

Index

- ¹²C, 272–273
¹³⁰Ba, 261
¹³²Ba, 261
¹³⁴Ba, 261
¹³⁸Ba, 261–262, 264
¹³C, 272–275, 277–278, 281, 285
¹⁴⁴Nd, 248
¹⁴⁷Sm, 248
¹⁴C, 272–273, 277, 285, 288
¹⁷⁶Hf, 248
¹⁷⁶Lu, 248
¹⁸⁷Os, 248
¹⁸⁷Re, 248
¹H, 272–273
²²³Ra, 216
²²⁴Ra, 216
²²⁶Ra, 216–222, 227–229, 233–236, 241, 256
²²⁸Ra, 216–221, 228–229, 233, 235, 256
 2-butoxyethanol, 160
²H, 272–273, 278, 281
³H, 272–273
 40 CFR 192, 222, 227
⁶Li, 247, 258–259
⁷Li, 247, 258–259, 261, 264
⁸⁶Sr, 247–249, 253, 255–256, 258–259, 264–265, 268
⁸⁷Sr, 247, 249, 253, 255–256, 258–259, 264–265, 268–269
- Aarhus Convention, 82
 abandoned mine drainage (AMD), 228, 232, 239, 241, 255, 314–315, 340, 353, 356, 381, 387, 392, 405
Accipiter gentilis, 373, 384
 Actinium, 216
 Adaptive Environmental Management Regime, (AEMR), 50–51
 Ahnet, 5, 10
 air quality, 39, 65, 74, 105, 107, 109–110, 114, 123–124, 129, 131
 Alabama, 10, 154
 Alaska, 10, 16, 154
- Alberta, 8, 12, 117, 128, 179, 188–189, 192–194, 197–198, 205–206, 208, 210–213, 383
 Algeria, 3, 5, 10, 15, 17
 Allegheny County, 106, 108–109, 111, 345, 362, 405
 Allegheny River, 345, 391–392, 394, 397, 400–401, 403, 405–407
 allelic richness, 351
 alpha decay, 180, 214–216, 219–220, 234, 238
 Amazonas, 4, 14
Ambloplites rupestris, 347, 350
 American Oil and Gas Historical Society, 23
 American robins, 371
 antimony, 32
 Antrim, 20–21, 281, 288, 293, 304, 308–310
 Apache, 9, 17
 Appalachian Basin, 17, 19, 38, 40–41, 93, 169, 220, 222, 228, 237, 241–243, 246, 251, 255–257, 259–262, 266, 268–269, 271, 289, 338–339, 361–363, 365
 Appalachian Fold Belt, 4, 12
 Appalachian Mountains Bird Conservation Region, 371, 373
 aquatic habitat, 354
 aquifer, 29, 58, 60, 154, 168, 239, 245, 255, 258, 264–266, 268
 Arab Oil Embargo, 89
Arcobacter halophilus, 346
Arcobacter marinus, 346
 Argentina, 3–4, 9, 15, 17
 Argonne National Laboratory, 154
 Arkansas, 10, 20, 33, 337
 Arkoma, 21, 191
 arsenic, 228, 230, 268
Arthrobacter, 346
 aseismic creep, 186, 188
 Austral, 4, 9
 Australia, 3, 7, 13, 16–17, 41, 44–45, 47, 52–53, 56–60, 62–65, 67, 69–78, 170
 Australian Bureau of Statistics, 53
 Australian Energy Market Operator, 52, 71

- Australian First Peoples, 69
 Australian Government Productivity Commission, 49
 Australian Petroleum Production and Exploration Association, 16, 50
 Automated Ribosomal Intergenic Spacer Analysis (ARISA), 345
- Bacillus*, 346, 360–361
Bacillus firmus, 346, 360
- Bakken, 4, 10, 12, 20–21, 92, 135–136, 147, 152, 169, 257, 268–269, 304, 309
- ban, 4, 7, 10, 12–13, 16, 56–57, 69, 83, 86, 88, 91, 94–95, 97
- barite, 220–222, 229, 232, 237, 242, 244, 251, 262, 268, 301
- barium, 32, 216, 220, 238–240, 242–243, 245–246, 268–270, 301, 330, 333, 356, 373
- Barnett, 20–21, 23, 33, 41, 114, 116, 122, 125, 128, 135–136, 146, 154, 160, 281, 293, 300–302, 304, 308, 310, 345, 360, 362
- basins, 3, 8–10, 12–14, 20, 44, 114, 116–117, 119, 123, 135, 154, 174, 182, 192, 223–224, 235, 264, 266, 281, 341, 358, 374, 386–392, 394–399, 402, 404, 407
- Bates Fork, 342–348, 350–358
- bats, 374
- Bazhenov, 5, 14
- Beaver, 37–38, 41, 96, 109, 111
- Becquerel, 214, 218
- Beetaloo, 8, 13, 44
- beneficial use, 49, 70, 77, 226, 228–229, 231, 239, 241
- benzene, 68, 107, 115–117, 119, 122, 127, 129, 160
- beta decay, 214–216, 234
- bioaccumulation, 229, 356
- biocide, 32, 292, 299–300, 304–307, 309, 340, 358
- biofouling, 292, 299, 301–302, 305–306
- biogenic methane, 272, 274, 278, 285, 287
- biogenic sulfide, 302–303, 306, 309
- biomass burning, 139
- birds, 368, 371, 381
- black carbon, 111–112
- Blacklick Creek, 228, 394, 397, 405
- Blackpool, 85–86
- Blacksville No. 2, 389
- blenders, 30–31
- blow out preventer, 29
- bluntnose minnow, 350
- boron, 230, 258, 270, 314, 356
- Bowen, 44, 58, 60, 71, 281, 379, 381
- Bradford County, 320, 322–323, 333
- Brazil, 3–4, 14–19
- breaker, 32
- bridge fuel, 132
- Briggs vs Southwestern Energy Production Co, 24
- brine trucks, 31
- British Columbia, 12, 179, 189, 194–195, 205, 208–209, 213
- British Gas, 47–48
- British Geological Survey, 85
- broad-winged hawks, 373
- bromide, 158, 163–169, 239, 330–331, 335, 344–346, 356, 402, 405–407
- brook trout, 375
- brown-headed cowbird, 367
- Browns Creek, 342, 344
- Brown, James Gordon, 84
- BTEX, 63, 107, 119, 122, 125, 160
- Bureau of Forestry, 366, 376
- Burgos, 4, 12, 226, 228, 237, 241, 243, 256, 269, 313, 336, 339, 370, 379
- Bush, George Herbert Walker, 89
- Bush, George W, 89
- butane, 24, 33, 35, 38, 114–115
- Buteo platypterus*, 373, 381
- Butler, 111
- Byerlee's law, 185
- calcium, 32, 158, 166, 216, 220, 229, 246, 256–257, 356
- California, 10, 12, 106, 124, 127, 147, 149, 154, 177, 189, 207, 209, 222, 225, 228–229, 240, 266, 275, 289–290, 342
- Cambrian, 6, 13, 21, 191, 245
- Cambrian-Ordovician Arbuckle Group, 191
- Canada, 3–4, 12, 16, 18–19, 88, 102, 128, 134, 160, 168, 170, 174, 189, 191, 193–195, 203–209, 212, 296, 300
- Canadian Shield, 258, 265
- Canning, 8, 13, 44
- carbon dioxide, 23, 38, 53, 63, 78, 98, 132–133, 141–142, 273, 281, 288
- carbon monoxide (CO), 65, 105–107
- carbon-12, 139
- carbon-13, 133, 139–141
- carbon-14 radiocarbon dating, 133
- Carter, Jimmy, 89
- casing, 29–30, 255, 313
- cation exchange, 219–220, 222, 243
- Catostomidae, 347–348
- cellar, 25, 29
- centralized waste treatment, 162, 222
- Centrarchidae, 347–348
- ceramic proppant, 32, 340
- Chaco-Parana, 14
- Chad, 3, 6
- change in fault loading conditions, 186, 188–189
- Chapter 32 Title 58 Oil and Gas Act, 25
- Cheat River, 394
- Cheney, Dick, 19
- Chevron, 9, 17, 63
- China, 3, 6, 8, 16, 18, 47, 90, 174, 258, 267–268, 296, 303, 310, 314, 362
- Chinchilla, 61, 68
- chipping sparrows, 371

- chloride, 158, 164–166, 170–171, 220, 222, 224, 233, 246, 302, 304, 315, 344–347, 356–357, 362, 395, 399, 405–406
- Class II injection well (UIC), 32, 225
- Clean Air Act, 89, 105, 125
- Clean Water Act, 89, 227, 244, 389
- Clinton, Bill, 89
- Clinton, Hilary, 90
- coal, 14, 25, 29, 32, 44, 47–48, 51, 53, 56, 58, 60–62, 68, 71–75, 77–79, 93, 106, 114–115, 123, 132–133, 138, 141–142, 144–145, 228, 237, 246, 255, 265–266, 273, 278, 281, 285, 287, 290, 336–338, 340–341, 345, 387, 395, 402, 407
- coal bed methane, 44
- Cobetia marina*, 346
- coefficient of static friction, 183, 201
- Colorado Oil and Gas Conservation Commission (COGCC), 25
- Collingham, 6, 13
- Colorado, 4, 10, 20, 25, 82, 90, 110, 114–116, 119, 121–122, 125–126, 129, 154, 160, 173, 186, 210, 238, 260, 278, 289–290, 304
- completion, 9, 30, 39, 50, 79, 84, 90, 138, 174, 192, 197, 246
- compressional waves, 177
- compressor stations, 37, 58, 64, 110, 117, 121, 131, 364, 367–368, 378
- Compton Effect, 215
- compulsory integration, 24
- condensate tanks, 29, 31, 117
- conditional use permit, 25
- conductor hole, 29
- Conemaugh River, 256, 394, 397, 405
- ConocoPhillips, 47
- CONSOL Energy, 389–391
- contamination, 61, 68, 242, 249, 269, 335, 338
- control center, 30–31
- conventional reserves, 10, 19
- Cooper-Eromanga, 44
- COP21, 132, 142, 144
- coprecipitation, 220, 228
- Corbett, 95–96
- Cordova Embayment, 12
- core forest, 363, 365–366, 373, 377
- corrosion inhibitor, 32
- Council of Australian Governance (GOAG), 48, 56, 72
- COVID 19 pandemic, 70
- creek chub, 350
- Cretaceous, 6, 9–10, 12–13, 21, 308
- crosslinker, 32
- crude, 19–20, 90
- cryogenic plants, 38
- coal seam gas (CSG), 44–45, 47, 49–51, 53, 56–58, 60–63, 65, 68, 71–72, 76
- Cuadrilla Resources Ltd, 60, 73, 84–86, 101
- cube fracking, 30
- Curie, Marie, 214, 218
- Curvibacter*, 346, 359
- Centralized Waste Treatment (CWT), 162, 166, 228
- Cyprinidae, 347–348
- Dallas, 10, 90–91, 101, 106, 189
- Darling Downs, 64–65, 75
- darters, 347–348, 357
- David Cameron, 84
- debutanizer, 38
- deep well injection, 4, 12, 94–95, 100, 161, 167, 307
- deethanizer, 38
- deicing, 166, 168, 230–231, 360
- deisobutanizer, 38
- Delaware River Basin Commission, 12, 24
- denitrification, 160
- Denton, TX, 10, 91, 101
- Denver-Julesburg Basin, 114–115, 117–119, 121, 127, 130, 160, 289
- depropanizer, 38
- derrick, 29
- Desulfosporosinus*, 302
- Desulfovibrio*, 302
- deviatoric stress, 183
- Devon Energy, 82
- Devonian, 9–10, 12, 14, 20–21, 40–42, 191–192, 194, 212, 237, 243, 249–251, 253, 255–256, 259–260, 262, 264–265, 268–269, 288–289, 309, 338
- diethanolamine, 38
- Diethylene glycol, 38
- dip, 177, 191, 354
- direct pore-pressure effect, 186
- directional drilling, 19–20, 23, 89, 134
- dislocation theory, 176
- displacement, 40, 176–177
- dissolved oxygen, 344, 357
- Doctors for the Environment, 49, 65, 72, 74
- downstream, 23, 33, 39, 134, 137, 139–141, 144, 163, 166, 227–229, 236, 241, 252, 341–342, 353, 357, 370
- drilling log, 30, 32
- drilling mud, 62, 221, 246, 263, 301, 303, 310, 362
- drilling waste, 25, 30
- drip gas, 24, 33, 38
- Duganella*, 346, 361
- Duncan, OK, 23
- Dunkard Creek, 389, 394, 396
- dust suppression, 62, 166, 226, 230
- Duvernay Formation, 192, 209, 211
- Etheostoma caeruleum*, 347
- Etheostoma flabellare*, 347, 350
- Etheostoma nigrum*, 347, 351, 353
- E.A.L. Roberts, 20
- Eagle Ford, 4, 10, 12, 20–21, 90, 115, 129, 135–136, 152–154, 293, 309

- earthquake, 9, 12, 73, 81, 84, 87, 91, 94, 97, 162, 169, 171, 173–174, 176–178, 180, 185–186, 188–189, 191–196, 200, 203–213
 East Siberia, 14
 eastern bluebirds, 368
 Eastern Mine Land Federal Consortium, 404
 Eclipse Resources, 29
 ecoregion, 347, 363
 effective normal stress, 180
 effective stress, 173, 182, 204
 electrofishing, 342, 347, 349
 electrometer, 214
 electrons, 214, 272
 Ellenburger Formation, 191
 Emmanuel Macron, 83
 Energy Policy Act of 2005, 19, 39, 43, 89
Enterobacter, 346
 Environmental Defense Fund, 137–138
 Environmental Protection Act, 48, 52, 77
 EOG Resources, 9
 epicenter, 176–177, 374
 epicentral distance, 177
 Epsilon, 7, 13, 16
Ericymba buccata, 348, 350
Ernest Rutherford, 214
 erosion, 25, 68, 363, 369–370
Erwinia, 346
Escherichia, 346, 360
 estimated ultimate recovery, 3, 33
 ethane, 19, 24, 33, 37–39, 42, 96, 116–117, 119, 147, 149, 274, 281, 287
 ethane cracker, 37–39, 96
Etheostoma blennioides, 347–348
Etheostoma flabellare, 348, 351, 353
Etheostoma nigrum, 348, 350
 ethyl benzene, 107
 ethylene, 32, 38, 301
 ethylene glycol, 32, 301
 Estimated Ultimate Recovery (EUR), 3, 33, 42
 European Union, 3
Eurycea bislineata, 354
Eurycea longicauda, 354
 evaporation ponds, 61–62
 exploding torpedo, 21
 ExxonMobil, 9, 38, 63

 fantail darter, 350–352
 fault plane, 177, 185
 fault trace, 177
 fault-slip potential, 174, 198
 Fayetteville, 20–21, 33, 147, 373
 Federal Energy Regulatory Commission, 37, 89
 fermentation, 273, 281, 286, 293, 299, 301
 fish kill, 386
 flare, 92, 133
 FLIR camera, 117
 flowback, 32, 93, 117, 138, 154, 169–170, 174, 219, 221, 236–239, 242, 246, 255–256, 258, 265, 267–268, 271, 292, 294, 300, 302, 305–306, 309–310, 315, 336–337, 339–340, 345, 360, 370, 389–391, 402
 focal mechanism, 177, 180
 Fonner Run, 342–348, 350–358
 forced pooling, 24
 forest, 57, 69, 342, 346, 355, 361, 363, 365–374, 377–383
 forest salamanders, 374
 formation water, 30, 62, 152, 191, 220, 240, 255–256, 265, 267, 340
 FracFocus Chemical Disclosure Registry, 32, 40
 fracking, 10, 14–18, 20, 29–30, 33, 39–40, 43, 56–57, 62, 73, 75–76, 78–79, 81–91, 93–97, 117, 125, 134, 152, 168, 170–171, 231, 268, 281, 284–285, 313, 340, 356–358, 367, 369–370, 373, 383
 fragmentation, 363, 365–367, 374–375, 378, 380–384
 France, 3, 5, 15, 81–83, 87, 96, 98–100, 188, 203, 270, 289
 Frasnian shale, 10
 freshwater mussels, 256, 375
 friction reducer, 32, 340
 Friends of the Earth, 82
 Front Range, 115, 125, 129, 278, 290
 fugitive emissions, 53, 58, 64–65, 72, 119, 147
 Fuling gas field, 258

 gadolinium, 32
 gamma rays, 214–215, 233
 gamma spectroscopy, 233–235
 Gasfields Commission, 48, 53, 73, 77
 gas-in-place, 3
 Gasland, 82, 100, 281
 gathering pipelines, 23–24, 30
 gelling agents, 32
 genetic diversity, 351–352, 358
 Georgina, 8, 13, 44, 76
 Germany, 5, 16, 83, 87, 96, 213
 Ghadames/Berkine, 5, 10
 global warming, 53, 65, 132, 142, 145–146
 glutaraldehyde, 32, 300–301
 Goldwyn, 13
 Golfo San Jorge, 9
 governance, 79, 150, 212
 green sunfish, 350
 greenhouse gas emissions, 63–64, 71, 98, 132, 140, 144
 Greenpeace, 82, 98
 greenside darter, 347
 groundwater, 29, 42, 50, 59–60, 68, 81, 85, 140, 148, 152, 154, 166, 191, 229, 246–247, 249, 251, 253–255, 258, 261, 267–269, 271–272, 280–282, 284, 287, 290, 313–314, 318, 320, 322, 324, 333, 337, 339, 370
 guar gum, 32, 301, 303
 Gunnedah, 44
 Gutenberg-Richter (G-R) formula, 177

- H. organivorans*, 346
 habitat loss, 363, 374
Halanaerobium, 294, 298–301, 303–307, 309
 Halliburton, 19, 23, 41
 Halliburton Loophole, 19
 Halomonadaceae, 294
Halomonas taenensis, 346
Halotheothrix, 346, 359
 Haynesville, 10, 20–21, 33, 90, 135–136, 147, 154, 293
 hazardous air pollutants (HAPs), 105–106, 122
 helium nuclei, 214
 herpetofauna, 367
 high energy photons, 214–215
 horizontal stress, 180
 Horn River, 4, 12
 Horton Bluff, 4, 12
 Hugoton, KS, 21
 hydraulic fracturing (HF), 3, 10, 13, 19–20, 29–31, 33, 39, 42, 56–58, 83–84, 86, 89, 91, 93, 109–110, 114, 123, 131, 134, 136, 140, 150, 154, 157, 160, 163, 167, 169–171, 173–175, 178, 185–186, 188–189, 191–192, 194, 196–198, 201, 204–212, 221, 230–232, 236, 239–240, 242–244, 246, 255–258, 260, 262, 265–267, 269–271, 281, 287, 289, 292–294, 296, 298–302, 305, 308–310, 313, 320–321, 324, 337–340, 359, 361–363, 373, 380, 382, 395, 402, 405
 hydrogen, 38, 69, 272, 274–275, 285, 290
 hydrogen sulfide, 38
 hydrologic cycle, 150, 154, 314, 328
 hypocenter, 176, 180
 ICP-MS, 336, 356, 359

Idiomarina, 346
 Illizi, 5, 10
 Impact Fee, 96
 impoundments, 24–25, 309, 358, 364
 Index of Biotic Integrity, 347
 Indiana, 10, 95, 99, 146, 374
 Indiana bat, 374
 Induced seismicity, 173–174, 206–207, 210
 injection-induced seismicity, 173–174, 225
 intermediate casing, 29
 intermediate string, 29
 International Permanent Peoples' Tribunal, 67
 Invasive, 368, 383
 iridium, 32
 iron control, 32
 iron roughneck, 29

 Jiangnan, 6, 8
 Johnny darter, 348, 350–352
 Johnson, Boris, 86–87
 Junggar, 6, 8
 Jurassic, 5, 9–10, 12, 14, 21
 Jurua Valley, 14

 Kangan gas field, 258
 Kansas, 10, 154, 186, 189, 191, 210

 Karoo, 6, 13, 15
 Keeling plot, 277
 kick off point, 26, 29
 Kiskiminetas, 394, 397, 405
 Kyoto Protocol, 142

 Lake Eyre Basin Wild Rivers Declaration, 49
 Lancashire, 60, 84–86, 101, 206
 Land Access Code, 51
 Land Access Framework, 48
 landfill, 24, 61, 221–222, 231, 278–279, 282
 landing point, 29
Lepomis cyanellus, 348, 350
 Liard, 4, 12
 Libya, 3, 6
 liquid nitrogen, 23
 liquid scintillation, 234
 liquified natural gas, 19, 38
 Liquified Natural Gas (LNG), 19, 38, 42, 44, 46–48, 52–53, 57, 63, 70–73, 75–76, 78
 lithium, 243, 246, 258, 266, 268–270, 314, 356
 Little Kanawha, 395, 398
 Lone Pine, 346
 Long-tailed Salamander, 354
 Louisiana, 10, 20, 33, 90, 154, 308, 356, 360, 362, 373, 381, 385
 Louisiana Waterthrush, 356, 360, 362, 373, 381, 385
 Loyalhanna Creek, 394, 397, 405
 Lycoming County, 322, 338, 366

 Manitoba, 12, 92
 Mann-Whitney U test, 112–113
 Marcellus, 10, 20, 24, 29, 33, 38, 40, 42, 93, 95, 100–101, 106, 109–111, 114, 116–119, 123, 126, 129–131, 135–136, 138, 147, 152–154, 157–158, 160–163, 168–169, 171, 220–221, 234, 236–241, 243, 245, 249–251, 253, 255–258, 260, 262, 264–270, 281, 287–288, 293, 300, 302, 304–305, 308–310, 314, 330–331, 336–342, 344–346, 350–351, 353, 355–361, 363–364, 368, 370–375, 378–384, 402, 405
 mass ratio, 336, 359
Massilia, 346, 362
 mast, 29
 Material Safety Data Sheet, 32
 Mauna Loa Observatory, 273
 MC-ICPMS, 247, 249, 262
 Maximum Contaminant Level (MCL), 314
 Melbourne Energy Institute, 64, 74
 mental health, 59, 75
 Mercer County, 322
 methane (CH₄), 23, 33, 38–39, 42, 47, 53, 64, 74, 82, 89–90, 92, 96–98, 115–119, 123–124, 126, 129–130, 132–142, 144–149, 246, 255, 266, 272–273, 275, 277–278, 280–281, 284–285, 287–290, 309, 337
 methane emissions, 64, 74, 89–90, 96, 98, 112, 117, 119, 124, 132–134, 136–140, 142, 144–149, 273, 278, 287, 289

- methanogen, 307
methanogenic, 293, 310
Methanohalophilus, 294, 298–300, 302, 307
Mexico, 3–4, 10, 12, 15, 17–19, 90, 116, 154, 160, 289, 308
Michigan, 10, 20–21, 154, 230, 288, 308–309
microbiome, 345–346, 358
Micrococcus, 346, 359
Microsatellites, 350–351
Microstegium vimineum, 376
midstream, 23, 33, 38–39
mineral rights, 23, 87–88, 91, 96
Mines Legislation (Streamlining) Amendment Bill 2012, 48
Mississippi, 10, 154, 189
Mississippian, 12, 20–21, 196, 255, 268
Mitchell, George, 23
Mohr diagram, 183
Mohr-Coulomb criterion, 183, 199
Molothrus ater, 367
monoethanolamine, 38
Monongahela River, 27, 94, 101, 164–165, 171, 339, 341, 350, 356, 360, 386–387, 389–392, 394–396, 399, 400–404, 407
Montana, 10, 21, 92, 257, 265, 268, 281
Montney, 189, 194, 196–198, 205–206, 209, 213
Montney Formation, 194, 205
Montney play, 194, 197–198, 205, 209
moratorium, 7, 12–13, 15, 49, 56–57, 84, 86, 95–96
Mount Wilson Observatory, 275
mouse hole, 29
Mouydir, 5, 10
Multiple Land Use Framework, 48, 72
Murteree, 13
Muskingum, 395, 398
Muskwa, 4, 12
Myotis septentrionalis, 374
Myotis sodalis, 374
- N,N, Dimethyl formamide, 32
NAAQS, 105, 107, 113–114, 123
Nafe-Drake relationship, 182
naphthalene, 160
Nappamerri, 7, 13
National Ambient Air Quality Standards, 105
National Energy Technology Laboratory, 19, 43, 264, 266, 360
National Pollutant Discharge Elimination System (NPDES), 227–229
National Pollutant Inventory, 65, 76
natural fractures, 30, 186
natural gas, 10, 15, 17, 19–20, 37–41, 43–44, 47, 53, 63–64, 78–79, 82, 84–86, 89–90, 92–93, 95–96, 109, 112, 114–117, 119, 123–126, 129–135, 137–142, 144–148, 156–157, 160, 167, 170–171, 236–237, 240, 246, 265–266, 278, 281, 285, 287, 289, 292–293, 300, 302, 306, 308–310, 313, 336, 340, 353, 361–362, 364, 367, 377–378, 380, 382, 384, 407
Natural Gas Act of 1938, 38
natural gas liquids (NGL), 38, 93, 96, 246
Natural Resources Defense Council, 150
naturally occurring radioactive materials, (NORM), 30, 62, 158, 161, 166, 170, 215–216, 219, 221–223, 225–226, 229–231, 233–235, 238, 241, 246, 313, 338
Nature Conservation Act 1992, 49
Nebraska, 10
NETL, 19, 39, 41, 43, 261, 267, 270, 360
Neuquén, 9
Nevada, 10
New South Wales (NSW), 13, 44, 55–57, 59, 65–67, 71–72, 76
New York, 10, 16–17, 20, 30, 42, 73, 79, 88, 90, 93, 99–102, 115, 134, 140, 142, 145–146, 152, 154, 168, 170, 205, 209, 230, 243–244, 267, 328, 334, 337, 361, 382
Niobrara, 10, 20–21, 219
nitrate, 107, 113, 123, 344, 356
nitroglycerine, 21
NO₂, 105–107, 109–110, 114, 123–124
nondisclosure agreement, 32
North Dakota, 10, 20, 25, 89–90, 92, 95, 98, 101, 116, 147, 152, 154, 170, 228–230, 237, 240, 257, 267–268, 382
North Dakota Industrial Commission, 92
northern goshawks, 373
Northern long-eared bat, 374
Northern Territory, 13, 44, 58, 60, 64, 67, 69–70, 73, 75–76
Northwest Territories, 12
Norway, 19
Nova Scotia, 12
- Obama, Barack, 89, 91, 95
Office of Fossil Energy, 89
Office of Groundwater Impact Assessment, 59
Ohio, 10, 20, 25, 29, 35, 37–38, 90, 93–95, 97, 99–100, 152–154, 166, 207, 212, 222, 262–263, 281, 285, 287, 290, 347, 349–350, 361, 365
Ohio Department of Natural Resources (ODNR), 25, 94
Ohio River, 152, 262–263, 388, 390–395, 398–405, 407, 408
oil, 3–4, 8–10, 12–17, 19–20, 23, 30, 32–34, 38–42, 49, 53, 55, 57, 63–65, 68, 72–74, 79, 81–83, 87–97, 105, 107, 109–110, 112–117, 119, 122–132, 135, 138–139, 141–142, 145–147, 149–154, 158, 160–161, 164, 166–171, 173–174, 178, 189, 191–192, 194, 197, 204, 206–207, 210, 216, 219–221, 223, 225, 230, 233–235, 237–239, 241–244, 246–247, 249, 254–259, 261–262, 264, 266–270, 272, 274, 278–282, 287, 289, 301–302,

- 307, 309, 313–318, 321, 324, 336–337, 346, 359, 362–363, 365, 370, 378–379, 381–383, 395, 407
- Oil-in-place, 3
- Oklahoma, 10, 20, 90, 152, 154, 169, 171, 174, 179, 186, 188–192, 197–198, 205–212, 225, 266, 360
- Oklahoma Corporation Commission (OCC), 191, 197, 210
- Olympus Energy, 29
- Ontario, 12
- ordinance, 10
- Ordovician, 6, 10, 12–13, 21, 191, 255
- Orenia, 298
- Otter Park, 4, 12
- ozone, (O₃), 65, 105–107, 110, 114–115, 121, 123–124, 126, 129–130
- Osborne, George, 85
- P waves, 177, 180
- Pacific Institute, 150
- Pacific Northwest National Laboratory, 23
- pad preparation, 23, 39
- Pair Production, 215
- Pantoea, 346
- Paraná, 9, 14
- Parecis, 14
- Paris Basin, 5, 82, 268
- Parkesia motacilla*, 356, 360, 362, 373
- Parnaíba, 14
- particulate matter, 105, 125, 130, 230
- Patchawarra, 7, 13
- Pawnee earthquake, 174
- Penn State University, 376
- Pennsylvania, 10, 20, 23, 25–26, 29, 31–33, 37–42, 79, 82, 88, 90, 93–102, 108–109, 111, 114, 116, 131, 138, 146–147, 152–154, 156–158, 162, 164, 167–169, 171, 221–222, 225, 227–228, 230, 232, 237–240, 242–245, 249–250, 252–253, 255–257, 263, 265–267, 269–270, 281, 287, 290, 307, 313, 315–318, 320–321, 328, 332, 334, 336–342, 344–345, 353, 355, 358, 361–366, 368–371, 374–384, 389–392, 399, 402, 404–407
- Pennsylvania Department of Conservation and Natural Resources (PA DCNR), 363–366, 368–370, 375–377, 380
- Pennsylvania Department of Environmental Protection (PADEP), 156, 317–318, 320, 325, 332, 334, 340, 361, 386, 389, 402, 404–405, 407
- Pennsylvania Supreme Court, 24
- Percidae, 347–348, 362
- Percina maculata*, 347–348
- perfling, 30
- perforating gun, 30
- perforation record, 32
- Permian, 5–6, 10, 13, 19–20, 90, 135–136, 160, 194, 205, 261, 268
- Permian Basin, 10, 21, 90, 135, 160, 261, 268
- permit, x, 13, 25, 38, 83, 93, 95, 197, 316, 337
- Perth, 8, 13, 44, 56, 78
- Peters Creek Watershed Association, 404
- Petroleum and Gas (Production and Safety) Act, 48–49
- Petroleum and Gas Inspectorate, 68, 76
- Photoelectric Effect, 215
- pigging station, 37
- Pimephales notatus*, 348, 350
- Pimenta, 12
- Pine Creek, 345, 362, 394, 397, 405–407
- pipeline, 25, 28, 30, 34, 37, 39, 81, 92, 229, 304, 309, 365–366, 368, 376, 378
- Pipeline and Hazardous Materials Safety Administration, 37
- Pithole Creek, 407
- Pittsburgh, 10, 15, 100, 108–109, 111–112, 131, 171, 290, 337, 341, 386, 393, 404
- play, 3, 13, 20, 40, 80, 97, 106, 152, 154, 160, 180, 189, 191–192, 194, 197, 210–211, 213, 237, 255, 270–271, 341, 363, 374–375, 382
- Plethodon cinereus*, 374
- Plethodon electromorphus*, 374
- Plethodon glutinosus*, 354
- Plethodon richmondi*, 374
- Plethodon wehrlei*, 374
- Plethodontidae*, 359, 374
- Pluspetrol SA, 9
- PM₁₀, 65, 105
- PM_{2.5}, 65, 105–107, 110–111, 113–115, 123
- Poland, 3, 5, 17, 212, 221, 239
- polonium, 214
- polycyclic aromatic hydrocarbons (PAHs), 111–112, 160
- polyethylene, 38
- pore pressure, 94, 173, 182–183, 185–186, 188, 199, 204, 210
- poroelasticity, 180, 182–183
- porosity, 3, 20, 182, 191, 196
- Potiguar, 14
- Potter County Conservation District, 407
- POTWs, 162–164, 389–391, 399, 402
- Powder River Basin, 255, 265–266
- Prairie Pothole, 258, 269
- precautionary principle, 48, 80
- predrill test, 25
- Preese Hall, 84
- pressure pumps, 30–31
- Prince Albert, 6, 13
- Prince Edward Island, 12
- produced water, 31, 59, 61, 64, 93, 152, 154–155, 157–158, 160–164, 166–167, 170–172, 191, 197, 205, 218–222, 224, 226, 228–243, 245–246, 249–251, 253–260, 262–264, 266, 269, 300, 305, 308–310, 313, 315, 337, 339–340, 345–346, 358, 395, 402, 407
- production casing, 29–30
- production hole, 29
- propane, 24, 33, 35, 38, 114–116, 281
- proppant, 23, 27, 30–33, 221, 231, 292, 340, 370
- Pseudomonas*, 304, 309, 359
- PTT Global Petrochemical, 38

- public drinking water standards, 166
publicly owned treatment works, 162, 164, 326, 399
pyrogenic, 273
- Qaidam Basin, 258
Quebec, 12
Queensland, 13, 44–45, 47–53, 55–56, 58–59, 61–65, 67–70, 72–78
Queensland Gas Company, 47
Queensland Gas Scheme, 48
- radiative forcing, 132
radioactive decay, 161, 214, 216–217, 247–248
radiobarite, 220, 228, 232
radiocelstite, 220, 232
radium, 30, 161, 166, 214–222, 224, 227–235, 238–241, 243–245, 267, 314, 405
radium-226, 161, 216–217, 222, 224
radium-228, 161, 166, 216
Radium-228, 216
radon, 30, 62, 78, 215–217, 219
radon-222, 216
Radon-222, 216
Rail Road Commission, 25
rainbow darter, 347, 362
rake, 177
Rangely conventional oil field, 173
rat hole, 29
ratio space, 315, 320–321, 324–325, 327, 333
Reagan, Ronald, 89
reclamation, 363, 365, 375–376, 378, 380
Reconcavo, 14
Red Bank, 394
red-backed salamanders, 374
Reggane, 6, 10
Rendell, Ed, 93, 95
renewable energy, 132
resin-coated sand, 32
Resource Conservation and Recovery Act, 89
reverse osmosis, 61–63, 389
Rhinichthys obtusus, 348, 350
Rhodococcus, 304
rig, 29
rigidity, 177
riparian habitat, 373
riparian trees, 357
Risked OIP/GIP, 3
risk-perception paradigm, 79–81, 83, 87–88, 90, 93, 95, 97
roads, 10, 111, 166, 171, 226, 230, 270, 364–367, 369–370, 375, 378–379, 382
rock bass, 347, 350
Rocky Mountain Arsenal, 173
Röntgen, Wilhelm, 214
Roseneath, 7, 13, 16
royalties, 23, 44, 55, 87–88, 97
rupture, 176–177, 185, 189, 200–201
Russia, 3, 5, 14, 17–18, 79, 99
- S waves, 177
Sabinas, 4, 12
Safe Drinking Water Act, 19, 39, 89, 314
salamander, 341, 354–355, 357–358, 361–362, 379, 382
Salinivibrio costicola, 346
Salvelinus fontinalis, 375
Sao Francisco, 14
Nicolas Sarkozy, 81, 83, 99
Saskatchewan, 12, 92, 257
Saudi Arabia, 79
scalar seismic moment, 177
scale inhibitor, 32, 301
Schuepbach Energy, 82
Scotland, 86
secular equilibrium, 217
seismic survey, 25, 84
Selexol, 38
Semotilus atromaculatus, 348, 350
Senate Select Committee on Unconventional Gas Mining, 55, 60, 66, 72, 75, 78
separators, 29, 31, 38, 310
Sergipe-Alagoas, 14
severance tax, 96
shale gas, 3, 8, 10, 13, 15, 17, 19–20, 32, 34, 41–42, 44–45, 58, 64, 81–89, 93, 95–97, 109–110, 112, 116, 124–125, 132–134, 136–139, 141, 144–146, 148, 150, 152–153, 160–161, 164, 169, 171, 206, 239, 243–246, 248, 259, 262, 265, 267–271, 274, 281, 284–285, 287–288, 292–293, 296, 299–300, 302–310, 313, 316, 336–339, 341, 356, 358, 360–363, 365–366, 368, 370–371, 373–375, 377–382, 384, 402, 405, 407
Shale Network, 316, 318–319, 324, 326, 333–334, 336
shale oil, 8–9, 153
shear modulus, 177, 201
shear stress, 183, 188
shear waves, 177
Shell Chemical, 38
Shewanella, 303, 307, 310
Shigella, 346, 361
Sialia sialis, 368
Sichuan, 6, 8, 174, 209, 258, 268, 303, 310
Silurian, 5–6, 10, 257
silverjaw minnow, 350
slick water, 19, 32, 39
Slimy salamander, 354
SO₂, 105–107
Society of Petroleum Engineers, 3, 17, 40–42, 267, 336, 359, 361
sodium, 158, 166, 222, 230, 246, 356
Solimões, 14
Songliao, 6, 8
South Africa, 3, 6, 13, 16–18
South Australia, 13, 44, 58
specific conductivity, 344–345, 356, 406
Spizella passerina, 371
split estate, 23

- SPUD, 342
 stable isotope, 216, 246, 256, 266, 269, 275, 277
 Stanolind, 23
 StimuFrac™, 23
 storage tanks, 35, 133, 310
 STORET database, 316
 Strategic Cropping Land Act 2011, 49
 strike, 177, 180, 183, 189, 191–192, 194, 196, 200
 strontianite, 229
 strontium, 32, 166, 216, 220, 243–246, 248, 253,
 265–266, 269, 314, 336, 356, 373, 405
 Subei, 6, 8
 Sulfate, 239, 241–242, 330, 386–387, 389, 391, 395,
 399, 402, 404–405, 407
 sulfate-reducing bacteria (SRB), 228, 300–303
 sulfidogenic, 300–301, 303, 305, 308
 Superfund, 89
 Surat, 44, 47, 59–60, 65, 70, 74, 76–77
 surface casing, 29
 surface rights, 23, 375
 surfactant, 32, 301, 340
 Susquehanna River Basin Commission, 24
 Sweden, 5, 19
 Sydney, 44, 65, 71, 73–74, 78

Tachycineta bicolor, 368
 Tampico, 4, 12
 Tannezuft shale, 10
 Tarim, 6, 8
 Tasmania, 46, 57
 Taubate, 14
 technically recoverable, 8, 15, 81, 93, 268
 technological stigma, 80
 technologically enhanced- naturally occurring
 radioactive material, 221
 Tecpetrol SA, 9
 Tenappera, 7, 13
 Tenmile Creek, 326, 328, 331, 340–342, 344, 347, 355,
 357, 361, 394–395, 405
 Tennessee, 10, 154
 TENORM, 221–222, 242
 tensile stress, 188
 tensor element, 178
 terrestrial habitat, 355, 380
 Texas, 10, 20–21, 23, 25, 33, 41, 82–83, 86, 90–94, 99,
 114–116, 121, 123–124, 128–129, 152, 154, 160,
 170, 189, 191, 207–208, 222, 225, 240, 268, 293,
 302, 304, 308–310, 345, 362, 381
Thalassospira, 346
 thermogenic, 273, 275, 277–278, 281, 290, 293, 302,
 308, 310, 362
 thiosulfate, 301, 303–304
 thorium, 161, 214–215, 217–218, 220, 222, 227, 233, 240
 Three Rivers QUEST (3RQ), 386, 390, 392, 407
 thumper truck, 25
 tight gas, 20, 23, 45
 tight shale, 19
 tiltmeters, 23, 40

 Timan Pechora, 14
 Timimoun, 6, 10
 Tindouf, 5–6, 10
 Tithonian, 12
 Titusville, 93
 toluene, 68, 107, 119, 127, 129, 160
 Tom Wolf, 96, 98
 TOTAL, 82
 Total dissolved solids (TDS), 158, 160, 162–163, 219,
 222, 224, 226, 228, 230, 233–234, 246, 250–251,
 254, 256, 258, 261–262, 294, 304, 314, 323, 346,
 354–355, 386, 395, 397, 399–400, 402, 404–405,
 407
 Total organic carbon (TOC), 185, 188, 293
 tracers, 32, 42, 140, 148, 246, 248–249, 251, 254–255,
 258, 264–265, 268, 270, 272–273, 278, 280, 289
 traffic, 39, 55, 81, 84, 107, 109–113, 123, 129, 131,
 176, 196, 204, 208, 363, 365–367
 traffic-light protocol, 196
 transmission lines, 37
 tree swallows, 368, 382
 triethylene glycol, 38
 trihalomethanes (TTHMs), 169, 406
 Tritium, 272
 Trump, Donald, 90
Turdus migratorius, 371
 Tuxpan, 4, 12
 Two-lined Salamanders, 354
 Tygart, 394, 396

 Uintah, 114, 116–119, 126–127, 135
 unconventional, 10, 12–16, 19–20, 27, 34, 38, 40–45,
 50–51, 56–57, 59, 62–64, 67–69, 72–74, 76, 78,
 81, 89, 105, 107, 109–111, 113–114, 116,
 122–124, 138, 154, 157–158, 162–163, 166–167,
 169, 171, 173–174, 178, 185, 189, 191–192, 194,
 204, 206, 219–222, 230, 239, 244–248, 250, 252,
 255, 257–265, 268–270, 278, 308, 310, 313–314,
 316–317, 321–322, 326, 330–331, 333, 336–337,
 339–341, 346, 356, 359–361, 363, 375, 378,
 380–381, 383, 405
 underground injection, 19, 94, 161, 164, 167, 171
 Unionoidea, 375
 unit consolidation, 24
 United Arab Emirates, 3, 7
 United Kingdom, iv, 8, 19, 84, 96, 101, 146
 United States, 3, 9–10, 19–20, 22–23, 37–39, 41–42,
 44, 79, 87, 92, 95, 97, 101, 105, 107, 124–126,
 128–131, 134, 139, 144, 146–150, 152–153, 156,
 158, 164, 168–169, 210, 218–219, 222, 226, 239,
 241, 244, 266, 269–270, 278, 280, 284, 288, 290,
 292, 337, 339, 355, 360–361, 367, 381, 383–385
 United States Army Corps of Engineers, 386, 404
 United States Department of Energy (US DOE), 14,
 17–19, 38–39, 41, 43, 89, 92, 98, 148, 226, 261,
 264, 266, 270, 360, 384
 United States Department of the Interior, 281, 284, 290
 United States Department of Transportation, 37

- United States Environmental Protection Agency (US EPA), 25, 32, 42, 89, 94, 101, 105–106, 113–114, 122–123, 131, 137–138, 140, 146, 148, 150–151, 160, 166–167, 171, 218, 226, 228, 230, 233, 244, 290, 316, 344, 347, 349, 361, 389, 404
- United States Energy Information Administration (US EIA) 3–4, 8–10, 12–14, 19–21, 38, 42, 50–51, 79, 99, 134, 136, 148, 207, 216, 244
- United States Geological Survey (USGS), 41, 93, 150, 164, 222–223, 226, 239, 242, 269, 318, 355, 386–387, 390–391, 395, 404
- Upper Devonian, 12, 249, 251, 253, 255, 259, 262
- Upper Green River Basin, 107, 114, 116–117, 125
- Upper Monongahela River Basin, 387
- upstream, 23, 39, 134–137, 139–141, 144, 166, 256, 327, 344, 346, 350, 354–357
- uranium, 30, 161, 214–215, 217–218, 222, 227, 238, 268
- Utah, 10, 110, 114, 116, 119, 121, 123, 126–127, 129, 131, 255, 268, 308
- Utica, 4, 10, 12, 20, 24, 29, 38, 95, 130, 135, 153, 255, 258, 269, 281, 287, 303–305, 339, 361, 363–364, 371, 373–375, 378, 380, 382
- Vaca Muerta, 4, 9, 17
- Venezuela, 3–4, 89
- Veracruz, 4, 12
- vertical stress, 180, 182
- Victoria, 13, 46, 56–57, 78
- Villard, Paul, 214
- Virginia, 10, 35, 100, 309, 314
- Volatile organic carbon (VOC), 106–107, 110, 113, 115–119, 121–123, 125–126, 128, 131
- Volga-Urals, 14
- Water Act 2000, 59–60
- water resources, 9, 42, 60–61, 150, 163–164, 166–167, 171, 244, 246, 261, 270
- water stress, 152
- water tanks, 27, 30–31
- WATERS database, 395, 402, 404
- well bore, 26, 30
- well location plat, 25
- West Fork, 394, 396
- West Siberia, 14
- West Virginia, 10, 20, 25, 30, 34, 37–38, 93–94, 114, 147, 153–154, 236, 239, 263, 314, 339, 365, 373, 379, 390, 392
- West Virginia Water Research Institute (WVWRI), 386–387, 395, 404–405, 407
- West Virginia, the Department of Environmental Protection, 25
- Western Australia, 13, 57, 63
- western blacknose dace, 350
- wet gas, 35, 37–39
- whipstock, 20
- White nose syndrome, 374
- Whitehill, 6, 13
- Williston, 4, 12, 229, 237, 257, 268, 281
- witherite, 229, 268
- Woodford, 20–21, 191, 194, 206
- World Stress Map, 180, 208
- Wyoming, 10, 20, 82, 107, 110, 114, 116–117, 119, 121, 123, 125, 129–130, 154, 222, 225, 228, 242, 255, 265–266
- x-rays, 214
- xylene, 107, 122, 129, 160
- Yangtze Platform, 6, 8
- Youghiogheny, 394, 396
- Youngstown, 94, 100, 338
- zipper fracking, 39
- $\delta^{13}\text{C}$, 276–277, 279, 284
- $\delta^{13}\text{C}\text{-CH}_4$, 277
- $\delta^2\text{H}$, 265, 279
- $\delta^2\text{H}\text{-CH}_4$, 280
- $\delta\text{D}\text{-CH}_4$, 277
- $\delta^{137}\text{Ba}$, 261
- $\delta^{138}\text{Ba}$, 261–262, 264
- δD , 275, 277, 281