QTL	Quantitative Trait Locus
REST	Representational State Transfer
RTM	Resin Transfer Molding
SIB	Sodium-Ion Battery
SMC	Sheet Molding Compound
SOC	Soil Organic Carbon
SOP	Standard Operating Procedure
SPARQL	SPARQL Protocol and RDF Query Language
SSC	Specific Surface Area
TEM	Transmission Electron Microscopy
TGA	Thermogravimetric Analysis

Tv	Topology Freezing Transition
UL	Underwriters Laboratories
UNB	University of New Brunswick
VAE	Variational Autoencoder
VARTM	Vacuum-Assisted Resin Transfer Molding
VOC	Volatile Organic Compound
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffraction

Appendix E — Division Quick Reference

DIVISION	LEAD TITLE	PRIMARY DISCIPLINE	KEY EQUIPMENT	BUDGET ALLOCATION
D1	Director, Hemp Biology	Plant Genetics / Agronomy	Greenhouse, field plots, sequencing	12%
D2	Director, Carbon Materials	Materials Science / Chemistry	Pyrolysis furnaces, BET, TEM, XRD	18%
D3	Director, Composite Engineering	Polymer Chemistry / Engineering	RTM, autoclave, DMA, TGA/DSC	20%
D4	Director, Energy Materials	Electrochemistry / Engineering	Galvanostats, glove boxes, cell assembly	15%
D5	Director, Construction	Civil Engineering / Architecture	Structural testing, fire testing	8%
D6	Director, Manufacturing	Industrial Engineering	CNC, 3D printers, molding presses	6%
D7	Director, Biotechnology	Biochemical Engineering	Fermenters, bioreactors, HPLC	7%
D8	Director, Food Science	Food Science / Nutrition	Extruders, sensory lab, GC-MS	4%
D9	Director, Environmental	Environmental Science	Soil testing, water analysis	3%
D10	Director, AI Platform	Computer Science / Data Science	HPC cluster, GPU servers	4%

D11	Director, Quality Assurance	Quality Engineering	Full characterization suite	2%
D12	Director, Commercialization	Business Development	Office, meeting, demo facilities	1%

Appendix F — Risk Register

RISK ID	DESCRIPTION	LIKELIHOOD	IMPACT	MITIGATION STRATEGY
R-001	Regulatory reclassification of hemp restricts cultivation or processing	Low	High	Active policy engagement; diversify geographic operations
R-002	Bio-based materials fail to meet performance specs vs. petroleum alternatives	Medium	High	Rigorous stage-gate testing; hybrid material strategies
R-003	Key personnel departure disrupts research continuity	Medium	Medium	Documentation standards; cross-training; competitive retention
R-004	Funding shortfall delays milestone achievement	Medium	High	Diversified funding (grants, equity, revenue, partnerships)
R-005	Supply chain disruption for hemp feedstock	Medium	Medium	Multi-region grower contracts; strategic inventory
R-006	Intellectual property infringement or freedom-to-operate blockage	Low	High	Patent landscape monitoring; defensive patenting; licensing
R-007	Competitor achieves similar breakthrough first	Medium	Medium	Publication strategy; speed-to-market focus; partnerships
R-008	Climate events damage field trials or crops	Medium	Medium	Greenhouse backup; insurance; multi-location trials

R-009	Customer adoption slower than projected	Medium	Medium	Customer co-development; pilot programs; education
R-010	Data breach or loss of Core Research Database	Low	High	Encryption, backups, access control, disaster recovery

Appendix G — Partner Contact Directory

ORGANIZATION	TYPE	FOCUS AREA	ENGAGEMENT STATUS
University of New Brunswick	Academic	Materials Science, Engineering	Letter of Intent signed
Dalhousie University	Academic	Agriculture, Food Science	Discussion phase
University of Alberta	Academic	Carbon Materials (Mitlin group)	Collaboration active
ZILA BioWorks	Industry	Composite Commercialization	Partnership active
NRC-IRAP	Government	Research Funding	Application submitted
AAFC	Government	Agricultural Research	Discussion phase
NRCan	Government	Energy Materials	Discussion phase
NB Economic Development	Government	Regional Growth	Discussion phase
Mi'kmaq First Nations	Indigenous	Traditional Knowledge, Land	Consultation ongoing
Fraunhofer Institute	International	Biocomposites	Exploratory
Wageningen University	International	Hemp Agriculture	Exploratory

Document Closure

"The goal is not a hemp product. The goal is a complete hemp innovation ecosystem."

Final Strategic Research Plan

Landry Industries | Hempoxies Division
Moncton, New Brunswick, Canada
Mikmaki / Wabanaki Territory

Document Version 2.0 | July 2026
Classification: Open Research — CC BY-SA 4.0

LANDRY HEMP RESEARCH PLATFORM (LHRP) V2.0
FINAL STRATEGIC RESEARCH PLAN
LANDRY INDUSTRIES | HEMPOXIES DIVISION
MONCTON, NEW BRUNSWICK, CANADA | MIKMAKI / WABANAKI TERRITORY
DOCUMENT DATE: JULY 2026