Index

a
acaroid resin 114
acoustic sensors 145–146
afterburning 33, 34
aftermath–residues 2
air entrainment 33, 34
2-amino-4,6-dinitrotoluene (2-A-DNT) 51
4-amino-2,6-dinitrotoluene (4-A-DNT) 51
ammonium dinitramide (ADN) 5, 80
ammonium perchlorate (AP) oxidizer 51, 70, 199
ammunition demilitarization 13–45, 176
anti-tank ‘Barmines’ 36
antitank ranges 60, 68
aqueous solubility (S_w) 58
artillery guns 66, 79
autonomous underwater vehicles (AUVs) 146

b
bathymetry 146
B_4C/KNO_3/KCl/Ca stearate/PVAc 125
beeswax 114
Best Available Techniques Not Entailing Excessive Costs (BATNEEC) principle 43–44
binders 26, 51, 96, 103, 104, 114, 117, 120, 124
bioaccumulation factor (BCF) 218
bioturbation 143, 154
5,5′-bis(1-hydroxytetrazole) 122
blow-in-place (BIP) detonations 59, 78
bulk propellants 32, 33


c
C4 92–97
calibre projectiles 64
cannon ammunition 22, 23
carbon reduction 171
characterization factors (CF) 184, 186, 219, 220, 224
Chemical Munitions Search and Assessment (CHEMSEA) 150, 157
Chemical Safety Assessment (CSA) 215
Chemical Safety Report (CSR) 216
chemical warfare agents (CWA) 139, 156, 160
Chemring Nobel Company 96
chlorobenzenes 108
chlorophenols 108
circular economy 171
civil authorities 1
civilian pyrotechnic systems 107
clean-up strategy 105
CO_2 estimates 38
Cold Regions Research and Engineering Laboratory (CRREL) 47
commercial demilitarization contract 15
commercially viable materials 19
Composition B (Comp B) 51, 69, 77, 82
contaminated water 58, 227
contamination management 7
corrosion 63, 64, 140–145, 151, 155–158, 233, 246
cost-efficiency analysis (CEA) 83
costs and associated logistics 15
CX-85 83–85, 89
data quality objective (DQO) process 53
Decision aid for marine munitions (DAIMON) 141
decision units (DUs) 53
deep sea dumping 13, 17
Defence Research and Development Canada (DRDC) 47
demilitarization 235
  basic stages of 17–20
  examples of cost and CO₂ 36
  facilities 20
  factors influencing 15–17
  maturity and use of 21–26
  munition manager’s perspective 44–45
  NATO AOP 4518 40–44
  open burning (OB) 29–33
  open detonation (OD) 29–31, 33–36
  scale of issue 14–15
  technical and environmental issues 27–29
  techniques and processes 20–21
Department of National Defence Director General Environment (DGE) 47
design for demilitarization (DFD) 235
  munition manager’s perspective 44–45
  NATO AOP 4518 40–44
design for disposal 173
detonation 2, 33–34
  residues 90–91, 233
detonators 32, 33, 94, 132, 243
3,3’-diamino-4,4’-dinitramino-5,5’-bi-1,2,4-triazololate 121
1,1-diamino-2,2-dinitroethylene (FOX-7) 80
diazodinitrophenol (DDNP) 181
dibutyl phthalate 105, 213, 220–223
diisononylphthalate 220
2,4-dinitotoluene 231
2,6-dinitroanisole 231
dinitroanisole (DNAN) 69, 80
4,5-dinitro-1,3-imidazole 121
2,4-dinitrotoluene (2,4-DNT) 51
2,6-dinitrotoluene (2,6-DNT) 51
dinitrotetrazalone (NTO) 80
dioctylsebacate 220
dioctyl terephthalate 220–224
dioxin/dibenzofuran cocktail of pollutants 108
dioxins 108
Directive 76/769/EEC 214
Directive 79/831/EEC 214
Director Land Environment (DLE) 47
disposal and waste burning 126–127
disposed military munitions (DMM) 139
DM12 detonation and deposition rate measurement 94
2,4-DNT 51, 52, 58, 59, 64–66, 78, 80, 81, 88, 89, 152
Doppler velocity log (DVL) 148
DRDC Valcartier 48, 61, 90
eccodesign 171, 173, 174, 194
Ecodesign Directive 173
ecoinvent database 179, 187
ecoinvent website 179
ecolabel 171
ecotoxicity 186, 187, 190, 192, 204, 220, 224, 237
ecotoxicology 8
effect factor 186
embedded electronics 41
EM sensors 146
end-of-life (EOL) disposal 41
end-of-mission (EOM) disposal 41
end-of-operational-life (EOOL) 41
Engineer Research and Development Center (ERDC) 47
environmental and safety legislation 213
environmental assessment 2, 16, 28, 38, 39, 64, 180, 200
environmental hazard assessment 1
environmental impact of munitions 2, 247
environmental life-cycle impacts 188, 191
Environmentally Sustainable Manufacturing for Energetic Formulations 243
environmentally sustainable RTAs 58
environmental management 1, 20, 68, 176, 194, 225, 243
Environmental Management System (EMS) ISO 14001 27
Environmental Occupational Health and Safety Assessment in Canada 63
Environmental Protection for Heavy Weapons Ranges (EPHW) 47
environmental releases 200, 204, 227, 231, 237, 249
environmental safety and occupational health (ESOH)
acquisition 233–234
conception 228–232
cost and time 208–210
current and evolving regulatory interests 207
data requirements 201–207
decision-making 238
demilitarization 235
disposal 237
ecotoxicity 237
engineering and manufacturing 234–235
evolving science and new tools 203
fate and transport 235–237
field monitoring 237
industrial hygiene 237–238
integration of flow charts 204
life cycle environmental assessment 200
material synthesis 231
M116, 117, 118 simulators 207–208
munition compounds and aetiology of 199–200
M-18 violet smoke 208
phased approach 201–203
Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) 238
reproduction/developmental effects 204–206
research and acquisition 200–201
research vs. testing 203–204
testing/demonstration 232–233
toxicology data requirement 228
Toxic Substances Control Act 238
Environmental Security Technology Certification Program (ESTCP) 104, 159
EPA 8330b method 56, 68
European Chemical Agency (ECHA) 215, 238
European Conference on Defence and the Environment (ECDE) 48
explosive footprints 61–64
explosive hazard 18, 20, 27
explosive ordnance disposal (EOD) 15, 53, 92, 235
explosive waste incinerator (EWI) 22, 23, 28
exposure factor 186, 203
f fate factor 186
Finnish Defence Administration 48
firing positions (FP) 51, 54, 59, 64–66, 68, 75, 78, 79, 91
fluffy layer of suspended matter (FLSM) 144
four-power programme 5
Free From Explosive Hazard 27
freshwater ecotoxicity 185
fuze 18, 82, 83, 92, 139
fuzeheads 117
g GIM 83–85, 89–91
explosive residues 91
Global Navigation Satellite System (GNSS) 148
GLObalnaya NAvigatsionnaya Sputnikovaya Sistema (GLONASS) 148
global warming 170, 183, 186, 189
greener munitions
definition 79, 242–243
development approach 79–82
green plastic explosive 92
hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) 77
IM 60-mm mortar based on PAX-21 77
M115A2 ground burst projectile simulator 77
M116A1 hand grenade simulator 77
M274 2.75” rocket simulator 77
munitions constituents of concern 77–78
RIGHTTRAC 82–92
source of munitions constituents 78–79
unexploded ordnances (UXO) 75
green plastic explosive
   HMX option 95–96
   PETN option 93–95
green procurement 171, 173
green pyrotechnic systems 104
groundwater plume contamination 49
gun propellant 51, 64, 79, 82, 83, 86, 88, 213, 220, 243
gun testing 89–90

h
Hawaii Undersea Military Munitions Assessment (HUMMA) 142, 143, 157
hazardous wastes 14, 18, 20, 28, 33, 56, 127, 199, 234
industrial demilitarisation 19
Health and Safety Executive (HSE) Explosives Industry Group 35
heavy metals 18, 49, 77, 104, 105, 108, 109, 115, 118–122, 155, 169, 170, 184
hexachloroethane (HCE) smoke systems 116
1,3,5-hexahydro-1,3,5-trinitrate (RDX) 199
hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) 77, 152
2,4,6,8,10,12-hexanitro-2,4,6,8,10,12-hexaaazaisowurtzitane (CL-20) 80
hexavalent chromium compounds 115
HK416 76
human health and ecosystems 169, 184, 185, 187, 213–215, 218–220, 225
human health (CTUh) and ecosystems (CTUe) 186
human-occupied vehicles (HOVs) 142
human toxicity 186, 187, 189, 192, 193, 220, 224
hydrolysis 58, 141, 144, 153, 229, 232

i
IM 60-mm mortar based on PAX-21 77
individual disposal/demilitarisation action 13
industrial demilitarization 13, 17, 19, 21, 22, 27, 30, 31, 36, 39, 44
Industrial Emissions Directive 28
industrial hygiene 208, 227, 234, 237–238
inertial navigation systems (INS) 148
input–output analysis 171
insensitive high explosive (IHE) 41, 69, 70
insensitive munitions (IM) 6, 70, 77, 82, 169
Intergovernmental Panel on Climate Change (IPCC) 185
in vitro–in vivo extrapolation (IVIVE) 207
ISO 9001 27
isocyanates 6, 117
just-in time manufacturing 111

l
L320 86–90
land management 246–247
large munitions 44
large-scale explosive waste incinerator 23
lead azide 105, 106
lead-free bullets/primers 76
lead styphnate (TNR-Pb) 106, 181
legislative impact 2–4
life cycle analysis 7, 91–92, 199
life cycle assessment (LCA) methodology 171–172
environmental and toxicological impacts 170
four interrelated phases 172
functional unit 175–176
goal and scope phase 174–178
ISO standards 14040 and 14044 172
life-cycle impact assessment (LCIA) 182–194
life-cycle inventory 178–182
life-cycle thinking 170–171
limitations of 194
purpose of 173–174
simplified representation 171
life-cycle costing 171
life cycle environmental assessment 200
life cycle impact assessment (LCIA) case study 188–194
characterization 183
classification 183
methods 185–187
normalization and weighting 183
software 187–188
life-cycle inventory (LCI) 172, 178–182
local exhaust ventilation (LEV) systems 117
long baseline (LBL) 148

m
magnesium teflon viton (MTV) 116–117
M115A2 ground burst projectile simulator 77
M116A1 hand grenade simulator 77
marine Mk144 illumination signal 122
material flow analysis 171
maximum acceptable concentrations (MACh) 58
metal-based colourant 113
methyl centralite (MC) 88, 89
military live-fire training ranges
analytical tool and adsorption method for MC in aqueous samples 67–68
DRDC Valcartier 48
emerging constituents 69–70
explosive footprints 61–64
firing positions 64–66
groundwater plume contamination mitigation measures 67–69
munition related contaminants 51
octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) 48
surface soil characterization 52
thermal treatment of shoulder rocket propellant contaminated surface and sub-surface soils 68–69
unexploded ordnance (UXO) 50
105-mm army artillery munition 82
105-mm Howitzer gun 89, 90
155-mm artillery munition (M777) 87
mobile demilitarisation plants 40
modified single-base (MSB) 86–89
Monitoring of dumped munitions (MODUM) 151, 154
M274 2.75” rocket simulator 77
M116, 117, 118 simulators 207–208
multicriteria analysis 171
Multiple Launch Rocket Systems (MLRS) 38
munition constituents (MC) 52, 225
munition manager’s perspective 44–45
munition-related contaminants 51–52
munitions, handling of 151–152
munitions and explosives of concern (MEC) 139
acoustic sensors 145–146
chemical degradation 152–153
corrosion 142–143
detection 150–151
ecotoxicological aspects 154–156
EM sensors 146
environmental aspects 141–142
fate and transport of constituents 144–145
geopolitical aspects 156–158
global collaboration 159–160
global EU and NATO efforts 160–161
handling 151–152
human capacities 161–162
in situ methods 141
location 150
long-term and long-distance transport 153–154
monitoring 151
navigation and positioning systems 148
optical sensors 146
platforms 146–147
remediation 141–150
research infrastructures 161
scientific advances 161
sea disposal process 145
technology innovation 161
munitions constituents (MCs) 47
of concern 77–78
RTA 58–61
source of 78–79
munitions, disassembly of 13, 27
Munitions Safety Information and Analysis Centre (MSIAC) 45
M-18 violet smoke 208
n
NAMMO Buck 29, 30
NAMMO NAD 29
national legislation and public acceptance 15
NATO AOP 4518 40–44
NATO Applied Vehicle Technology (AVT) 48
NATO AVT 115 4
NATO AVT 177 4
NATO AVT 179 4
NATO AVT 197 4
NATO AVT 269 4
NATO AVT-249 task group 48
NATO Collaboration Support Office tasked AVT-197 48
NATO Cooperative Demonstration of Technology (CDT) 48
NATO Industrial Advisory Group (NIAG) 21
NATO RTO AVT-177 symposium 63
NATO Support Agency 8
NATO Support and Procurement Agency (NSPA) 16, 247
navigation and positioning systems 148
neurotoxin 6
N-guanyleura-dinitramide (FOX-12) 80
nitramines 51, 80, 95, 231
nitrate esters 7, 51, 231
nitroaromatics 81, 153, 231
nitroaromatic-trinitrotoluene (TNT) 2, 4, 6, 80, 152
nitroglycerin (NG) 51, 59, 69, 97, 231
nitroguanidine (NQ) 51, 59, 86
nitrotiazalone (NTO) 69, 80
North American RTAs 49, 51, 82
Norwegian Armed Forces 76
Norwegian servicemen 6
OHSAS 18001 27
old red lead/silicon primer 115
One health approach 199–210
on-site disruption and disposal 8
open burning (OB) 4, 22, 25, 29–33, 66, 78, 128, 170, 235, 249
vs. EWI incineration of SAA 39
open detonation (OD) 4, 13, 22, 25, 29–31, 33–36, 52, 170, 176
optical sensors 145, 146
ordnance disposal site 247
Organization for Security and Cooperation in Europe (OSCE) 23
oxydiethane-2,1-diyil dibenzoate 220, 224
ozone depletion 183, 184
p
pentaerythritol trinitrate (PETN) 80
option 93
perchlorates 7, 49, 51, 59, 77, 78, 97, 104, 108, 109, 112, 120, 199
chlorate 116, 122–124
periodates 120, 123
persistent, bioaccumulative, or toxic (PBT) 216
phosphorus (V) nitride (P3N5) 118
physical destruction techniques 20
plastic-bonded explosives (PBX) 41
plume dispersion 33, 34
plume formation 33, 34
polychlorinated biphenyls 123
post-detonation residues 62, 77, 91, 93
Prevention of Marine Pollution by Dumping of Wastes 139
Programmatic Environmental Safety and Health Evaluation (PESHE) 200
propellant production 192, 220
propellant residues 54, 59, 60, 65, 66, 68, 79, 236
propellant’s environmental hazard assessment 1
propelling charge system 66
pyrotechnics 5, 227
civilian pyrotechnic systems 107
‘clean-up’ strategy 105
compositions 103, 104
disposal and waste burning 126–127
environmental effect 103, 104
environmental legislation 127, 129
green pyrotechnic systems 104
heavy metal 115, 118–122
integration 129–133
list of ingredients 104
magnesium teflon viton (MTV) countermeasures 116–117, 127
obscurent smokes 124
packaging waste 118
perchlorate and chlorate 116, 122–124
perchlorate levels 104
production 109–110
pyrotechnic devices 112
qualification 107
raw materials acquisition and quality control 112–114
Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) 105–106
resins, binders and solvents 117
and simulators 32
site location 110–112
smokes 116
specific materials production 114–115
storage 117–118
suitably qualified and experienced person (SQEP) issues 128–129
usage and disposal 118
volatilization smokes 116, 124–125

quality assurance/quality control (QA/QC) 57, 231
quantitative structural activity relationship (QSAR) models 230
quantitative structural property relationship (QSPR) 230

range and training areas (RTA) characterization 47
R440 dim illuminant 122
RDX 6, 49, 51, 52, 58–60, 63, 68, 77, 79, 80, 82, 83, 85, 92–97, 149, 152–156, 182, 199, 213, 231
RDX/TNT 36, 37
reactive injection moulding 249, 250
Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) 2, 105, 238
European defence capabilities 213 overview of 214–215
regulation 793/93 214
regulatory thresholds 218
remotely operated vehicles (ROVs) 142
removal from storage 17–18
residual material disposition 20
resins 114, 117
resonant acoustic mixing technology 249
reuse, recovery and recycling (R3) methods 18, 26, 41
Revolutionary Insensitive, Green and Healthier Training Technology with Reduced Adverse Contamination (RIGHTTRAC)
cost-efficiency analysis (CEA) 83, 91
fate, transport and toxicity 88–89
field demonstration 89
IM properties 83–84, 87–88
main explosive charge 83
105-mm army artillery munition 82 performance 83
propellant charge 86
rising gas 143
rocket motors 18, 26, 29, 32, 33, 45, 243

Safe Drinking Water Act 97
safety data sheet (SDS) 106
sea disposal 139, 140, 145, 146
sea disposal process 145
sea-disposed munitions 140, 143, 161
sea-dumped munitions 4, 160, 245
sea dumping 13, 159, 176, 241
SENTINEL project 107
settling sediments 143
short baseline (SBL) 148
shoulder rocket propellant contaminated surface and sub-surface soils 68–69
SimaPro 187, 188
single-base propellant 51, 86, 87
size reduction/removal 18
small arms ammunition (SAA) 15, 28, 29, 32, 33, 39, 40
small arms ammunition destruction oven (SAADO) 33
small arms propellant residues 65
small-scale incinerator and products 22
smokeless propellant 5
snow sample filtration 62
soil sorption constants \((K_d)\) 58
solvents 32, 56, 105, 116, 117, 125, 243
space agencies 1
SS Richard Montgomery 158, 245
steel/lead projectile 188–193
Strategic Environmental Research and Development Program (SERDP) 47, 77, 104, 159, 210, 239, 243
styphnate 105, 106, 152
substances of very high concern (SVHC) 105, 213, 214, 216
substantial residues 170
suitably qualified and experienced person (SQEP) issues 128–129
surface soil characterization cleaning 57–58
data quality and sampling objectives 53–55
risk to the receptors through the transport of munitions constituents 58–61
safety aspects 53
soil samples 56–57
surface soil sampling pattern 55
surface to near-surface UXOs 64
surface vessels 146–148
system boundaries 172, 175–178

T
Technology Demonstration Program (TDP) 77
terrestrial toxicity 80, 85, 88
thermal treatment 32, 68–69, 170
toxicological life-cycle impacts 189
Toxic Substances Control Act 238
trichloroethane (TCE) 105
1,3,5-trinitrobenzene (TNB) 58, 154–156, 231
2,4,6-trinitrotoluene (TNT) 6, 51, 59, 77, 80, 152, 156, 176, 200, 231
twin screw extrusion 249

U
ultrashort baseline (USBL) 148
unexploded ordnance (UXO) 35, 50, 75, 92, 139, 170
United Nations Environment Programme/Society of Environmental Toxicology and Chemistry (UNEP/SETAC) 185
unplanned disposal 8, 247
unmanned surface vehicles (USVs) 147
unmanned vehicles 146
unused/surplus munitions 247
USA peer-reviewed funding program 47
U.S. Army Corps of Engineers 6
U.S. Army Environmental Quality Technology Program 208
U.S. Army’s Green Ammunition Program 76
US Environmental Protection Agency 2, 49, 78, 104, 201, 238
U.S. EPA Contaminant Candidate List 3 (USEPA web site) 97
U.S. EPA Interim Lifetime Drinking Water Health Advisory 78
USEtox method 185–189, 193, 194, 218–220, 224
U.S. Massachusetts Military Reservation (MMR) 49, 76
US Strategic Environmental Research and Development Program (SERDP) 47, 77, 104, 159, 243

V
volatilization smokes 116, 124–125

W
Wallop Defence Systems site 117
waste disposal 19, 20, 110, 126
waste management 110–112, 116, 126, 176
watercraft 147
water solubility of energetic materials 81
‘whistle, bang, flash’ simulators 207–208