SHOSHONE-BANNOCK EXPOSURE SCENARIO FOR USE IN RISK ASSESSMENT

Map sent to Washington in 1863 by James Doty showing the territory of the interrelated Shoshonean bands (https://theblureview.org/identity-sovereignty-idahos-native-peoples/)

Prepared by Barbara Harper, PhD, DABT

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A. Regulatory Context

The initial step in developing exposure scenarios for use in risk assessment at contaminated sites (CERCLA, NRDA, and state equivalents) or for a NEPA process (and state equivalents) is to review the Applicable or Relevant and Appropriate Regulations (ARARs) because they provide guidance on the principles of protecting human health and the environment that in turn guide scenario development.

ARARs include federal and state standards, tribal environmental standards where applicable and legislated by a tribe, and a range of federal requirements, guidance, and policies regarding surface water quality, drinking water quality, air quality, protection of natural resources (endangered species, migratory birds, landscape protection, cultural resource protection, others), protection of cultural resources (NAGPRA, AIFA, NHPA) and requirements for consultation with affected Tribes[1]. When Tribal resources are affected on or off reservations, there may be tribal Treaties that, according to the US Constitution, are the 'supreme law of the land.' These Treaties, as well as tribal environmental standards and tribal land use goals, are not simply "to be considered;" they are "to be complied with." It is within Agency discretion whether to treat additional documents such as the EJ Executive Order 12898 (Environmental Justice) or EO 13007 (protection of sacred sites), EO 13175 (Consultation), or 13580 (designation of federal natural resource Trustees) as ARARs, although over time they have taken on the stature of policy since every federal agency has mirror guidance to implement those and other Executive Orders. **Appendix 1** discusses a range of guidance and policies that are relevant to the development or selection of exposure scenarios used for risk assessment and remediation. Several are discussed here.

The "Phosphate Patch" in southeastern Idaho is of similar magnitude to the Silver Valley (Coeur d'Alene River Valley; Bunker Hill). The State of Idaho developed policy[2] for the Silver Valley that could logically be applicable to the Phosphate Patch.

> *"The Idaho legislature declares that environmental protection and improvement of the Coeur d'Alene basin to protect human health and enhance natural resources is very important to the state. Therefore, it is the policy of the state to provide in this chapter a system for environmental remediation, natural resource restoration and related measures to address heavy metal contamination in the basin. The system provided in this chapter is intended to protect and promote the health, safety and general welfare of the people of Idaho in a manner consistent with local, state, federal, and tribal participation and resources."* (Idaho 39-8102. Policy of state).

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[1] http://www.achp.gov/docs/fed%20consultation%20authorities%202-09%20ACHP%20version_6-09.pdf

[2] 2015 Idaho Statutes Title 39 - HEALTH AND SAFETY. Chapter 81 - BASIN ENVIRONMENTAL IMPROVEMENT ACT. http://law.justia.com/codes/idaho/2015/title-39/chapter-81/section-39-8102/

The most important document for the sites relevant to the Shoshone Bannock Tribe is the Treaty of 1868. It states the following:

The reservation is "*set apart for their use*." "*...their permanent home, and they will make no permanent settlement elsewhere; but they shall have the right to hunt on the unoccupied lands of the United States so long as game may be found thereon*..." The head of a family shall ..."*have the privilege to select, in the presence and with the assistance of the agent then in charge, a tract of land within the reservation of his tribe, not exceeding three hundred and twenty acres in extent*."

Since some of the mining took place on the Reservation on Tribal and allotment land, the Treaty of 1868 is clearly an ARAR. This means that Tribal members may live (i.e., establish a homestead) anywhere on the reservation, as the federal government intended. The Gay Mine area includes both tribal land and allotments. Since the federal government intended that Tribal members live on and support themselves from their allotment, this requires the tribal exposure scenario, which is a <u>RESIDENTIAL TRIBAL HOMESTEADER</u> with a garden, well, and livestock. This scenario is not limited to on-reservation locations, but may also be applied elsewhere as warranted.

The Treaty says: "*they shall have the right to hunt on the unoccupied lands of the United States so long as game may be found thereon*."

The US Forest Service says "*they shall have the right to hunt on the unoccupied lands of the United States so long as game may be found thereon...[pertaining to] lands administered by the Boise, Payette, and Sawtooth National Forests*."

This refers subsistence uses in Usual and Accustomed Areas, and may be supported by a <u>NON-RESIDENTIAL TRADITIONAL USE</u> exposure scenario. This scenario includes seasonal developed (with groundwater use) or undeveloped (with surface water use) camps but not actual homesteads. However, forest parcels (like in-holdings) may be residential at some point in the future, for instance if federal lands are given to a state, or if federal lands are given to a Tribe in a land swap or other action. Therefore, applying a residential scenario to forest lands would have the advantage of Preserving All Future Use (PAFU). If the remedy protects only non-residential use, the future option for more intense use or for acquisition by the Bureau of Indian Affairs has been prevented, requiring an institutional control to ensure perpetual safe use.

B. Shoshone Bannock Introduction

The Shoshone-Bannock peoples in Southeastern Idaho are grouped with the Northern and Eastern Shoshone. Linguistically they are related to other Uto-Aztecan languages of the Shoshone, Gosiute, Northern Paiute, Bannock, Ute, and Southern Paiute, as well as to the Hopi and Aztecs to the south and to the Southern Plains Comanche.

Cultural elements from the Columbia Plateau, Great Basin, and Plains ecocultural regions are evident in Southeastern Idaho, where the three physiographic areas meet. However, major anthropological studies generally focus on the cores of those three regions, resulting in a rather sparse literature for the Snake River Valley and adjacent Rocky Mountain areas (Steward 1938, Ray 1938, Murphy and Murphy 1960, Plew 1983). The most salient anthropological work about natural resource patterns of the Shoshone and Bannock peoples comes from Verne Ray and Julian Steward, as well as additional observations from the diaries kept by emigrants coming over the Oregon Trail. Contemporary anthropology and archaeology is led by Mark Plew and his students at Boise State University, although largely focused on the middle and western Snake River valleys, not the eastern areas around Fort Hall.

In Southeastern Idaho, the Indian's contact with the white man may be divided into four periods: (1) Exploration and penetration of the territory by trappers, approximately 1776 to 1840; (2) emigration (e.g., Oregon Trail) which usually passed on through the country to more fertile lands on the coast, but also settled Utah and the Humboldt Valley, 1840 to 1860; (3) settlement by miners and agriculturists and the climax of strife between whites and Indians, 1860 to 1870; (4) removal Indians to reservations where they still remain (Steward 1938, Ray 1938). In 1857 the great Comstock lode at Virginia City had been discovered in western Nevada. Within 10 years prospectors penetrated the remotest parts of the territory. After the fur trade declined in the 1840s, the Oregon Trail became a highway of emigration, passing through Fort Hall and then down the Snake River Valley to Fort Boise and thence westward. The Treaties of 1868 established the Fort Hall and Wind River reservations, and the buffalo were exterminated in Idaho, replaced by open range cattle grazing.

In the 1870's, this part of Idaho entered into another phase of exploration. Disenchanted miners from the California and northern Idaho gold fields had spread out into all corners of the territory to search for the elusive Eldorado (Lee, 2000). Gold was discovered in Caribou Basin in 1870, and prospectors covered all of southeastern Idaho in their search. In the years 1871-1877, the first formal scientific expedition visited southeastern Idaho. With the passage of the Lode Law of 1866 and the Placer Law of 1870 and the later consolidation into the General Mining Law of 1872, mining claims were located in various places in southeastern Idaho. The claims were even being staked on phosphate rock, but not for phosphate. Those early claims were located mistakenly for either copper glance (chalcocite) or coal because of the black, earthy nature of phosphate. No one suspected that the black rock really was valuable for phosphate. Many of those claims were developed by prospects and in some cases by extensive tunneling. None of the intended minerals were found and the prospectors went elsewhere, leaving numerous pits and tunnels behind. In 1897, R. A. Pidcock found some older workings on a black, soft formation in Rich County, Utah. Thinking that he had found a gold mine, he located a number of claims and sampled the “ore.” The samples were analyzed and were shown to contain no gold or silver, but did contain phosphoric acid in large amounts (32%). This was the first specific documentation of phosphate rock.

At the time of the phosphate discovery, there was no market and no great “rush” occurred to stake out the deposit. After the value of the western phosphate was recognized, mining claims were located specifically for phosphate throughout northern Utah, southeastern Idaho and southwestern Wyoming. After years of legal issues surrounding how to regulate phosphate mining, a number of bills were introduced but not passed regarding the utilization and disposition of the phosphate deposits. Because of the continuing confusion of phosphate lode vs. placer claims and all the litigation and the potential for further court actions, Congress finally stepped in and validated placer locations for deposits of phosphate rock in 1914 and 1920, and the mines were established during this time frame.

The phosphate was mapped on the Fort Hall Indian Reservation in 1913. In 1946, the Simplot Company negotiated and obtained Tribal and allottee leases on about 7,000 acres, and mining started in 1946. The Simplot Fertilizer Company also obtained a Tribal business lease authorizing the company to commence phosphate extraction on February 4, 1946. The Simplot Company opened the Gay Mine that same year, and ultimately became the longest operating open pit phosphate mine in Idaho. Approximately 45 pits were dug with an average depth of 250 feet, and several pits exceeded 300 feet in depth. By the early 1960's, the Gay Mine was producing over 1 million short tons of phosphate rock per year, ceasing mining operations in 1993.

NATURAL RESOURCE USE

Indigenous human activities were related to the flora and fauna, topography, climate, and distribution of sources of water (Steward 1938). As hunting and gathering was the basis of subsistence, certain material devices, seasonal movements of families, population density, and the location and nature of cooperative enterprises were adjusted to the kind and distribution of plant and animal species. These salient features of the natural landscape are so interrelated with one another and with the cultural landscape that altitude, rainfall, relative abundance of edible foods, sources of water, and consequently population concentration largely coincide.

The Basin-Plateau peoples were hunters and gatherers, Analysis of human ecology in the Basin-Plateau area requires consideration first of certain features of the natural landscape or environment; second, of cultural devices by which the environment was exploited ; and third, of resulting adaptations of human behavior and institutions (Steward 1938). The important features of the natural environment were topography, climate, distribution and nature of plant and animal species, and, as the area is very arid, occurrence of water. Ecological factors and material technology made the extended family the most stable sociopolitical group. Resource limitations made larger villages generally impractical, while expediency and efficiency in obtaining resources prevented the groups from being smaller. Other factors, however, brought families into association in larger groups: location of winter residences with reference to food resources, water, firewood, and other natural advantages; communal hunting and fishing enterprises and some communal irrigation; possession of the horse which allowed a larger foraging range and thus larger encampments; and unusual abundance of certain foods in some localities (e.g., Camas prairie).

The ecology of the Snake River valley bottom is sagebrush. Vale (1975) reviewed twenty-nine journals and diaries from the Oregon Trail era for their vegetation descriptions of the sagebrush-grass area in an attempt to assess the relative importance of herbaceous plants and woody brush in the northern Intermountain West. The early writings suggest a pristine vegetation visually dominated by shrubs. Stands of grass apparently were largely confined to wet valley bottoms, moist canyons, and mountain slopes, with more extensive areas in eastern Oregon near the Blue Mountain and Cascade Ranges. The major area was covered by thick stands of brush.

The natural flora was most important, for the Shoshonean economy was essentially based on gathering (Steward 1938). Moreover, distribution of food animals also depended somewhat upon flora. Steward gives a list of about 200 Indian names of plants, most with scientific names and their uses for food, medicine, and manufacturing. He lists 50-100 species in each of the ecological zones across the region.

Steward identified the ecological zone, or biome, most relevant to southeastern Idaho as the Upper Sonoran zone, the Artemisia (sage) belt that occupies most of the valleys and many foothills and consequently the bulk of the area north of the thirty-seventh parallel[3]. Flora is xerophytic, adapted to aridity and generally excludes grasses and herbaceous forms. It is subdivided into two formations, which are adapted to soil conditions: northern desert shrubs and salt desert shrubs. Dominant species of the northern desert are Sagebrush (*Artemisia tridentata*), small sagebrush (*Artemisia nova*), little rabbitbrush (*Chrysothamnus (*now *Ericamerica) puberulus*), shadscale (*Atriplex confertifolia*), winter-fat (*Eurotia lanata*), hop-sage and coleogyne (*Grayia spinosa* and *Coleogyne ramosissima*), bud sagebrush (*Artemisia spinescens*), malt saltbrush (*Atriplex corrugata*), and gray molly (*Kochia vestita*). *Artemisia tridentata* and *A.*

[3] The 37th parallel forms the southern border of Utah.

nova served only in a minor degree at times of food shortage. Occurrence of grasses and other food plants in this area was either limited to the narrow moist border of streams or was sporadic in moist years, growing in restricted parts of the valleys and hills. However, Indian testimony and early observers indicate that many areas now occupied especially by rabbitbrush had much more grass before the introduction of cattle and sheep.

North of the Snake River plains the flora rapidly becomes less xerophytic. It contains a greater number of tubers, roots, grasses, and berries, many of which were important food plants. The grasses were also of great importance in affording grazing for buffalo and other game and in making it possible for the Indians to keep horses. The plateau along the Snake River is largely dominated, like the valleys farther south, by Artemisia, Atriplex, and other xerophytic plants. Along the upper reaches of the river, however, and on some of its tributaries are flood plains supporting grasslands and a few trees, especially willow (*Salix*) and cottonwood (*Populus*). Increased precipitation at greater altitudes produced many "prairies" which abounded in food plants, especially *Quamasia quamash* (Pui-sh) (camas), *Valeriana edulis* (tobacco root) , and species of *Agropyron* (wheat grass) . Several such prairies lie along the northern edge of the Snake River plains, the most important being Camas Prairie. Others occur in the mountains to the north. In early historic times the distribution of horses among the Shoshone was restricted to the region of grasslands and prairies north of the Snake River and along the upper course of the Snake River. Passing north toward the coniferous forest zone in Idaho, the pinyon pine (*Pinus monophylla*) is absent, but such edible berries as service berry (*Amelanchier*) and wild cherry (*Prunus*) grow in considerable abundance associated with other shrubby plants. The coniferous forests include yellow pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga*), white fir (*Abies grandis*), and larch (*Larix occidentali*).

The Shoshone and Bannock of Southern Idaho included several subgroups who lived under similar ecological conditions and dwelt in geographic continuity, and were demarcated by ecological provinces and food resources. The Snake River and its major tributaries such as the Boise River were rich in salmon, so in many places the seasonal round was organized around salmon, along with roots, dried game, sagehens, blue grouse, rabbits, camas in the early summer at the large spring-summer gatherings at Camas Prairie (now Fairfield, Idaho), followed by fall fish runs and hunting of elk, deer, bear, and some bighorn sheep. Generally, early observers and anthropologists identified camas and fish as primary staples in the Snake River bottom, along with game. Small winter camps were located in river bottoms with shelter and firewood. Further upriver at Glenn's Ferry and Shoshone Falls were large salmon fisheries. The salmon runs did not extend above Shoshone Falls, 120 feet in height.

Above American Falls, the native population consisted of both Shoshone and Bannock Indians, who seasonally pursued the buffalo of which there were originally herds on the upper Snake River. As horses became available and bison were depleted in Idaho, the Indians rode east to Wyoming to hunt buffalo. The main subsistence was the dried meat of buffalo, elk, and deer, supplemented by dried fish, roots, and berries. After the winter camps broke up, people hunted followed by movement downriver to fish for salmon at Glenn's Ferry and Shoshone Falls, followed by dispersal for hunting for game and waterfowl (and their eggs), fishing for local fish, as well as gathering seasonal roots and other plant foods.

The native populations identified themselves as "Summer Salmon Eaters, "Groundhog Eaters," or "Big Salmon Eaters." Other bands also identified themselves by other food species, such as jackrabbit, sunflowers, yamp-root, Hak (an unidentified seed, and later Wheat Eaters after introduction of wheat), roots in general ("Diggers"), Pispengwi eaters (small minnows), cottonwood salmon, deer, squirrel, groundhog (possibly the Grey ground squirrel *Citellus townsidii*), elk, mountain sheep, and so on (Murphy and Murphy 1960, Ray 1938, Steward 1938). As evident in Figure 1, resources vary from area to area, and people ate what was locally available, supplemented by trade and resource acquisition trips.

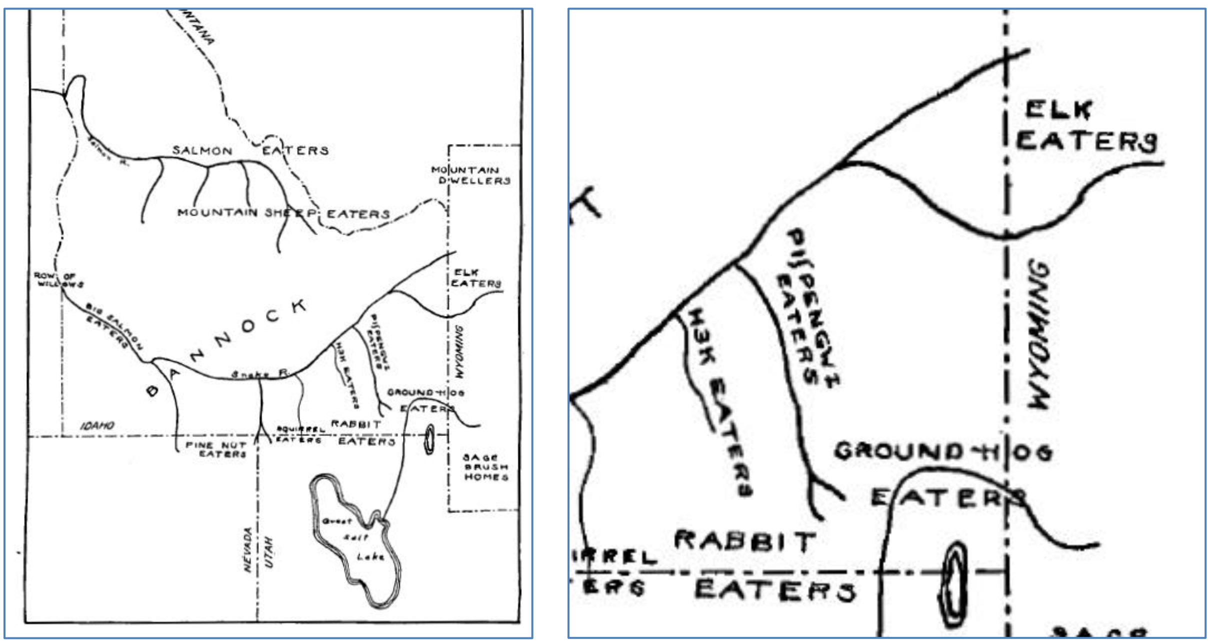

Figure 1. Local native band names

From Ray, 1938

Salmonid runs in southern Idaho occurred three times a year (Steward 1938, Plew 1983). During March and April the runs were largely of steelhead trout, *Salmo gairdnerii,* called *tahma agai* 'spring salmon'. The second run, in late spring-early summer, usually began in May or June. It consisted of the Chinook salmon, *Oncorhynchus tshawytscha,* locally called *taza agai* 'summer salmon.' The fall run of salmon, *yuva agai*, occurred between September and November and was largely fall chinook.

Resident fish (Steward, 1938; National Park Service) are as follows

- Pispengwi: small minnows flourishing in several places of the Snake River bottoms. In the winter they burst through the ice in great numbers and lay on the surface where they were gathered for food and dried for future use. The species is not identified. Several small species were *Leuciscus halteatus*, shiner, below Shoshone Falls, and *L. hydrophlox* above the falls, along with a few other species. Also native to the Snake River drainage are the Utah chub (*Gila atraria*, largest of the minnows at12 inches, preferring slow, warm waters with abundant aquatic vegetation), longnose dace (*Rhinichthys cataractae*), redside shiner (*Richardsonius balteatus*), and speckled dace (*Rhinichthys osculus*).
- *Entosphenus tridentatus*, 3-tooth lamprey, occurred in the Salmon River and in the Snake River, probably only below the falls.
- *Acipenser transmontanus*, Columbia River sturgeon, could be taken below the falls of the Snake River in the spring when the water was muddy. These reached 8 to 9 feet in length.
- The cut-throat or black-spotted trout, *Salmo mykiss,* is the main native trout throughout these rivers.
- *Goregonus williamsoni*, Rocky Mountain whitefish or "mountain herring" occurs throughout the rivers and streams.
- *Pantosteus jordani*, black sucker or blue sucker, occurs throughout the Snake River; as well as *Catostomus macrocheilus* (*columbianus*), Columbia River sucker;
- *Acrocheilus alutaceu*s, chisel-mouth, squaremouth, or hard-mouth, occurring throughout the Snake River;
- *Mylocheilus caurinus*, Columbia chub, occurring in large schools in the Snake River;
- *Ptychocheilus oregonensis*, northern pikeminnow (formerly squawfish), occurring below the falls of the Snake River.
- Several small species were *Leuciscus halteatus*, shiner, below Shoshone Falls, and *L. hydrophlox* above the falls, along with quite a few other species of shiners, dace, and minnows.

Plew (1980) suggested more flexibility in subsistence strategies in the Middle Snake River area than simply relying on salmon. He looked at caloric needs of groups of people, the acquisition costs of various resources, and the availability of different resources, and the nutritional content of salmon, deer, biscuitroot, bitterroot, and camas as representative of different strategies. Plew concluded that there was variability among individual groups, with probably less emphasis on salmon that implied by ethnographic accounts. Some groups were sedentary near the salmon fisheries, maintained fishing and processing equipment, and controlled fishing sites. Other groups were likely semi-mobile who relied on high yield, low cost crops (especially camas and biscuitroot, *Lomatium*), and highly mobile groups who emphasized high yield resources with low acquisition costs obtainable over extended periods of time (mostly large game). He also suggests that different groups rotated among strategies, or that family groups may have had dual strategies and experts in different acquisition practices, pooling their yields during winter camps. Nevertheless, while it is likely that different family bands elected different strategies in different years, nevertheless each strategy, especially hunting and fishing, is highly skilled and taught within and among families. Therefore, familial acquisition patterns tend to be fairly stable.

During some years, some groups elected a semi-mobile strategy that relied less on salmon and more on plants. Camas provides more calories per acquisition costs, has a longer harvest season, require less technology (fishing gear, cleaning equipment, drying and smoking sheds; game hunting implements, tanning processes, and so on), and are easier to acquire by a wider range of people (younger, older). Camas and other root crops are more calorie dense than the salmon that have lost a significant amount of fat as they migrate over the long distances, require a minimal amount of processing, do not lose mass during cleaning as fish do, and can be gathered over longer periods rather than only during specific runs of salmon. Plew also suggests that some groups elected to be more mobile, focusing on large game that require minimal preparation, and are easily transported and stored if the hunter has the skill and traditional knowledge to have a high success rate. Mule deer provided fresh meat during the winter, and are also available year-round. This strategy involves greater risk in regard to meeting winter energy requirements if the hunt is unsuccessful, however.

Steward (1938) provides lengthy descriptions of many Shoshone areas. Three of the most relevant are summarized below. Other areas not summarized include 20 areas occupied by the Western Shoshone, including the Boise and Snake River. The Eastern and Northern Shoshone areas include the Lemhi and central Idaho, Fort Hall Bannock and Shoshoni, Bannock Creek (Kamudiika) Shoshoni, Cache Valley (Paqgwidiika), and the Salt Lake Valley.

ANTELOPE VALLEY IDAHO

In the Antelope Valley area (north across the valley from Pocatello), the elder men talked of pine nut trips, mudhen drives, antelope hunts, rabbit drives. Maize horticulture with irrigation may have been practiced prior to the arrival of the white man. Each family had its own garden. Men dug shallow trenches with a digging stick into which women dropped bunches of seeds at intervals and covered them with earth. Farmed plots were inherited by a man's wife or children. One observer in 1869 encountered some 200 "Snake Indians" in Snake Valley, "who are in the habit of occupying the valley in planting and harvesting season, raising scanty crops, which they cache for the winter use, and then retire to the mountains" Steward (1938).

LEMHI, IDAHO

Throughout the mountains, subsistence was principally on seeds, roots, mountain sheep, deer, and salmon. Antelope were scarce; there were no buffalo. The fertile and lower Lemhi Valley had some antelope. Moreover, the Lemhi Shoshoni could keep horses with which to make expeditions to the south and east for buffalo and to the west for seeds and roots, especially camass. In fact, many seeds utilized by Lemhi grew along the Snake River but not in the salmon district or were more abundant near the Snake River, so that possession of horses was a great advantage. The main plant foods listed were: Seeds which could be stored for winter: Five species or kinds of sunflower (*Helianthus*); lamb's quarters (*Chenopodium*); Sophia; rye grass; cattail; ‘wada’ (unidentified seed); stickseed (*Lappula*), rose, pine (not pinyon) nuts. Sunflower seeds and lambs quarters were pounded and mixed with service berries to make a kind of bread. Onions and other greens were eaten. Roots that could be stored for winter included a thistle; yamp, ‘nop’ (unidentified); valerian; ‘kan’ (unidentified); ‘soiga’ (unidentified); ‘pasigo' (perhaps *Calochortus*) procured only at Camas Prairie; cattail; ‘pi’ (unidentified); ‘bavo’ (unidentified); ‘ winigo’ (unidentified); ‘payump’ (unidentified); ‘hunib’ (unidentified). Roots which could not be preserved included a cactus; ‘pawa’ (possibly Rumex, eaten green); onion; prickly pear cactus, and others. Berries that were preserved included service berry and chokecherry. Elderberries were only eaten fresh. This region is far north of the occurrence of pinvon pine (*Pinus monophylla*), but nuts of the white pine were gathered in some quantity.

A number of related families usually traveled together and the women picked and gathered. Nuts were carried back to the winter village in buckskin bags and, if there were a surplus, it was cached in the mountains to be gotten on future trips. There was no ownership of pine-nut or other food areas. Game was not abundant, although deer, antelope, rabbits were hunted. Young water fowl were sometimes taken. A variety of resident fish were also available (Steward 1938).

FORT HALL, IDAHO

Two linguistic groups, the Shoshoni and the Northern Paiutes peaking Bannock, occupied the Fort Hall region since prehistoric times. The Shoshoni at Fort Hall are distinguished from those in western Idaho by having had some horses and a comparatively high degree of political solidarity at an early period. They called themselves Bohogue (bohovi, sagebrush +gue, butte, i. e., the butte northeast of Fort Hall). This term was sometimes used to include the Bannock.
The Bannock, a horse-owning group with strong Plains traits living in close association with the Shoshoni, called themselves Bana'kwiit (ba, water+ nakwiit, possibly a nominal ending).

The environment of the Fort Hall Shoshoni and Bannock is like that to the west and south. It consists largely of arid, sage-covered desert plains which were largely destitute of game. The Fort Hall area had very few deer and elk except in the mountains, only a small number of mountain sheep, antelope, and bear, and only two kinds of rabbits. The main asset was salmon, which ran up the Snake River only to Shoshone Falls and therefore required a long trip downstream. Buffalo occurred in the eastern part of the area, and there had been many near Fort

Hall in 1834. But buffalo were extinct in northern Utah by 1832 and in Idaho by about 1840. Fragments of evidence indicate that at this time the economy was substantially like that of the Western Shoshoni. At Camas Prairie they usually scattered out to gather roots and seeds. Of vegetable foods, camas was most important. Others were pasigo (perhaps *Calochortus gunnisoni*), pak (*Helianthus annuus*), yamp or yomba (*Carum gairdneri*), ak (*Sophia sonnei*), kosiak (probably *Helianthus spp.),* yuhauk (probably *Helianthus spp.),* buhuak (*Helianthus spp.)*[4], and kuiyu (tobacco root). As many of these as could be preserved were later transported back to Fort Hall.

Some families remained during the summer in the vicinity of Fort Hall or went to the region of Bear Lake for roots, berries, mountain sheep, and other game. In the fall some families went south to the Grouse Creek region for pinyon nuts. The Bannock and Shoshoni always wintered together at Fort Hall, though a few families remained in the east and, after the agency was founded, some went to "near Yellowstone" to receive rations. There was no segregation of Bannock and Shoshoni in winter encampments, nor any named subdivisions. The greatest number stayed along the bottom lands of the Snake River above American Falls. Bannock Creek was formerly occupied by a somewhat distinct group, the Kamudiikap. To supplement the food laid up during the summer, small groups, but never the entire band, went into the plains west of the Snake River to hunt antelope. Deer were taken by individuals or by small groups of hunters in the mountains near Fort Hall or in the juniper belt to the north or to the west toward Camas Prairie. Rabbits did not occur in sufficient numbers at this time to justify communal drives. Waterfowl were taken in small drives, carried on by one or two families. Fish which could be taken in the tributaries of the Snake River above American Falls were trout, toyavi, sucker, perch and Tasigi (same as Lemhi pahiwa'*), "like a minnow."

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[4] It is not clear if there is more than one name for the common sunflower. The genus *Helianthus* is a large one, made up of sixty-seven species; several grow in Idaho. The most common is (*Helianthus annuus*). Nuttall's sunflower is a fairly common, tall, perennial plant characterized by sunflower-like flowerheads and narrow, lanceolate, mostly opposed leaves. The plants prefer moist or recently moist soil, and grow to fairly high elevations in Idaho mountains. It is unlikely to be Rocky Mountain dwarf sunflower, *Helianthella uniflora*. Another possibility is Arrowleaf Balsamroot (Balsamorhiza sagittata; shoots are eaten before flowering),

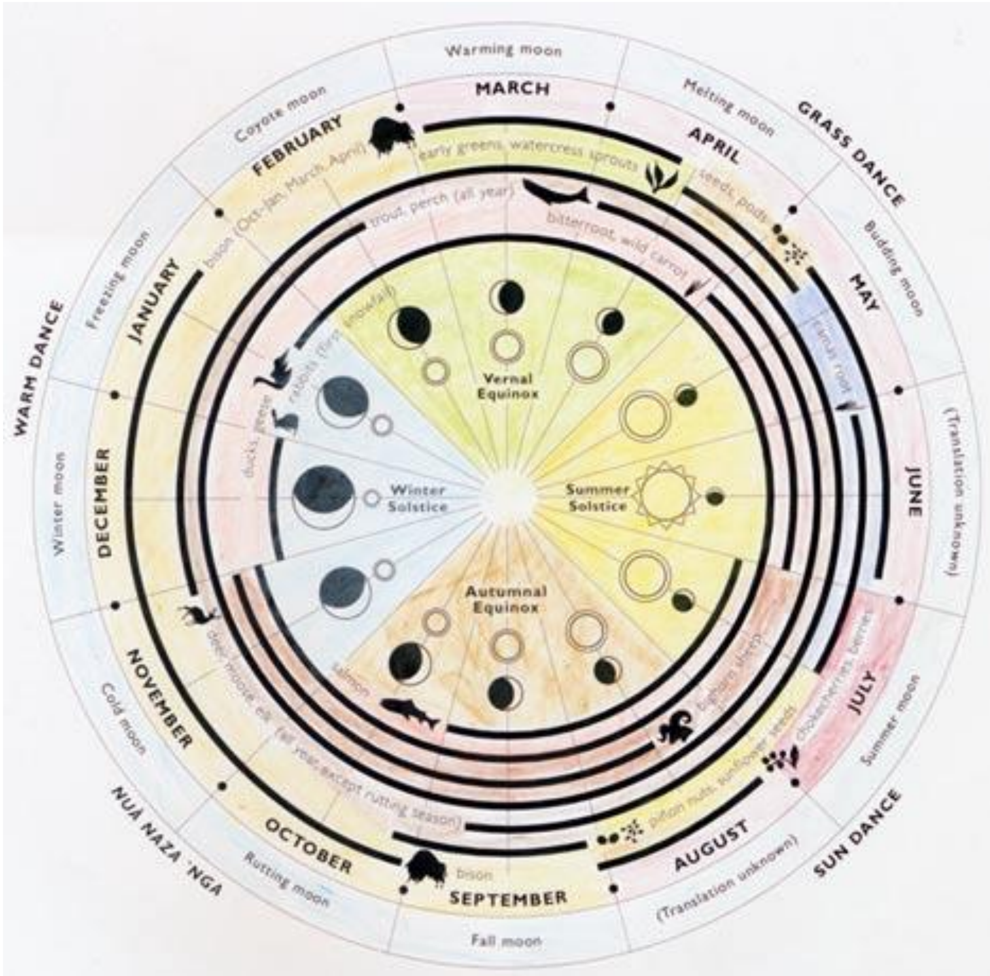
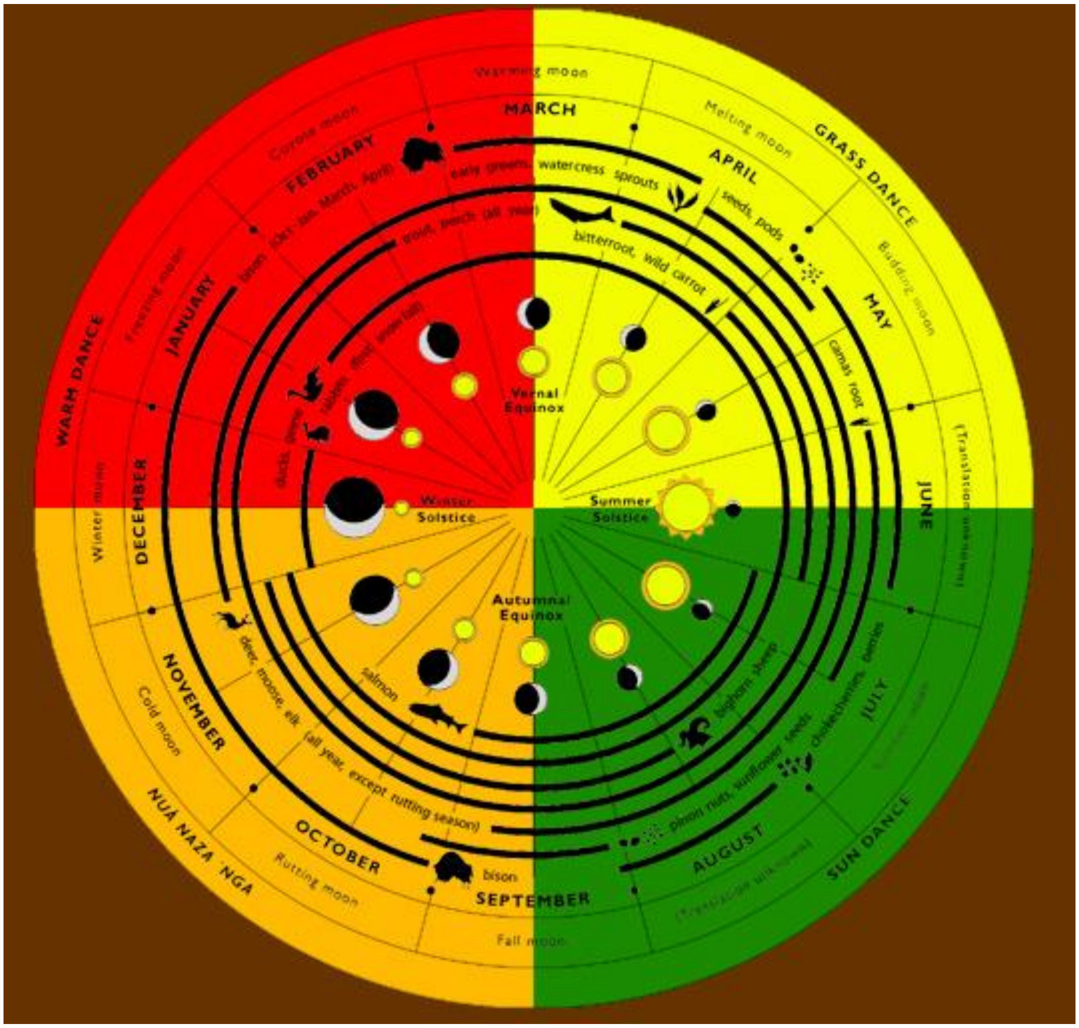


Figure 2. A Shoshone Great Circle or seasonal round

From: http://www.trailtribes.org/lemhi/great-circle.htm



https://homepages.rpi.edu/~eglash/eglash.dir/complex.dir/comp_eth/calendar.jpg

C. The Ecological Setting of the "Phosphate Patch"

The Phosphate Patch is an area in southeastern Idaho with a long history of mining (Lee, 2001). In Southeast Idaho's phosphate mining region, earth-moving activities have disturbed seleniferous geologic formations, exposing previously immobile Se to oxidative weathering, thereby mobilizing Se into the environment (Knotek-Smith et al., 2006). Phosphate mines in the area are known to contain high levels of selenium in their waste rock. Rainwater and weathering allow the selenium to leach from the waste rock piles and enter nearby surface water. Once mobile, the Se leaches into surface waters and soils, freely entering the biosphere where it can concentrate in toxic levels.

Selenium is well-known to hyperaccumulate selenium in some species of plants.[5] Historically these plants have been called indicator plants, known to prospectors who searched for different kinds of ores based on plant assemblages. The indicator plants for selenium-phosphate include certain species of Astragalus, Neptunia and Stanleya (prince's plume, *Stanleya pinnata)*, and some woody asters such as Western Aster (*Symphyotrichum ascendens*). *Astragalus crotalariae*, *A. bisulcatus* and *Stanleya pinnata* are hyperaccumulators; *Astragalus lentiginosus* is not (Sors and Ellis2005 and many others).

Selenium is an essential element, but is also toxic at higher doses. Researchers in this region have long linked fatal cases of selenium toxicity in livestock to these seleniferous mine wastes (Piper et al, 2000). The vast majority of these livestock deaths involve the ingestion of Western Aster (*Symphyotrichum ascendens*), a native perennial forb documented to hyperaccumulating Se. Selenium in high concentrations can be toxic to a variety of fish and wildlife and is also known to bio-accumulate, and affect organisms in the aquatic food chain.

Toxicity to livestock remains a problem to this day, and poses concerns for future use of not only the mine sites, but much larger deposition areas where soil, dust, and runoff have come to be located. In 2012 at least 95 domestic sheep died from eating western aster at the Henry Mine site.[6] Sheep can exhibit signs of toxicity or die after as little as 4 weeks of grazing on Se soils (Fessler et al., 2003). Area wide investigation activities in the Southeast Idaho Phosphate Mining Resource Area (Resource Area) were initiated in 1996 after several horses were diagnosed with selenosis, and subsequently euthanized, as a result of grazing in a pasture irrigated with selenium-contaminated water emanating from a historic mine site. Contaminants of concern include (at a minimum) Cadmium, Chromium, Nickel, Selenium, Vanadium, Zinc, and radionuclides (IDEQ, 2004). Fluoride may also be elevated (Severson and Gough, 1976).

[5] https://www.ars.usda.gov/pacific-west-area/logan-ut/poisonous-plant-research/docs/selenium-accumulating-plants/
[6] USU lab says closed Idaho phosphate mine killed 95 sheep, posted at: http://www.standard.net/stories/2012/10/12/usu-lab-says-closed-idaho-phosphate-mine-killed-95-sheep

The setting for this scenario is in the upper Snake River basin and nearby foothills and mountains, primarily in Bannock and Caribou Counties. The purpose of the following general ecological description is to help identify the most prevalent staple edible resources that are provided by the natural habitat.

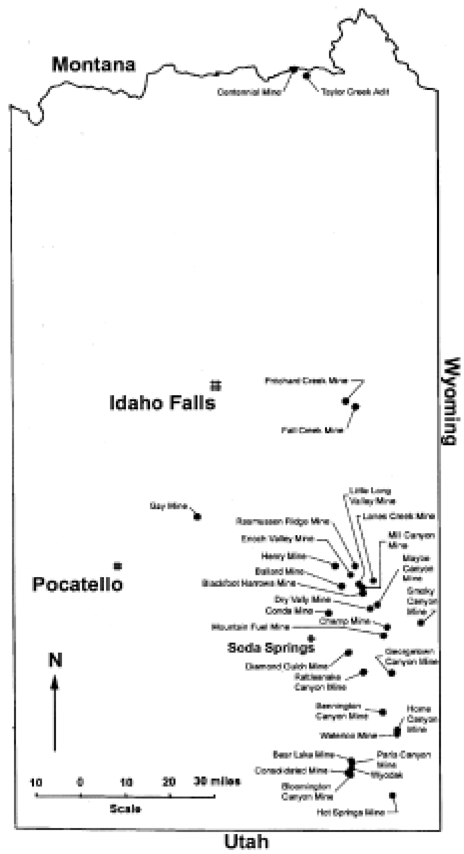
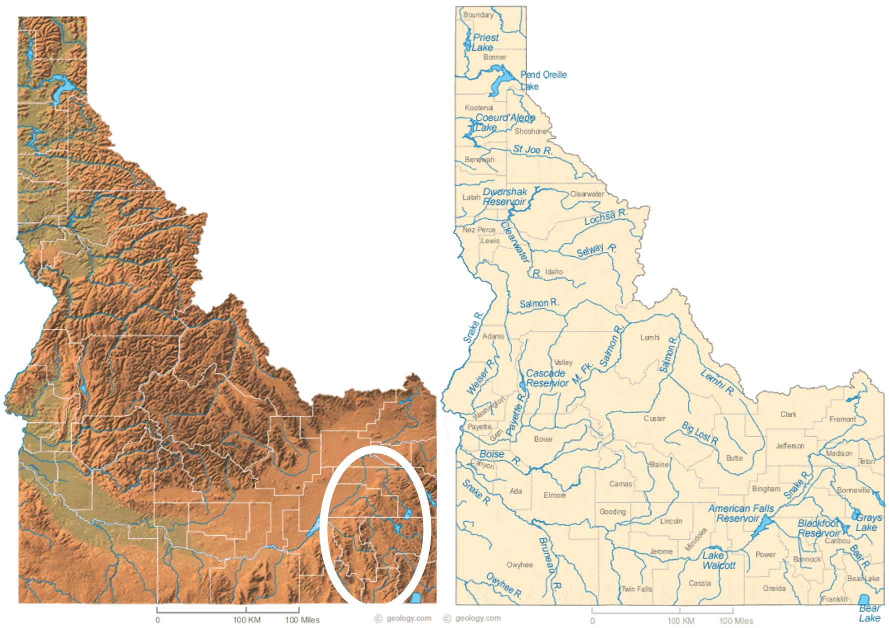
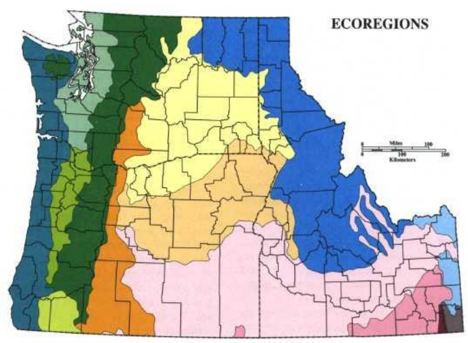


Figure 1. Generalized location map showing phosphate mines in southeastern Idaho.

Figure 3. Phosphate mine locations,

from Lee, 2001.





Coast Range	Blue Mountains
Puget Lowland	Snake River Basin / High Desert
Willamette Valley	Northern Basin And Range
Cascades	Northern Rockies
Sierra Nevada	Middle Rockies
Eastern Cascades Slopes And Foothills	Wyoming Basin
Columbia Basin	Wasatch And Uinta Mountains

Figure 4. Location of the Phosphate Patch and physiographic area

The broadest ecological description of the study area is the Snake River Basin/High Desert and Northern Basin and Range.[7] The Snake River Basin or Upper Snake River Plain forms part of the xeric intermontane basin and range area of the western United States. It is considerably lower and more gently sloping than the surrounding ecoregions. The ecoregion is characterized by nearly level river terraces, floodplains, and lake plains containing many canals and rivers. Elevation varies from 4,400 to 5,000 feet. Potential natural vegetation is sagebrush steppe, with saltbush-greasewood communities in the southwest.

The ecoregion is largely in the rain shadow of the Cascade Mountains and thus receives little precipitation. Latitude and physiography are influential factors in distinguishing this ecoregion from other similar ecoregions, such as the Wyoming Basin and Great Basin Shrub Steppes. The Snake/Columbia Shrub Steppe is lower in elevation than the Wyoming Basin, and the two are separated by mountainous areas. The ecoregion exhibits more desert-like vegetation in southeastern Oregon, where elevation is considerably higher and precipitation lower

The Northern Basin and Range ecoregion (just south of the Snake River Basin) consists of arid tablelands, intermontane basins, dissected lava plains, and widely scattered low mountains. The bulk of the region is covered by sagebrush steppe vegetation. The ecoregion is drier than the Columbia Plateau, it is higher and cooler than the Snake River Basin the north and east, and contains a lower density of mountain ranges than the adjacent ecoregion to the south.

The dominant vegetation in the Northern Basin and Range ecoregion is sagebrush (*Artemisia* spp.), typically associated with various wheatgrasses (*Agropyron* spp.), Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass, bluegrass, cheatgrass, rabbitbrush, squirreltail, needle-and-thread, Indian ricegrass, and fourwing saltbush. The ecoregion contains a number of isolated mountain ranges in the southern parts of Idaho and Oregon, and here the sagebrush shrublands grade into bunchgrasses and juniper woodlands. Some parts of these ranges contain areas of Douglas-fir (*Psuedotsuga menziesii*), subalpine fir (*Abies lasiocarpa*), and aspen (*Populus tremuloides*).).

Riparian areas in both the Snake Basin and Northern Basin feature sedges, perennial grasses, willows, and cottonwood. These habitats contain extensive wetlands, which provide vital waterfowl habitat in the Pacific Flyway.

[7] This text was originally published in the book Terrestrial ecoregions of North America: a conservation assessment from Island Press. The terminology follows designations by Omernick, Bailey and Kuchler. Examples of ecosystem maps include: http://academic.evergreen.edu/projects/virtualatlas/thematic/vegetation/veg_zone.htm; http://en.wikipedia.org/wiki/Snake_River_Plain_(ecoregion) http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na1309_full.html

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources.[8] Idaho is made up of semiarid shrub- and grass-covered plains, irrigated agricultural valleys, volcanic plateaus, forested mountains, woodland- and shrubland-covered hills, glaciated peaks, lava fields, and wetlands. Ecological diversity is enormous. There are 10 level III ecoregions and 71 level IV ecoregions in Idaho and many continue into ecologically similar parts of adjacent states. The level III and IV ecoregion map below was compiled at a scale of 1:250,000 and depicts revisions and subdivisions of earlier level III ecoregions that were originally compiled at a smaller scale (USEPA, 2000; Omernik, 1987), and is the result of an interagency collaboration.

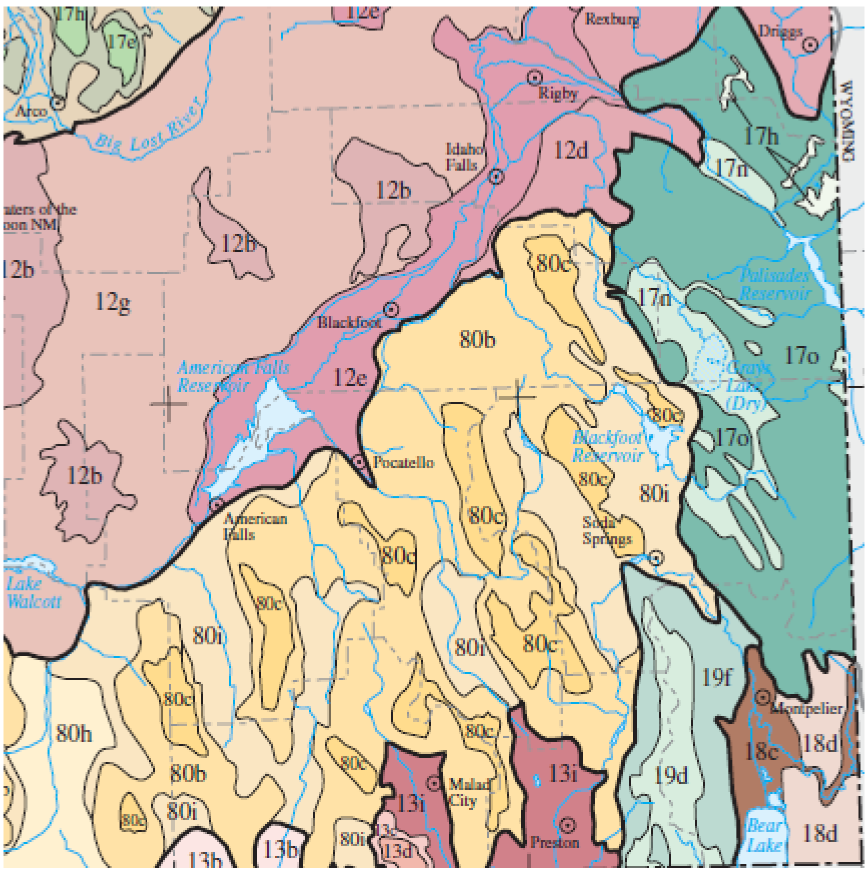


Figure 5. EPA's Idaho map, Ecoregion Level IV.

http://ecologicalregions.info/htm/id_eco.htm

[8] http://ecologicalregions.info/htm/id_eco.htm

The Phosphate Patch includes a number of ecoregions, roughly as follows:[9]

- 10% Middle Rockies High Elevation Valleys (17n)
- 30% Middle Rockies Partly Forested Mountains (17o)
- 5% Wyoming Basin Sub-Irrigated High Valleys (18c)
- 5% Wyoming Basin Foothill Shrublands and Low Mountains (18d)
- 10% Wasatch and Uinta Mountains, Wasatch Montane Zone (19d)
- 10% Wasatch and Uinta Mountains, Semiarid Foothills (19f)
- 10% Semiarid Hills and Low Mountains (80b)
- 10% Northern Basin and Range, High Elevation Forests and Shrublands (80c)
- 10% Northern Basin and Range, Sagebrush Steppe Valleys (80i)

17: Middle Rockies
The climate of Ecoregion 17 lacks the strong maritime influence of Ecoregion 15. Mountains have Douglas-fir, subalpine fir, and Engelmann spruce forests and alpine areas; Pacific tree species are never dominant and forests can have open canopies. Foothills are partly wooded or shrub- and grass-covered. Intermontane valleys are grass- and/or shrub-covered and contain a mosaic of terrestrial and aquatic fauna that is distinct from nearby mountains. Many mountain-fed streams occur. Granitics and associated management problems are less extensive than in Ecoregion 16. Recreation, logging, mining, and summer livestock grazing are common land uses. Stream fish assemblages are similar to those found in Ecoregions 15 and 16 and are dominated by salmonids and cottids. The Lost Streams of Idaho constitute aunique set of isolated lotic environments that are separated from other systems by the Eastern Snake River Basalt Plains (12g). Fish populations may also be seasonally isolated by the intermontane valleys of Ecoregion 17aa. The Pahsimeroi and Lemhi rivers are important Chinook salmon spawning streams.

17n = ~10%
High Elevation Valleys: The Cold Valleys contain bottomlands, terraces, marshlands, alluvial fans, and foothills that are nestled below the Partly Forested Mountains (17o). Mean annual frost-free season is brief, 40 to 90 days, and shorter than in the Sagebrush Steppe Valleys (80i). Potential natural vegetation is mostly sagebrush steppe. Wet bottomlands support sedges, rushes, and willows. Pastureland, rangeland, and small grain, alfalfa, and potato farming occur. Fields, streams, and marshes are important habitat for both nesting and migratory birds.

17o = ~30%
Partly Forested Mountains:The steep, dry Partly Forested Mountains vary in elevation from about 6,000 to over 9,000 feet. Soils have a cryic temperature regime and are rocky and shallow. They support open-canopied forests, shrublands, and grasslands; Douglas-fir, lodgepole pine, and aspen are most common on north-facing slopes and gently sloping uplands while mountain big

[9] Estimates provided by Idaho Department of environmental Quality

sagebrush and mountain brush dominate southfacing slopes. Its vegetation is distinct from surrounding ecoregions. Ecoregion 17o is used as summer range and for timber production

18: Wyoming Basin
Ecoregion 18 is a broad intermontane basin containing rolling plains, high hills, and mesas. It is most extensive in Wyoming but also extends into other states including Idaho. Ecoregion 18 is dominated by arid grasslands and shrublands and lacks the extensive forests of neighboring, mountainous Ecoregions 17 and 19. Land use is primarily livestock grazing but irrigated hayland also occurs.

18c = ~5%

Sub-Irrigated High Valleys: The Wet Valleys ecoregion is characterized by wetlands, lakes, canals, cold winters, and a short growing season. Nearly flat, poorly drained floodplains and low terraces are widespread and support sedges, rushes, cattails, marsh grasses, annual bluegrass, and clover. Well-drained alluvial fans and foothills covered in sagebrush grassland act as a transition to the surrounding and much more rugged Partly Forested Mountains (17o), Semiarid Bear Hills (18d), and Semiarid Foothills (19f). Mollisols occur and have a frigid temperature regime. Land use is irrigated hayland, meadow pastureland, and rangeland. Land use and drainage conditions are all different from neighboring ecoregions.

18d = ~5%

Foothill Shrublands and Low Mountains: The Semiarid Bear Hills ecoregion is located in the rain shadow of high mountains. Its terrain is hilly and is distinct from the nearly flat Wet Valleys (18c) and the much more rugged Wasatch and Uinta Mountains (19). Bunchgrasses and mountain big sagebrush occur and contrast with the forests of nearby, mountainous ecoregions. Land use is primarily grazing and is unlike the mosaic of irrigated hayland, meadow pastureland, and rangeland of Ecoregion 18c.

19: Wasatch and Uinta Mountains
Ecoregion 19 contains a core area of high, precipitous mountains with narrow crests and valleys. At middle elevations, Douglas-fir and aspen parkland are common. At highest elevations and on steep, north-facing slopes, Engelmann spruce and subalpine fir occur. Semiarid foothills support widely spaced juniper in a matrix of sagebrush grassland. Perennial streams provide water to lower, more arid regions. Summer livestock grazing is an important land use and is more common than in Ecoregion 17. Bear Lake supports three endemic species of fish.

19d = ~10%

Wasatch Montane Zone:The Wasatch Montane Zone is found above about 7,400 feet elevation. Its mountains are covered in a mixture of mountain big sagebrush, mountain brush, and conifer forests. Douglas-fir and aspen parkland are common on north-facing slopes and many less sloping areas. Mountain big sagebrush, snowberry, and understory grasses grow on south-facing slopes. Engelmann spruce and subalpine fir grow at highest elevations and on steep, north-facing slopes. The vegetation mosaic is unlike the sagebrush grassland and widely spaced junipers of the lower Semiarid Foothills (19f).

19f = ~10%

Semiarid Foothills: The Semiarid Foothills ecoregion ranges in elevation from about 5,500 to 8,200 feet. Widely spaced junipers occur in a matrix dominated by mountain big sagebrush and bluebunch wheatgrass. Overall, the vegetation is distinct from that of the higher, wetter Wasatch Montane Zone (19d). Livestock grazing is common. Some rangeland has been cleared of trees and reseeded to grasses.

80: Northern Basin and Range

Ecoregion 80 consists of dissected lava plains, rolling hills, alluvial fans, valleys, and scattered mountains. It is higher and cooler than Ecoregion 12 and has more available moisture than Ecoregion 13. Basins support sagebrush grassland or saltbush greasewood vegetation; cool season grasses and Mollisols are more common in the basins of Ecoregion 80 than in the hotter and drier basins of Ecoregion 13 where Aridisols support sagebrush, shadscale, and greasewood. Ranges are covered in mountain sagebrush, mountain brush, Idaho fescue, Douglas-fir, or aspen. Juniper woodlands occur on rugged, stony uplands. Both rangeland and cropland occurs. Ecoregion 80 lies between Ecoregion 13 to the south and Ecoregions 11 and 12 to the north; its southern boundary is the highest shoreline of Pleistocene Lake Bonneville which once inundated much of Ecoregion 13 but not Ecoregion 80. Stream fish communities share features of Ecoregions 12 and 17. In the Owyhee Mountains, Ecoregions 80j and 80k, isolated by the surrounding lower, warmer regions, once supported anadromous fish.

80b = ~10%

Semiarid Hills and Low Mountains:The Semiarid Hills and Low Mountains ecoregion occupies the elevational band between Ecoregion 80c and the lower, less rugged Ecoregions 12e, 80a, and 80i. Potential natural vegetation is mostly sagebrush steppe. Cool season grasses are more common than in the drier Ecoregion 13c which has less available moisture and has a potential natural vegetation of Great Basin sagebrush. Forest components are much less common than in Ecoregion 80c. Juniper woodland grows on rock outcrops but is not as common as in Ecoregion 13d. Land use is primarily livestock grazing.

80c = ~10%

High Elevation Forests and Shrublands: The High Elevation Forests and Shrublands ecoregion is mountainous and occupies the elevational band above Ecoregion 80b. It is characterized by a mix of conifers, mountain brush, and sagebrush grassland. North-facing slopes and many flatter areas support open stands of Douglas-fir, aspen and lodgepole pine; overall, forest components are more common than in Ecoregions 80a and 80b which are dominated by sagebrush grassland or juniper woodland. Winters are colder and mean annual precipitation is greater than in lower ecoregions.

80i = ~10%

Sagebrush Steppe Valleys: The Sagebrush Steppe Valleys ecoregion is flanked by the hills and mountains of Ecoregions 80b and 80c. It is dominated by sagebrush grassland and lacks the woodland of Ecoregion 80b, the open conifer forest of Ecoregion 80c, and the saltbush–greasewood of Ecoregions 13b and 80h. Perennial bunchgrasses are more abundant than in the Sagebrush Basins and Slopes (13c) in Utah. Valleys mostly drain to the Snake River and fish assemblages are unlike those of the internally-drained basins to the south in Ecoregion 13. Grazing is the dominant land use but non-irrigated wheat and barley farming is much more common than in the semiarid basins of Ecoregion 13. The Sagebrush Steppe Valleys (80i) ecoregion is less suitable for cropland agriculture and has less available water than many parts of the Snake River Plain (12).

FISH

Reservoirs, rivers, and streams include stocked and native species, Larger species include (some are stocked) Rainbow Trout, Cutthroat Trout, Brown Trout, Brook Trout, Lake Trout, Bull Trout, Chinook, Salmon, Kokanee Salmon, Coho Salmon, Grayling, Whitefish, Steelhead, White Sturgeon, Mountain Whitefish, Smallmouth Bass, Largemouth Bass, Sunfish, Carp, Crappie, Bluegill, Yellow Perch, Channel Catfish, Bullhead Catfish, and Pumpkinseed.[10] Meyer et al sampled smaller Non-game fish in 1738 upper reaches in the Snake River watershed and identified 18 species of sucker, sculpin, dace, and a few other genera.

GAME

Most of the Phosphate Resource Area are in the game management areas units 72 (Bannock Elk Zone) and 76 (Diamond Creek Elk Zone). Both units include portions of Bear Lake and Caribou Counties.[11] Unit 72 does not have a land use cover data, but it includes 55% private land, 16% state land, 12% US Forest land, 8% BLM, 6.5% Indian land. Unit 76 includes 37% rangeland, 34% forest, 10% dryland agriculture, 11% irrigated agriculture, and 3% riparian.

Unit 76
Big Game: Deer, Elk, Pronghorn, Bear, Moose
Upland Birds: Quail, Chukar, Dove, Gray Partridge, Forest Grouse, Sage Grouse, Sharp-Tail, Pheasant
Small Game: Rabbit & Hare, Furbearers
Waterfowl: Sandhill Crane, Goose, Duck, Coot, Snipe

Unit 72

[10] https://idahohighcountry.org/cat/fishing/; https://idfg.idaho.gov/rules/fish; http://www.idahoafs.org/fishes.php
[11] https://fishandgame.idaho.gov/ifwis/huntplanner/unit.aspx?ID=98

Big Game: Deer, Elk, Moose
Upland Birds: Quail, Chukar, Dove, Gray Partridge, Forest Grouse, Sage Grouse, Sharp-Tail, Pheasant
Small Game: Rabbit & Hare, Furbearers
Waterfowl: Sandhill Crane, Goose, Duck, Coot, Snipe

D. The Exposure Scenarios: Tribal Homesteader and Traditional Use Practitioner.

General Approach

This document focuses only on the human exposure component of a risk assessment. The broader aspects of health and well-being that are at risk from contamination are clearly recognized, but are beyond the scope of this memorandum. Many other components of tribal health and well-being are also at risk from contamination of natural resources. Tribal members associate the loss of culture, language, education, identity, and heritage directly with the practices that are unavailable as a result of contamination. These cultural losses adversely affect all tribal members individually as well as affecting the community as a whole. A public health approach to risk assessment naturally integrates human, ecological, and cultural health into an overall definition of community health and well-being that is widely used in public health but not in risk assessment. The combination of traditional lifeways and public health is adaptable to indigenous communities that, unlike westernized communities, turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life, or "ethnohabitat" or "eco-cultural" area. This memorandum, however, addresses only the methodology for evaluating human exposures to contamination if information about contaminant concentrations is available.

EPA guidance documents do not include complete exposure scenarios for Native Americans or for agricultural lifestyles. The Native American scenarios that have been developed[12] reflect specific traditional practices and foods that are unique to each Tribe and its local ethnohabitat. Each diet is tailored to the specific resources that are present in the ecology and documented in the anthropological literature as well as by tribal interviews where possible. This Shoshone Bannock report adds a Tribal Homesteader scenario.

The historical and current ecological and climatological descriptions provide information about plants, animals, biodiversity, relative proportions of different habitat types, seasonality, and physiographic features of the environment. This information is needed to support estimates of dietary staples (the resources that are most abundant and reliable), and environmental characteristics that affect contact rates with soil, sediment, and water (for example, proportion of wetlands versus dry upland habitats).

Ethnobotanical and ethnohistorical literature describes the general diversity of plants used for food, medicine, or materials in various regional ecotypes and helps derive dietary intake values. Traditional ecological knowledge (TEK) combines anthropological and environmental

[12] http://superfund.oregonstate.edu/conducting-research-tribal-communities

knowledge with tribal knowledge, teaching, and observation. This information identifies the most important resources used by the Tribe, and the importance of various ecological functions and services, as well as refinement of estimates of frequency, intensity and duration of major activity types.

In some cases, a completely traditional diet may have been identified in the anthropological foraging theory literature, but more often the major dietary staples are identified but not fully quantified within a nutritionally complete diet. Information about natural resources and their uses is used to estimate relative importance of the major food categories. This is combined with nutritional information to estimate a nutritionally complete subsistence diet for as many major regional habitat types as are appropriate.

There is little data directly relevant to environmental contact rates with abiotic media for indigenous styles other than the foraging theory literature, which tends to be non-specific. The approach taken to direct exposure factors begins with a description of the major activity categories. The crosswalk between major activities (hunting, fishing, gathering, and so on) and the abiotic exposure pathways (soil ingestion, sediment ingestion, water intake, and inhalation) is based on estimates of activity levels and the frequency, duration, and intensity of individual practices within each activity category. Physiological information adds knowledge of activity levels, the relation between inhalation rates and calorie needs, and other biomedical information provides some assurance that a reasonable and physiologically coherent set of exposure parameters had been developed.

This report also recommends that careful consideration be given if only some of the traditional activity categories are proposed (e.g., a hunting-only scenario). The terms “fish, hunt or gather” are shorthand labels that identify some of the most visible activities within a traditional lifestyle, but they each include a wide range of associated activities such as preparation, processing, using or consuming, and various traditional and cultural activities. A subsistence economy includes people with a wide range of ‘jobs’ such as food procurement, processing, and distribution; transportation (pasturing and veterinary); botany/apothecary services; administration and coordination (chiefs); education (elders, linguists); governance (citizenship activities, conclaves); finance (trade, accumulation and discharge of obligations); spiritual health care; social gathering; and so on. The categories of ‘fish, hunt, and gather’ each include a full cross section of these activities. This is why ‘hunting’ is not just the act of shooting and eating an animal, but includes a full cross-section of all the activities that a hunter-specialist does as a full-time occupation.

The basic process for developing the direct exposure factors is to:

1. Start with an understanding of the major categories of traditional activities (such as hunting, fishing, gathering, basket making and so on),
2. Describe enough of the sub-activities that the complexity and interconnection of resources and activities can be appreciated,
3. Identify the major activities that contribute to exposure, and then
4. Iteratively crosswalk between activities, frequency, intensity, and duration of environmental contact to develop exposure factors.

The scenario documentation then describes the activities that people undertake, including hunting, gathering foods and medicines, fishing, collecting firewood, making material items, and various other cultural and domestic activities. Once the activities comprising a particular lifestyle are known, they are translated into a form that is used for risk assessment. This translation captures the degree of environmental contact (frequency, duration, and intensity) that occurs through activities and diet, expressed as numerical "exposure factors." Exposure factors for direct exposure pathways allow the estimation of exposure to any contaminants in abiotic media (air, water, soil, and sediment), via inhalation, soil ingestion, water ingestion, and/or dermal exposure. Indirect pathways refer to contaminants that are incorporated into biota and may subsequently reach people who ingest or use them.

For the direct exposure factors, each of the major activity categories includes activities that result in exposure to each medium. For example, by estimating the relative amount of time spent in activities that result in high, medium, or low soil contact rates for each activity category, an overall soil ingestion rate was estimated. However, this report recommends not attempting to be overly quantitative in enumerating the myriad of activities and resources in each category because this implies more precision than is warranted. Thus, each crosswalk is a systematic estimate but not a statistical exercise.

Signature activities may be described separately, such as basket making (gathering, preparing materials, making the basket, using the basket for food storage or cooking), or wood gathering (firewood, tipi poles, etc., with high-energy expenditures during felling, trimming, splitting, stripping, and so forth).

For each category of activities, the information needed for risk assessment is frequency of activity (e.g., daily), duration (e.g., 70 years), and intensity of environmental contact.

Table 1. Major Activity Categories

Activity Type	***General Description***
Hunting	Hunting includes a variety of preparation activities of low to moderate intensity. Hunting occurs in terrain ranging from flat and open to very steep and rugged. It may

	also include setting traplines, waiting in blinds, digging, climbing, etc. After the capture or kill, field dressing, packing or hauling, and other very strenuous activities occur, depending on the species. Subsequent activities include cutting, storing (e.g., smoking or drying), etc.
Fishing	Fishing includes building weirs and platforms, hauling in lines and nets, gaffing or gigging, wading (for shellfish), followed by cleaning the fish and carrying them to the place of use. Activities associated with smoking and constructing drying racks may be involved.
Gathering	A variety of activities is involved in gathering, such as hiking, bending, stooping, wading (marsh and water plants), digging, and carrying.
Sweatlodge Use	Sweatlodge building and repairing is intermittent, but collecting firewood is a constant activity.
Materials and Food Use	Many activities of varying intensity are involved in preparing materials for use or food storage. Some are quite vigorous such as pounding or grinding seeds and nuts into flour, preparing meat, and tanning hides, Many others are semi-active, such as basket making, flintknapping, construction of storage containers, cleaning village sites, sanitation activities, home repairs, and so on.

The Scenarios

Two exposure scenarios are presented: (1) Tribal Residential Homesteader, and (2) Non-Residential Traditional Practitioner. **It is important to emphasize that these scenarios are <u>not</u> necessarily split along on-reservation and off-reservation lines.** The Tribal Residential Homesteader is applicable anywhere on the reservation as well as other locations off-reservation, according to the determinations of the Shoshone Bannock government.

The **<u>Tribal Homesteader</u>** is a person (or family) who lives on and supports himself (and his family) on the homestead, raising crops and livestock, and obtaining water from a well for domestic use, irrigating crops, and watering livestock. Activities include farming, ranching, and similar agriculturally-oriented activities as well as traditional tribal activities. The diet includes both homegrown crops (kitchen garden, row crops, hay or alfalfa for the livestock) and wild foods and medicines obtained through hunting, fishing, gathering, and trade. The homesteader uses firewood for winter heating, obtained from the study area (e.g., mine site).

This report presents a general Homesteader RME, an upper percentile that is unspecified because some of the exposure factors are central tendency or representative "averages." If the risk assessment uses both RME and CTE estimates, the Homesteader RME is the person/family who gets 100% of his food from the allotment, and the Homesteader CTE is the person/family who gets 50% of his food from his allotment and 50% from wild sources. The term 'trade' is shorthand for trading, obtaining wild food from other family members or from the Tribe, at ceremonies, and other non-homestead sources. It does not require that the homesteader leave the homestead for extended periods of time, but does include excursions for hunting, fishing, gathering, and similar activities.

The **Traditional Use Practitioner** is a person who lives in the community but who spends extended periods of time to hunt, fish, gather, and pursue similar traditional activities in natural areas, such as national or state forests. If the risk assessment uses both RME and CTE estimates, the Traditional RME is the person who obtains a completely wild diet, and the Traditional CTE would obtain some portion (unspecified; requires Tribal consultation) of his food and medicine from wild sources, for example based on tag limits or other restrictions.

Table 2. Major Non-Dietary Exposure Parameters for Homesteader and Traditional Use Scenarios

Parameter	Value	Comment
Exposure Frequency	365d/yr homestead; Snow-free days for traditional user.	
Exposure Duration	70 years (6 yrs + 64 yrs)	
Body Weight	70 or 80 kg	If a BW of 70 is used, the dietary calories total 2000/d. If a BW of 80 is used, the dietary calories total 2200/d*
Inhalation Rate	20 m^3 /d	This is the default EPA central tendency rate, and may be low considering that the lifestyle is more active than the US national central tendency.
Water Ingestion Rate	2L + 1L per sweat lodge use	Uses groundwater at the homestead and at developed campgrounds. Uses surface water during other traditional use (TBD after consultation).
Soil & Dust Ingestion Rate	330 mg/d, sieved to <63μm.	See Appendix 2. Given the arid climate, dustiness of the past mining activities, the nature of farming and ranching activities, the unpaved roads, etc., a finer grain size than 250 μm or 150 μm is reasonable.
Sweat Lodge Frequency	1 hr/day	Consult with Tribe if a different value is proposed
Other parameters	EPA defaults	E.g., skin surface area, swimming, etc.
Children	Scaled similar to EPA defaults. Soil ingestion = same as adults.	
Firewood from mine site	4 cords per year.	Aspen from the mine site. Consult with the Tribe if another value is proposed.
* https://health.gov/dietaryguidelines/2015/guidelines/appendix-2/		

Dietary Approach

This section describes the derivation of the traditional diet and also presents a homesteader diet.

Natural resources are gathered for food and medicine according to their seasonal availability. Many resources are both eaten fresh and stored for use throughout the year. There are clear seasonal variations in the diet, but the goal of most exposure scenarios is an annual average diet. This is because risks are calculated for annual and lifetime exposures. However, higher exposures might occur during seasonally-focused diets. For example, risks from eating fish are evaluated on a chronic (annual and multi-year) basis, but there may be health concerns from seasonally high (acute) exposures. This report provides a provisional tool that will allow the Tribe to develop both annual average diets as well as diets tailored to different locales and to different seasons.

The general steps in describing a traditional diet are to:

1. Review information about ecological settings and natural resources, ethnohistorical and contemporary natural resource use, archaeological evidence, tribal history and interviews;
2. Review the seasonal aspects of resource availability – it is important to remember that the goal is an annual average diet.
3. Review databases of contemporary foods and diets for comparability, native foods currently eaten, ethnic data, regional data, and contemporary quantities;
4. Identify dietary staples and develop overall percentages of major food categories including medicinal plants for a completely subsistent diet(s);
5. Estimate total calories and quantities of food provided by the diets;
6. Refine estimates of major staples and food categories, macronutrients, and other factors. This is a reasonable estimate, not a statistical estimate with ranges.

After the major food categories and representative foods are determined, the representative species were identified and caloric information is retrieved from the USDA database[13] for either the exact species, a member of the same or nearest plant family, and the exact animal or other animal from a similar habitat and feeding guild (e.g., wetland omnivore or upland browser). The data for fresh or cooked foods matches the form of native foods eaten as closely as possible. The USDA data were derived from recent studies on contemporary domesticated and wild foods, including some information on different methods of food preparation. Some of the information was obtained by USDA in response to requests from Indian Tribes and is appropriate as to species and cooking method. In other cases nutrient data are not available (such as for wild tubers or bulbs), so data for the nearest domesticated species can be used. In most cases this

[13] http://www.ars.usda.gov/main/site_main.htm?modecode=12354500

would probably not alter the high-level food pyramid or food circle, even though native peoples recognize that flavor, texture, and "strength" differ between wild species and domesticated cultivars.

Table 3. Nutritional Data for Representative Species

<table>
<tr><th>Food Category</th><th>Kcal per 100g
(Representative species)*</th><th>Food Category</th><th>Kcal per 100g
(Representative species)*</th></tr>
<tr><td>Resident fish and other aquatic resources</td><td>Mixed trout, cooked – 190
Crayfish, wild cooked - 82
Turtle, raw - 89</td><td>Bulbs</td><td>Leek, onions and other bulbs (bulb & leaf) – 31</td></tr>
<tr><td rowspan="2">Anadromous and marine fish and shellfish</td><td rowspan="2">Salmon, cooked – 180
Shad, cooked - 252
Herring, dry cooked – 200
Pollock, dry cooked - 118
Eel, dry cooked – 236
Oyster, dry cooked – 70
Clam, moist cooked – 148
Lobster, moist heat cooked - 98
Seal, raw – 142
Beluga, raw - 111</td><td>Berries, fruits</td><td>Raw elderberries – 73
Raw strawberries - 70</td></tr>
<tr><td>Other vegetables (above-ground)</td><td>Beans, cooked pinto, kidney or white – 143
Peas, boiled pigeon or split - 120
Squash, cooked winter – 37
Squash, cooked Navajo - 16</td></tr>
<tr><td rowspan="2">Game, large and small</td><td rowspan="2">Deer, elk, buffalo, roasted – 158
Moose, roasted – 134
Moose liver, braised - 155
Rabbit, wild, roasted – 173
Beaver, roasted – 212
Muskrat, roasted - 236</td><td>Greens, Tea (includes leaves, stems, medicinal plants, flavorings)</td><td>Raw dandelion greens – 45
Raw watercress – 11
Fiddleheads, raw - 34</td></tr>
<tr><td>Honey, Maple syrup, other</td><td>Honey – 304
Maple syrup - 261</td></tr>
<tr><td rowspan="2">Fowl and Eggs</td><td rowspan="2">Quail, cooked – 234
Duck, cooked - 200
Duck eggs – 185
Pheasant (for wild turkey) - 247</td><td>Seeds, Nuts, Grain</td><td>Corn, Navajo strain steamed - 386
Raw dried sunflower seeds – 570
Chia seeds – 490
Hazelnut, dry roast – 646
Butternuts, dried - 612</td></tr>
<tr><td>Roots, Bulbs, Tubers</td><td>Raw chicory root – 73
Boiled burdock root – 88
Potato, baked tuber - 200</td></tr>
</table>

Homesteader and Traditional Diets

The USDA guidelines 2015-2020[14] suggests the following for a US eating style (as opposed to a Mediterranean or vegetarian eating style) for a 2200 kcal[15] diet. A body weight of 80 kg has been proposed for the risk assessment. A maintenance caloric intake for 176 pounds is2640 kcal/d. A moderately active man needs 176 lbs x 15 kcal/lb = 2640 kcal/d; a woman needs 2000-2200.[16] The daily calorie rate of 2200kcal is quite modest considering the activities that both the homesteader and the traditional practitioner undertake. If a body weight of 70 kg is used, the total calories may be adjusted to a 2000 kcal rate.

The homesteader's diet is 100% self-produced and the exposure point concentration would be based on the homestead. The exact statistic for the exposure point concentration is determined though discussion among the Tribe, agencies, and risk assessors. For example, the 95UCL is a central tendency statistic that is prone to being diluted through the selection of a large study area. The combination of a central tendency exposure point concentration plus the modest average diet results in a central tendency risk estimate even if 100% of the homesteader's diet is self-produced. Thus, although this report refers to the 100% homestead-produced diet as the RME, this is really a misnomer.

Table 4. USDA recommended American diet, 2200 kcal/d (modified for protein)

Food Category	*USDA Recommendation (Note variations in units)*	*Conversion to grams per day*
All Vegetables	3 cups/day	450 (all cooked except fruit), averaged across all types.
Dark Greens, broccoli	2C/wk (collard greens, 1C = 190g; cooked broccoli, 1C =184g)	
Red-Orange vegetables	6 C/wk (cooked tomatoes, 1C = 240g; Cooked winter squash, 1C = 200g)	
Legumes (not peas or lima beans)	2 C/wk (Pinto beans cooked 1C = 171g)	
Starchy vegetables (corn, potatoes, peas, lima beans)	6 C/wk (corn, cooked, 1C = 157g; potatoes, cooked, 1C = 155g)	
Other vegetables	6 C/wk (cooked cabbage, 1C = 150; onions cooked, 1C = 90g)	
Fruits	2C/d (blueberries raw, 1C =150g)	300

[14] https://health.gov/dietaryguidelines/2015/guidelines/appendix-3/
https://ndb.nal.usda.gov/ndb/search/list?fgcd=Branded+Food+Products+Database&ds=Branded+Food+Products).

[15] Calories are units of energy. Various definitions exist but fall into two broad categories.

- The small calorie or gram calorie (symbol: cal) is the approximate amount of energy needed to raise the temperature of one gram of water by one degree Celsius at a pressure of one atmosphere.
- The large calorie or kilogram calorie (symbol: Cal), also known as the food calorie and similar names, is defined in terms of the kilogram rather than the gram. It is equal to 1000 small calories or 1 kilocalorie (symbol: kcal).

[16] https://www.k-state.edu/paccats/Contents/PA/control.htm;_LiveStrong.dhhs.gov.

Grains	7 oz/d (whole and refined each 3.5 oz/d or 100g)	200
Protein - 6 oz/d or 170 g/d (USDA); 8 oz or 220 g/d (Homesteader).	seafood, 9 oz/wk or 37g/d; meat-dairy-eggs-poultry, 28 oz/wk or 20 g/d; nuts seeds 5 oz/wk (100 almonds) NOTE: this amount is increased to 8 oz/d for the homestead family.	(170 – USDA) 220 - Homesteader
Fats, Oils	29g/d	30
		1200 g, 2.65 lbs/d of solids without broth.

Dark-green vegetables: All fresh, frozen, and canned dark-green leafy vegetables and broccoli, cooked or raw: for example, broccoli; spinach; romaine; kale; collard, turnip, and mustard greens.

Red and orange vegetables: All fresh, frozen, and canned red and orange vegetables or juice, cooked or raw: for example, tomatoes, tomato juice, red peppers, carrots, sweet potatoes, winter squash, and pumpkin.

Legumes (beans and peas): All cooked from dry or canned beans and peas: for example, kidney beans, white beans, black beans, lentils, chickpeas, pinto beans, split peas, and edamame (green soybeans). Does not include green beans or green peas.

Starchy vegetables: All fresh, frozen, and canned starchy vegetables: for example, white potatoes, corn, green peas, green lima beans, plantains, and cassava.

Other vegetables: All other fresh, frozen, and canned vegetables, cooked or raw: for example, iceberg lettuce, green beans, onions, cucumbers, cabbage, celery, zucchini, mushrooms, and green peppers.

Protein: In general, 1 ounce of meat, poultry or fish, ¼ cup cooked beans, 1 egg, 1 tablespoon of peanut butter, or ½ ounce of nuts or seeds can be considered as 1 ounce-equivalent from the Protein Foods Group.

Whole grains: All whole-grain products and whole grains used as ingredients: for example, whole-wheat bread, whole-grain cereals and crackers, oatmeal, quinoa, popcorn, and brown rice.

Refined grains: All refined-grain products and refined grains used as ingredients: for example, white breads, refined grain cereals and crackers, pasta, and white rice. Refined grain choices should be enriched.

Quantity equivalents for each food group are:

- Vegetables and fruits, 1 cup-equivalent is: 1 cup raw or cooked vegetable or fruit, 1 cup vegetable or fruit juice, 2 cups leafy salad greens, ½ cup dried fruit or vegetable.
- Grains, 1 ounce-equivalent is: ½ cup cooked rice, pasta, or cereal; 1 ounce dry pasta or rice; 1 medium (1 ounce) slice bread; 1 ounce of ready-to-eat cereal (about 1 cup of flaked cereal).
- Dairy, 1 cup-equivalent is: 1 cup milk, yogurt, or fortified soymilk; 1½ ounces natural cheese such as cheddar cheese or 2 ounces of processed cheese.
- Protein Foods, 1 ounce-equivalent is: 1 ounce lean meat, poultry, or seafood; 1 egg; ¼ cup cooked beans or tofu; 1 Tbsp peanut butter; ½ ounce nuts or seeds.

It can be argued that a true farm diet includes more meat and eggs than 6 ounces per day (4 ounces of meat plus 1 egg). Considering the calorie efficiency of harvesting local livestock, a somewhat greater amount of protein (8 ounces) is used in the homesteader diet. Even this may be an underestimate. f a family of 4 eats 6 ounces of meat per day per person, and 2 a 1000 pound steer yields 430 pounds of muscle meat, then 2 steers yield enough meat for the family's annual needs.

Traditional diet

The concept of traditional diets differs from the USDA recommendations in that there is obviously no processed packaged food, and people ate what was locally available, in proportions and ratios that are nutritionally adequate and that reflect foraging efficiency (skill, traditional knowledge, and acquisition costs). A number of traditional diets have been developed for risk assessment, as mentioned above. The traditional diet for the Shoshone Bannock area is based on several factors:

1. The traditional diet is not simply the homesteader diet with substituted foods. Rather, it reflects the actual ratios of natural resources that are traditionally consumed, with more meat and less grain, as well as slightly different ratios of the other food categories.
2. Salmon are not included because they do not occur above Shoshone Falls, but a lesser amount of other resident fish is available throughout the area. The EPA default for Native American fish consumption rate is 142.4 g/d (EPA 2000; page 1-7).
3. Deer, elk, and roots were the primary staples, with small game, fowl, fish, seeds, and berries approximately equal in importance in the fully subsistent diet.
4. The goal of the risk assessment will be to estimate the risks to the hunter who gets his tag limit for his family. It is not to estimate how much game can be harvested from a particular area, thus the carrying capacity is not an issue. It is evident that a successful hunter can supply enough meat for many people beyond his immediate household, therefore it is reasonable to assume that all the meat in a RME traditional diet is from locally harvested game[17].

Table 5. Tag limits

Tag Limits per hunter	Average meat per animal (pounds)	Total annual meat per hunter (wet weight; pounds)	Grams/day available to each person (household of 4 people).
2 Mule Deer	175.8	351.6	109g
3 Elk	350	1050	327g
1 Moose	950	950	295g

5. Total harvest rates for 46 species of plants, including several tree species, was provided by the Shoshone Bannock Tribe. Many additional species were identified by Steward (1938, Appendices D and E), which support a determination that 3 cups per day of plant products are a reasonable amount to include in the traditional diet, except that modern grains are included.

[17] SBT citation need methods for the two tables.

Food category	Amount	Estimate of Daily Calories
Game	8 oz, 225 g/d	600 kcal
Fish	5 oz, 142.4 g/d	200 kcal
Fowl	1.5 oz, 40 g/d	80 kcal
Roots, tubers, rhizomes	1C, 200 g/d	150 kcal
Greens, Bulbs, other	1C, 150 g/d	100 kcal
Berries, Fruit	1 C, 100 g/d	75 kcal
Seeds, Nuts	½ C, 50 g/d	200 kcal
Grain (modern)	7 oz, 200 g/d	400 kcal
Honey, teas, etc.	30 g/d	100 kcal
Fats, oils	30 g/d	260 kcal
Total	*1168 g (2.6 lbs.)*	*2265 kcal*

6. Given generally similar calorie densities between wild and cultivated/domesticated foods, the two differences between the homesteader and traditional diets are (1) different ratios among the food categories, and (2) more importantly, the source of the food. For example, deer and elk browse while cattle graze, and the homeranges of the wild species may be quite large, thus diluting the exposure point concentration. Thus, cattle grazing on a mine site would be expected to ingest more contaminants than an elk browsing over a larger area. Therefore, caution should be exercised against simply substituting one species for another in a generic food pyramid.

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Appendix 1. ARARs

APPENDIX 1 - ARARs

For a large mining site the number of ARARs can be substantial. For the Silver Valley (also known as Bunker Hill and the Coeur d'Alene Valley), one of the three Operable Units has the following ARARs:[18]

TABLE 8-11 Number of ARARs, by Category and Jurisdiction, Identified as Pertinent to Bunker Hill Mining and Metallurgical Complex Operable Unit 3

	Jurisdiction			
Category of ARARs	Federal	State	Tribe	Local
Waste management and repository design	2	5		
Air quality	1	3		
Surface-water quality	3	4		
Drinking water quality	1	1		
American Indian concerns and cultural resources protection	4			
Special status species	2	2		
Sensitive environments	3	2		
Other requirements	1	1		
Other policies and guidances to be considered[a]	9	1		
Total (ARARs, to be considered)	17, 9	18, 1	0, 0	0, 0

[a]These are not formal ARARs but rather guidance, policy, or other unpromulgated materials

In the Silver Valley case there were no tribal ARARs identified, even though the Coeur d'Alene and Spokane Tribes are affected. For the Phosphate Patch the following discussion discusses a number of policy statements that could be considered as ARARs, or at least relevant guidance.

In addition to the Treaty of 1868, there are several federal policies that could be ARARs or, at a minimum, guidance on assessing risk and developing remedies.

1. "EPA Policy for the Administration of Environmental Programs on Indian Reservations."[19]

"The keynote of this effort will be to give special consideration to Tribal interests in making Agency policy and to insure the close involvement of Tribal Governments in making decisions and

[18] From: National Research Council (2006). Superfund and Mining Megasites: Lessons from the Coeur d'Alene River Basin. Washington DC: National academies Press. DOI: https://doi.org/10.17226/11359

[19] https://www.epa.gov/tribal/epa-policy-administration-environmental-programs-indian-reservations-1984-indian-policy.

managing environmental programs affecting reservation lands." In particular, EPA "*will recognize Tribal governments as the primary parties for setting standards, making environmental policy decisions, and managing programs for reservations,*" and "*in keeping with the Federal Trust responsibility, will assure that Tribal concerns and interests are considered whenever EPA's actions and/or decisions may affect reservation environments."* EPA then explains this principle as follows: "*EPA recognizes that trust responsibility derives from the historical relationship between the Federal government and Indian Tribes as expressed in certain Treaties and Federal Indian law. In keeping with that trust responsibility, the Agency will endeavor to protect the environmental interests of Indian Tribes when carrying out its responsibilities that may affect the reservations."*

"Forest Service National Resource Guide to American Indian and Alaska Native Relations." State and Private Forestry. FS-600, April 1997.[20]

"*The Forest Service's success in establishing and maintaining the governmentto-government relationship will be based on an appreciation of and about Indian Country and those attributes unique to respective national forests and grasslands and local tribes*." "*The challenge facing the Forest Service today is to reconcile many requirements of law so that National Forest System lands can be administered in a way that meets public needs while recognizing the rights of Indian tribes."*

Bother of these policies support the notion that Tribes determine their own land uses and that management of federal resources off reservation can be a joint effort. Since these policies were written, the concepts of consultation, collaboration, resource management, landscape management, and related concept have evolved greatly. Clearly the Tribe can set cleanup standards on their reservation in order to protect the highest and best use of the residential allotments.

A similar policy was not located for the State of Idaho, which was established on July 3, 1890, long after the 1868 Treaty.

2. "<u>Consideration of Tribal Treaty Rights and Traditional Ecological Knowledge in the Superfund Remedial Program" (OLEM 9200.2-177, 2017).</u>

"EPA will subsequently consider all relevant information obtained to help ensure that EPA's actions do not conflict with treaty rights, and to help ensure that EPA is fully informed when it seeks to implement its programs and to further protect treaty rights and resources when it has discretion to do so." This guidance directs project managers to ask "What treaty rights exist in, or what treaty-protected resources rely upon, the specific geographic area? and How are treaty rights potentially affected by the proposed action?" "To the extent that tribal treaty rights and TEK help inform Superfund Remedial Program implementation, their roles should be explained and documented, as appropriate, in site decision documents and administrative records."

[20] https://www.fs.fed.us/people/tribal/ *and* https://www.fs.fed.us/people/tribal/tribint.pdf.

“Forest Service Research and Development Tribal Engagement Roadmap” (Forest Service FS-1043 March 2015) is a parallel document that recognizes that the “*United States continues to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, tribal trust resources, and Indian tribal treaty and other rights*.” The USFS seeks to incorporate traditional knowledge into USFS research and management practices. The USFS policy recognizes that “*the U.S. Government ratified approximately 400 treaties with Indian nations, agreeing to preserve their ability to exercise their sovereign rights as were reserved by the signatory tribes.”* The first USFS goals is to “*Ensure the agency redeems its trust responsibility and protects American Indian and Alaska Native reserved rights as they pertain to Forest Service programs, projects, and policies*.” Objective 1.3 is to “*Evaluate—and modify if needed—policies in support of the agency’s trust responsibility, tribal reserved rights on National Forest System lands, and implementation of programs and policies established to benefit tribes*.”

> These two policies support the use of traditional knowledge in the development of cleanup remedies, such as the traditional use of native plants for food, medicine, and manufacture.

3. U.S. Environmental Protection Agency's "Policy on Environmental Justice for Working with Federally Recognized Tribes and Indigenous Peoples" (Memo and policy from Gina McCarthy, July 24, 2014, to all EPA employees).

"This policy establishes principles to ensure that achieving environmental justice is part of the EPA's work with federally recognized tribes, state-recognized tribes, individual tribal members, indigenous community-based and grass-roots organizations, and others living in Indian country." "The EPA recognizes the right of the tribal governments to self-determination and acknowledges the federal government’s trust responsibility to federally recognized tribes, based on the U. S. Constitution, treaties, statutes, executive orders, and court decisions."

> This policy not only requires consultation, but also to recognize situations where disadvantaged communities might bear disproportionate impacts, or where special attention to the federal trust obligations is needed.

4. U.S. EPA “Transmittal of Amendments to Superfund Hazard Ranking System Guidance Incorporating Native American Traditional Lifeways.” (OSWER 9200.0-66, March 20, 2007).

"*EPA should consider, to the extent allowed under the HRS, Native American traditional lifeways when assessing a site for listing."*

> Although this Directive specifies the Hazard Ranking System, it is logical that if tribal lifeways are used in the listing of a site, those same lifeways should be used to develop remedies for the site.

5. Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. This Order directs each federal agency, as defined in

the Order, to "*make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States."* The Executive Order applies equally to Native American programs.

- Sec. 1-103 (4) "*identify differential patterns of consumption of natural resources among minority populations and low-income populations*."
- Sec. 4–4. Subsistence Consumption of Fish and Wildlife. 4–401. Consumption Patterns. "*In order to assist in identifying the need for ensuring protection of populations with differential patterns of subsistence consumption of fish and wildlife, Federal agencies, whenever practicable and appropriate, shall collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence. Federal agencies shall communicate to the public the risks of those consumption patterns."*

  It should be noted that tribal homesteaders "subsist" on (i.e., derive sustenance from) their allotments. Their uses are not limited solely to fish and wildlife for the purposes of risk assessment. In its 1997 Environmental Justice Guidance under the national Environmental Policy Act, the CEQ issued guidance on key terms related to subsistence consumption in a reprinting of Executive Order 12898. The following definitions were developed by an Interagency Working Group on Environmental Justice, established by the Executive Order and chaired by the EPA. Subsistence consumption of fish and wildlife is defined as "dependence by a minority population, low-income population, Indian Tribe or subgroup of such populations on indigenous fish, vegetation, and/or wildlife, as the principal portion of their diet." A differential pattern of subsistence consumption is defined as "differences in rates and/or patterns of subsistence consumption by minority populations, low-income populations, and Indian Tribes as compared to rates and patterns of consumption of the general populations."

6. Interagency MOU on Environmental Justice. REGARDING INTERAGENCY COORDINATION AND COLLABORATION FOR THE PROTECTION OF TRIBAL TREATY RIGHTS, 2016.[21]
"*The signatory agencies (Parties) enter into this Memorandum of Understanding (MOU) to affirm our commitment to protect tribal treaty rights and similar tribal rights relating to natural*

[21] https://www.epa.gov/tribal/memorandum-understanding-regarding-interagency-coordination-and-collaboration-protection and https://www.fs.fed.us/spf/tribalrelations/sacredsitesmou.shtml. Signatory Agencies included the U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Department of Justice , U.S. Department of Commerce, U.S. Department of Defense, U.S. Environmental Protection Agency, U.S. Department of Transportation, White House Council on Environmental Quality, and the Advisory Council on Historic Preservation.

resources through consideration of such rights in agency decision-making processes and enhanced interagency coordination and collaboration."

> The USEPA conducts many programs supporting the safety, health, and environment of Indian Tribes on Reservations, and some off-reservation. The USFS efforts primarily focus on the protection of sacred sites. It can logically be argued that this MOU applies equally to the safe exercise of Treaty-reserved rights to hunt, fish, and gather.

7. <u>Federal fiduciary Trust obligations</u>, quoting the Interagency MOU 2016 (see above). The United States' trust responsibility to tribes is "one of the primary cornerstones of Indian law." Dep't of Interior v. Klamath Water Users Protective Ass'n, 532 U.S. 1, 11 (2001) (quoting Felix Cohen, 8 Handbook of Federal Indian Law 221 (1982)). Any federal action that affects a tribe is subject to this fiduciary duty. Nance v. E.P.A., 645 F.2d 701, 711 (9th Cir. 1981). Because of its trust responsibility, federal agencies actions with respect to tribal resources are held to "the most exacting fiduciary standards." Seminole Nation v. United States, 316 U.S. 286, 297 (1942).

EPA, Interagency MOU: "*Under the U.S. Constitution, treaties are part of the supreme law of the land, with the same legal force and effect as Federal statutes. Treaties bind both the Federal Government and the signing Indian tribe or tribes, and generally constitute recognition of rights to lands and resources, as well as rights to fish, hunt, and gather. As such, the Federal Government has an obligation to honor and respect tribal rights and resources that are protected by treaties. This means that federal agencies are bound to give effect to treaty language and, accordingly, must ensure that federal agency actions do not conflict with tribal treaty rights. Integrating consideration of tribal treaty rights into agency decision making processes is also consistent with the Federal Government's trust responsibility to federally recognized tribes*."

USFS (https://www.fs.fed.us/research/docs/tribal-engagement/consultation/roadmap.pdf): As part of the Federal Government and responsible for implementing Federal Government programs, Forest Service R&D has responsibility for ensuring this trust responsibility is redeemed.

8. <u>A Guide to Preparing Institutional Control Implementation and Assurance Plans at Contaminated Sites, OSWER 9200.0-77, EPA-540-R-09-002, December 2012</u>.

Section 2.1 says "*Site managers and site attorneys should consider whether the site would meet unlimited use and unrestricted exposure (UU/UE) as one of the factors in deciding when an IC is appropriate at a site. UU/UE generally is the level of cleanup at which all exposure pathways present an acceptable level of risk for all land uses.*" "*As response components, ICs typically are designed to achieve the substantive use restrictions selected in a response selection document in order to achieve the cleanup objectives. The evaluation of whether an IC is needed at a site is a site-specific determination. Site managers and site attorneys should consider whether the site would meet unlimited use and unrestricted exposure (UU/UE) as one of the factors in deciding when an IC is appropriate at a site. UU/UE generally is the level of cleanup at* *which all exposure pathways present an acceptable level of risk for all land uses*." (see also USEPA, OSWER 9355.0-89. EPA-540-R-09-001, 2012.)

Unlimited Use/Unrestricted Exposure (40CFR.300.430.4.ii, National Contingency Plan). "*If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after initiation of the selected remedial action."*

9. "Land Use in the CERCLA Remedy Selection Process", OSWER Directive 9355.7-04, May 25, 1995.
"Considering Reasonably Anticipated Future Land Use and Reducing Barriers to Reuse at EPA-lead Superfund Remedial Sites" OSWER Directive 9355.7-19, March 2010.
"*In evaluating the potential reasonably anticipated future use options for a site, Regions should consult with the site's stakeholder community (i.e., local governments, community groups, the site's owners, individuals, states, tribes, etc.) to obtain input on future use options and to discuss how particular remedies may affect a site's future use options*." "*EPA should gain an understanding of the reasonably anticipated future land uses at a particular Superfund site to perform the risk assessment and select the appropriate remedy*." "*Another opportunity to consider the reasonably anticipated future land use is during the Superfund site baseline risk assessment. This risk assessment is developed during the remedial investigation (RI) process, and evaluates exposures under both current and future land use conditions, using information gathered from a number of sources. These sources include the community itself*." EPA "*recommends risk assessors* "*assume future residential land use if it seems possible based on the evaluation of available information*."" "*Remedial action objectives developed during the RI/FS should reflect the reasonably anticipated future land use or uses; Future land use assumptions allow the baseline risk assessment and the feasibility study to be focused on developing practicable and cost effective remedial alternatives. These alternatives should lead to site activities which are consistent with the reasonably anticipated future land use. Land uses that will be available following completion of remedial action are determined as part of the remedy selection process. During this process, the goal of realizing reasonably anticipated future land uses is considered along with other factors. Any combination of unrestricted uses, restricted uses, or use for long-term waste management may result.*"
EPA's OSWER Directive No. 9355.7-04 says that *"If the site is located in a community that is likely to have environmental justice concerns, extra efforts should be made to reach out to and consult with segments of the community that are not necessarily reached by conventional communication vehicles…"* One of the factors that must be considered is the presence of *"cultural factors (e.g., historical sites or Native American religious sites)."*

10. OSWER DIRECTIVE 9355.0-30, April 22, 1991. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions.

"*The preamble to the NCP states that EPA will consider future land use as residential in many cases. In general, residential areas should be assumed to remain residential; and undeveloped areas can be assumed to be residential in the future unless sites are in areas where* *residential land use is unreasonable. Often the exposure scenarios based on potential future residential land use provide the greatest risk estimates (e.g., reasonable maximum exposure scenario) and are important considerations in deciding whether to take action (55 Fed. Reg. at 8710*).”

Appendix 2. Soil Ingestion Rate

SOIL INGESTION RATE (revised 2017)

Indigenous Soil Ingestion Rate = 330 mg/d (all ages, all scenarios) Sieved to grain sizes < 63 µm Applies to the Tribal Homesteader and Traditional Use Scenarios

SUMMARY

Soil ingestion includes consideration of direct ingestion of dirt, mud, or dust Indoor and outdoor), swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. The soil ingestion rate is based on a review of EPA guidance, soil ingestion studies in suburban, rural, and indigenous settings, pica and geophagia, and dermal adherence studies. It is also based on homesteading (farming, ranching, gardening) and traditional resource use scenarios use with their higher environmental contact rates and local climatic and geologic conditions.

A soil ingestion rate of 400 mg/d for all ages is the upper bound for suburban children (EPA, 1997), and within the range of outdoor activity rates for adults. Farming, ranching, and traditional Native American lifestyles and natural resource use were not considered by the EPA guidance, but could logically be considered to be similar in soil contact rates to construction, utility worker or military soil contact levels. The current EPA recommended rate of 330 mg/d is lower than the previous high-contact rate of 480 mg/d to allow for some low-contact days, but it should not be lower because there are many "1-gram" days and events such as tilling soil, wrangling livestock, gardening, root digging, plant and material gathering, basketmaking and other use of natural materials, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, firewood splitting, hide tanning, and similar activities. Based on professional judgment, we do not believe that data are adequate to distinguish between homesteading and traditional natural resource-based soil contact rates, and therefore use a single rate for both homesteader and traditional practitioner scenarios.

An updated review (2017) is added at the end of this review, with the conclusion that 330 md/d for all ages is now recommended, based on mass-balance studies of Al and Si, but recognizing that there is still a tremendous variance and uncertainty about true soil ingestion rates as reflected by different trace elements. The gastrointestinal absorption or bioavailability of trace elements needs further investigation, whether from food or other sources, and whether in solid, dissolved, or nanoparticle form, since soil ingestion rates are based on the ingestion/ excretion ratios of various trace elements. It should also be recognized that the older references (Haywood and

Smith 1993; La Goy 1987; Haywood 1985) made measurements and assumptions that are still as valid now as when they were made, and high-contact activities such as wilderness sports, ranching, or certain rural settings have never been fully measured.

The derivation of the soil ingestion rate is based on the following points:

- The foraging-subsistence lifestyle and the farming-ranching lifestyle are lived in closer contact with the environment than a suburban or urban lifestyle from which most of the soil ingestion data are derived.
- The house is assumed to have little landscaping other than the natural conditions or xeriscaping, some naturally bare soil, a gravel driveway, no air conditioning (more open windows), and a wood burning stove in the winter for heat. Rural and farm roads are often unpaved.
- All persons participate in day-long outdoor group cultural activities at least once a month, such as pow-wows, horse races, and seasonal ceremonial as well as private family cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. These are considered to be 1-gram events or greater. Similar events for farming, ranching, and homesteading are assumed.
- 400 mg/d is the upper bound for suburban children (EPA, 1997); traditional or subsistence activities are not suburban in environs or activities
- This rate is within the range of outdoor activity rates for adults (between 330 and 480). However, the recommended level is lower than 480 to allow for some low-contact days.
- The low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999) such as root gathering days, tule-camas-wapato gathering days, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).
- This rate does not account for pica or geophagy.
- Primary data is supported by dermal adherence data in gatherers and ‘kids in mud’.
- This rate includes a consideration of residual soil on roots through observation and anecdote, but there is no quantitative data.

1. EPA Guidance (through 2009)

EPA has reviewed the studies relevant to suburban populations and has published summaries in its Exposure Factors Handbook (1989, 1991, 1997, and 2011). In the 1997 iteration of the

Exposure Factors Handbook[22], EPA reviewed the available scientific literature for children and identified seven key studies that were used to prepare recommended guidelines for evaluating the amount of soil exposure. The mean daily values in these studies ranged from 39 mg/day to 271 mg/day with an average of 146 mg/day for soil ingestion and 191 mg/day for soil and dust ingestion.

In 1997, EPA recommended 100 mg/d as a central tendency for children, 200 mg/day as a conservative estimate of the mean, and a value of 400 mg/day as an “upper bound” value (exact percentile not specified), and 10 mg/d for pica children. Most state and federal guidance uses 200 mg/d for children.   In 2011, EPA recommended an unspecified upper percentile soil ingestion rate for the general population of children of 200 mg/d for both soil-only and soil plus dust, 1000 mg/d for pica children, and 50,000 mg for geophagy. There are no recommendations for other populations of children. The “general population” refers primarily to the groups of children studied in suburban settings (home, daycare), including several Superfund sites. No studies of indigenous or rural children were used; either they have not been studied, or the ingestion rates were not mass-balance studies.

Other EPA guidance such as the Soil Screening Level Guidance[23] recommends using 200 mg/d for children and 100 mg/d for adults, based on RAGS HHEM, Part B (EPA, 1991) or an age-adjusted rate of 114 mg-y/kg-d. A value for an ingestion rate for adult outdoor activities is no longer given in the 1997 Exposure Factors Handbook for adults as “too speculative.” However, the soil screening guidance still recommends 330 mg/d for a construction or other outdoor worker, and risk assessments for construction workers oftenuse a rate of 480 mg/d (EPA, 1997; Hawley, 1985). Other soil ingestion rates are also used by risk assessors. For example, some states recommend the use of 1 gram per acute soil ingestion event[24] to approximate a non-average day for children, such as an outdoor day. This ingestion rate is now (2011) limited to pica children <6 years of age.

[22] Environmental Protection Agency. 1997. Exposure Factors Handbook. Volumes I, II, III. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/P-95/002Fa.

[23] EPA (1996) Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, July 1996 (http://www.epa.gov/superfund/resources/soil/toc.htm#p2), and EPA (2002) Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites. OSWER 9355.4-24 (http://www.epa.gov/superfund/resources/soil/ssg_main.pdf),

[24] MADEP (1992). Background Documentation For The Development Of An "Available Cyanide" Benchmark Concentration. http://www.mass.gov/dep/ors/files/cn_soil.htm

2. Military Guidance

The US military originally assumed 480 mg per exposure event[25] or per field day. For military risk assessment, the US Army used the Technical Guide 230 (TG) as the tool to assist deployed military personnel when assessing the potential health risks associated with chemical exposures.[26] No database is available to estimate incidental soil ingestion for adults in general or for military populations either during training at continental U.S. facilities or during deployment. Department Of Defense (2002)[27] recommendations for certain activities such as construction or landscaping which involve a greater soil contact rate was formerly a soil ingestion rate of 480 mg/day. This value sis based on the assumption that the ingested soil comes from a 50 µm layer of soil adhered to the insides of the thumb and the fingers of one hand. DOD assumed that the deployed military personnel would be exposed at both the high ingestion rate and a mean ingestion rate throughout the year. The two ingestion rates were averaged (half the days were spent at 480 and half at 50 mg/d) for a chronic average rate of 265 mg/d.

The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[28].

3. Studies in suburban or urban populations

Written knowledge that humans often ingest soil or clay dates back to the classical Greek era. Soil ingestion has been widely studied from a perspective of exposure to soil parasite eggs and other infections. More recently, soil ingestion was recognized to be a potentially significant pathway of exposure to contaminants, and risk assessments initially used a high inadvertent, based on studies of pica children (e.g., Kimbrough, 1984). This triggered a great deal of research with industry (e.g., the Calabrese series) or federal funding (e.g., the DOE-funded studies of fallout and bomb test contamination).

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[25] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

[26] USACPPM TG 230A (1999). Short-Term Chemical Exposure Guidelines for Deployed Military Personnel. U.S. Army Center for Health Promotion and Preventive Medicine.
Website: http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

[27] Reference Document (RD) 230, "Exposure Guidelines for Deployed Military" A Companion Document to USACHPPM Technical Guide (TG) 230, "Chemical Exposure Guidelines for Deployed Military Personnel", January 2002. Website: http://chppm-www.apgea.army.mil/desp/; and http://books.nap.edu/books/0309092213/html/83.html#pagetop.

[28] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. www.grid.unep.ch/btf/missions/september/dufinal.pdf

Some of the key studies are summarized here. Other agencies (including the EPA[29] and California OEHHA) have reviewed more studies and provide more detail. To quote form OEHHA:

> "There is a general consensus that hand-to-mouth activity results in incidental soil ingestion, and that children ingest more soil than adults. Soil ingestion rates vary depending on the age of the individual, frequency of hand-to-mouth contact, seasonal climate, amount and type of outdoor activity, the surface on which that activity occurs, and personal hygiene practices. Some children exhibit pica behavior which can result in intentional ingestion of relatively large amounts of soil."[30]

In general, two approaches to estimating soil ingestion rates have been taken. The first method of involves measuring the presence of (mostly) non-metabolized tracer elements in the feces of an individual and soil with which an individual is in contact, generally in controlled (largely indoor) situations. The other method involves measuring the dirt adhered to an individual's hand and observing hand-to-mouth activity. Results of these studies are associated with large uncertainty due to their somewhat qualitative nature, but some studies include specific activities relevant to outdoor lifestyles.

3.1 Studies in Children

Early studies in children focused on pica (see below) and unique food-related events. In particular, one study of soil ingestion from "sticky sweets" was estimated at 10 mg to 1 g/d (Day et al, 1975).

Hawley (1985) estimated that the amount ingested by young children during outdoor activity between May and October is 250 mg/d. For outdoor activities from May through October, Hawley estimated the ingestion amount as 480 mg per active day, assuming that 8 hours is spent outdoors per day, 2 d/week.

Other early tracer studies in American children (Binder, et al., 1986) resulted in large ranges of estimates of soil ingestion for several reasons. In the Binder study (as in all subsequent studies), the particular tracer element makes a large difference in soil ingestion estimates. Clausing et al. (1987) followed basically the same approach for Dutch children. Neither study included the trace minerals from food or medicine. A third study (Van Wijnen et al., 1990) used the same

[29] http://www.epa.gov/ncea/pdfs/efh/sect4.pdf.

[30] California Office of Environmental Health Hazard Assessment, Technical Support Document for Exposure Assessment and Stochastic Analysis, Section 4: Soil Ingestion. http://www.oehha.ca.gov/air/hot_spots/pdf/chap4.pdf

approach, and was the first to include a consideration of camping and the presence or absence of gardens.

Thompson and Burmaster (1991) reanalyzed the original data on children from Binder et al. (1986) to characterize the distribution of soil ingestion by children. In studies with large numbers of children, pica children may be present, but most studies did not try to diagnose pica. On the other hand, not all children with high ingestion rates are pica children, so caution must be exercised when identifying pica children merely on the basis of high soil ingestion. The reanalysis indicates a mean soil ingestion rate of 91 mg/d, and a 90th percentile of 143 mg/d.

Davis et al. (1990), in Calabrese's laboratory, included an evaluation of food, medicine, and house dust as a better approximation of a total mass balance. As with the earlier studies, using titanium as the tracer results in estimates of extremely large soil ingestion rates (titanium is a common additive in food and commercial products), while Al and Si tracers resulted in a much lower and narrower range of soil ingestion rates. Titanium, however, is problematic because of its variability in food, Al is difficult to control since it is the third most abundant soil mineral and present in many household products, and Si is widespread and an essential trace element for plants and animals (although apparently not for humans). This illustrates the difficulty of using mineral tracers to calculate mass balance and soil ingestion, but trace studies nevertheless provide the most quantitative estimates.

Calabrese et al. (1989) based estimates of soil ingestion rate in children in a home and university daycare setting on measurements of eight tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium). The study population consisted of 64 children between one and four years old in the Amherst, Massachusetts. They used a method similar to Binder et al. (1986) but included an improved mass balance approach. They evaluated soil ingestion over eight days rather than three days, and collected duplicate samples of food, medicine, and house dust. In addition, the children used tracer-free toothpaste and ointment. The adult (n = 6) validation portion of the study indicated that study methodology could adequately detect soil ingestion at rates expected by children. Recovery data from the adult study indicated that Al, Si, Y, and Zr had the best recoveries (closest to 100%). Zirconium as a tracer was highly variable and Ti was not reliable in the adult studies. The investigators conclude that Al, Si, and Y are the most reliable tracers for soil ingestion. This was also the first study to evaluate whether pica children were present in the sampled population; one diagnosed pica child was found.

Stanek and Calabrese (1995a) adjusted their 1989 data for the 64 children. The primary adjustment was related to intestinal transit time, which allowed an adjustment for clearance of minerals on days when fecal samples were not collected. They concluded that daily intake based on the "overall" multi-tracer estimates is 45 mg/day or less for 50 percent of the children and 208 mg/day or less for 95 percent of the children. When extended to an annual estimate, the range of average daily soil ingestion in the 64 children was 1 – 2268 mg/d; the median (lognormal) was 75 mg/d, the 90th % was 1190 mg/d, and the 95th% was 1751 mg/d. The known pica child was not included, and individual "outlier" results for individual tracers were also omitted. Even so, the range of rates is so large that it is evident that there are still methodological difficulties.

Stanek and Calabrese (1995a) also evaluated the number of days a child might have excessive soil ingestion events. An estimated 16% of children are predicted to ingest more than 1 gram of soil per day on 35-40 days of the year. In addition, 1.6% would be expected to ingest more than 10 grams per day for 35-40 days per year.

Stanek and Calabrese (1995b) published a separate reanalysis combining the data from their 1989 study with data from Davis et al. (1990) and using a different methodology. This methodology, the Best Tracer Method (BTM), is designed to overcome inter-tracer inconsistencies in the estimation of soil ingestion rates. The two data sets were combined, with estimates as follows: 50th = 37 mg/d, 90th = 156mg/d, 95th = 217mg/d, 99th = 535mg/d, mean = 104mg/d. Even with this method, they conclude that the large standard deviation indicates that there are still large problems with "input-output misalignment." They also says that soil ingestion cannot even be detected, in comparison to food, unless more than 200 mg/d is ingested, rather than lower rates as they indicated in 1989.

Stanek et al. (2000) conducted a second study of 64 children aged 1-4 at a Superfund site in Montana, using the same methods as they did in their earlier study, with 3 additional tracers. Soil, food and fecal samples were collected for a total mass balance estimate. The home or daycare settings were not described, nor were the community conditions or the typical daily activities of the children, and 32% of the soil ingestion estimates were excluded as outliers. In addition, only soil with a grain size of 250 um or less was used; no explanation of concentration differences between large and small grain sizes were given (see discussion on dermal adherence) and no concentration data were included.

3.2 Studies in Adults

Only a few soil ingestion studies in adults have been done because the attention has been focused on children, who are known to ingest more soil and are more vulnerable to toxicity of contaminants. Stanek, Calabrese and co-authors (1997) conducted a second adult pilot study (n = 10) to compare tracers. This study was done as a method validation, and was "not designed to estimate the amount of soil normally ingested by adults." Each adult was followed for 4 weeks.

The median, 75th percentile, and 95th percentile soil ingestion estimates were 1, 49, and 331 mg/day, with estimates calculated as the median of the three trace elements Al, Si, and Y.

4. Studies in Indigenous Populations

Studies of soil ingestion in indigenous populations have largely centered on estimates of past exposure (or dose reconstruction) of populations affected by atomic bomb tests such as the Marshall Islands (tropical island) and Maralinga (Australian desert) evaluations.

Haywood and Smith (1992) evaluated potential doses to aboriginal inhabitants of the Maralinga and Emu areas of South Australia, where nuclear weapons tests in the 1950s and 1960s resulted in widespread residual radioactive contamination. Annual doses to individuals following an aboriginal lifestyle could result in an annual effective dose equivalent of several mSv within contours enclosing areas of several hundred square kilometers. The most significant dose pathways are inhalation of resuspended dust and ingestion of soil by infants based on measurements of dust in air, activity diaries, and modeling. Haywood and Smith constructed a table showing hours per week sleeping, sitting, hunting or driving, cooking or butchering, and other activities. The authors state that in this climate

"*virtually all food, whether of local origin or purchased, has some dust content by the time of consumption due to methods of preparation and the nature of the environment. A total soil intake in the region of 1 gpd was estimated based on fecal samples of nonaboriginals during field trips. This must be regarded as a low estimate of soil ingestion by aboriginals under camp conditions. In the absence of better information, a soil intake of 10 gpd has been assumed in the assessment for all age groups."*

They noted a "very high occurrence of cuts and scratches with a high percentage being classified as dirty...puncture wounds on the feet were frequent. "

The Marshall Island indigenous peoples have also been studied. In a study of the gastrointestinal absorption of plutonium, Sun and Meinhold (1997) assumed a soil ingestion rate of 500 mg/d. This was based on the primary work of Haywood and Smith who "reported an average soil intake of 10,000 mg/d in dose assessments for the Emu and Maralinga nuclear weapons testing sites in Australia." The authors state that:

"*Haywood and Smith specifically discussed the effects of lifestyle on plutonium ingestion for the Australian aboriginal people: an average soil intake of 1,000 mg/d was established from the fecal samples of the investigators who made field trips to the affected areas*."

"*It is difficult to quantitatively compare the amount of soil ingested by the Marshall Islanders and the Aboriginal people because of their different lifestyles. However, both societies live in close contact with their natural environment, although the Australian aboriginal people are nomadic, while the Marshallese have a lifestyle nearly like to that of industrial nations. LaGoy (1987) reported a maximum intake of 500 mg/d for adults in developed nations who do not exhibit habitual pica. This value, then, was taken to be a reasonably conservative average for the Marshallese people. Therefore, this work adopts 500 mg/d as the average life-time intake of soil by the Marshallese*."

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Certain lifestyles, occupations, and living conditions will likely put different individuals or different groups at risk to inadvertent soil ingestion. Because of their high dependence on the land, indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Most of the studies that Simon reviewed were related to geophagia (intentional soil ingestion; see below), which is relatively common worldwide. Simon recommends using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommends using 3 g/d for all indigenous children. Geophagia is assumed not to occur; if geophagia is common, Simon recommends using 5 g/d. These are all geometric means (lognormal) or modes (triangular distribution), not maxima.

These estimates are supported by studies of human coprolites from archaeological sites. For instance, Nelson (1999) noted that human coprolites from a desert spring-fed aquatic system included obsidian chips (possibly from sharpening points with the teeth), grit (pumice and quartzite grains from grinding seeds and roots), and sand (from mussel and roots consumption). Her conclusions are based on finding grit in the same coprolites as seeds, and sand in the same coprolites as mussels and roots. She concludes that "*the presence of sand in coprolites containing aquatic root fibers suggests that the roots were not well-cleaned prior to consumption. Charcoal was present in every coprolite examined*."

5. Geophagia

Despite the limited awareness of geophagia in western countries, the deliberate consumption of dirt, usually clay, has been recorded in every region of the world both as idiosyncratic behavior of isolated individuals and as culturally prescribed behavior (Abrahams, 1997; Callahan, 2003; Johns and Duquette, 1991; Reid, 1992). It also routinely occurs in primates (Krishnamani and Mahaney (2000). Indigenous peoples have routinely used montmorillonite clays in food preparation to remove toxins (e.g., in acorn breads) and as condiments or spices (in the

Philippines, New Guinea, Costa Rica, Guatemala, the Amazon and Orinoco basins of South America). Clays are also often used in medications (e.g., kaolin clay in Kaopectate). But the most common occasion for eating dirt in many societies, especially kaolin and montmorillonite clays in amounts of 30g to 50g a day, is pregnancy. In some cultures, well-established trade routes and clay traders make rural clays available for geophagy even in urban settings. Clays from termite mounds are especially popular among traded clays, perhaps because they are rich in calcium (Callahan, 2003; Johns and Duquette, 1991).

There are two types of edible clays, sodium and calcium montmorillonite[31]. Sodium montmorillonite is commonly known as bentonite; the name is derived from the location of the first commercial deposit mined at Fort Benton, Wyoming USA. Bentonite principally consists of sodium montmorillonite in combination with 10 to 20% of various mineral impurities such as feldspars, calcite, silica, gypsum, and others. Calcium montmorillonite, the second type of montmorillonite, is also known as "living clay" for it principally consists of nutritionally essential minerals.

Geophagia has long been viewed as pathological by the western medical profession. However, this practice is so widespread and physiologically significant that is presumed to be important in the evolution of human dietary behavior due to its antidiarrheal, detoxification, and mineral supplementation potentials (Reid, 1992; Krishnamani and Mahaney, 2000).

Krishnamani and Mahaney (2000) propose several hypotheses that may contribute to the prevalence of geophagy:

(1) soils adsorb toxins.

(2) soil ingestion has an antacid action.

(3) soils act as an antidiarrheal agent.

(4) soils counteract the effects of endoparasites.

(5) geophagy may satiate olfactory senses.

(6) soils supplement nutrient-poor diets. Some clays release calcium, copper, iron, magnesium, manganese, or zinc in amounts of nutritional significance (Johns and Duquette, 1991). This is especially important in pregnancy and at high altitudes.

[31] http://www.the-vu.com/edible_clay.htm

Several studies of geophagia in pregnancy have been done. In countries such as Uganda where modern pharmaceuticals are either unobtainable or prohibitively expensive, ingested soils may be very important as a mineral supplement, particularly iron and calcium during pregnancy (Abrahams, 1997). One widely held theory suggests that iron deficiency is a major cause of geophagia[32]. Several reports have described an extreme form of geophagy (pica) in individuals with documented iron deficiency, although there has been uncertainty as to whether the iron deficiency was a cause of pica or a result of it. Because some substances, such as clay, are believed to block the absorption of iron into the bloodstream, it was thought that low blood levels of iron could be the direct result of pica. Some studies have shown that pica cravings in individuals with iron deficiency stop once iron supplements are given to correct the deficiency, suggesting that iron deficiency induces pica (and other) cravings during pregnancy. In addition, low blood levels of iron commonly occur in pregnant women and those with poor nutrition, two populations at higher risk for pica.

Edwards et al. (1994) studied 553 African American women who were admitted to prenatal clinics in Washington, D.C.. Serum ferritin concentrations of pica women were significantly lower during the second and third trimesters of pregnancy; the average values for three trimesters of pregnancy for both ferritin and mean corpuscular hemoglobin were significantly lower in pica women than their nonpica counterparts. Although not significantly different, the iron (66 vs. 84% RDA) and calcium (60 vs. 75% RDA) contents of the diets of pica women were less those of nonpica women. Again, low ferritin and hemoglobin are hypothesized to result in pica.

A further hypothesis is presented by Callahan (2003). Regular consumption of soil might boost the mother’s secretory immune system. Monkeys that regularly eat dirt have lower parasite loads. In some cultures, clays are baked before they are eaten, which could boost immunity from previous exposures. For decades aluminum salts, like those found in clays, have been used as adjuvants in human and animal vaccines. Adjuvants are compounds that nonspecifically amplify immune response. Aluminum compounds make effective adjuvants because they are relatively nontoxic; the charged surfaces of aluminum salts absorb large numbers of organic molecules. Note that Al is one of Calabrese’s preferred tracers due to the assumption that it is not adsorbed and inert at trace levels (it is quite toxic at high levels).

6. Acute Soil Ingestion and Pica

There is a gradient between geophagy and pica, and there is not a clear distinction between the conditions. Pica is an obsessive-compulsive eating disorder typically defined as the persistent eating of nonnutritive substances for a period of at least 1 month at an age in which this behavior is developmentally inappropriate. The definition also includes the mouthing of nonnutritive

[32] http://www.ehendrick.org/healthy/001609.htm

substances. Individuals presenting with pica have been reported to mouth and/or ingest a wide variety of nonfood substances, including, but not limited to, clay, dirt, sand, stones, pebbles, hair, feces, lead, laundry starch, vinyl gloves, plastic, pencil erasers, ice, fingernails, paper, paint chips, coal, chalk, wood, plaster, light bulbs, needles, string, and burnt matches.

Pica is generally thought of as a pediatric condition, but pica diagnoses include psychiatric conditions like schizophrenia, developmental disorders including autism, and conditions with mental retardation. These conditions are not characterized by iron deficiency, which supports a psychological component in the cause of pica.

Pica is seen more in young children than adults, with 10-32% of children aged 1 to 6 may exhibit pica behavior at some point[33]. LaGoy (1987) estimated that a value of 5 gpd is a reasonable maximum single-day exposure for a child with habitual pica. In June 2000, the U.S. Agency for Toxic Substances and Disease Registry appointed a committee to review soil pica. The committee settled on a threshold of pathological levels as consumption of more than 5000 mg of soil per day but cautioned that the amount selected was arbitrary[34]. With this criterion, studies in the literature estimate that between 10 and 50% of children may exhibit pica behavior at some point. While this threshold may be appropriate in relatively clean suburban settings, it may not be appropriate for defining the pica threshold in rural settings where average soil ingestion is likely to be higher.

The occurrence of pica has been discussed with respect to risk assessment, especially for acute exposures. Calabrese et al. (1997) recognized that some children have been observed to ingest up to 25-60 g soil during a single day. When a set of 13 chemicals   were evaluated for acute exposures with a pica exposure rate, four of these chemicals would have caused a dose approximating or exceeding the acute human lethal dose.

Regulatory guidance recommends 5 or 10g/d for pica children. Some examples are:

(1) EPA (1997) recommends a value of 10g/d for a pica child.

(2) Florida recommends 10g per event for acute toxicity evaluation[35].

(3) ATSDR uses 5 g/day for a pica child[36].

[33] http://www.nlm.nih.gov/medlineplus/ency/article/001538.htm#Causes,%20incidence,%20and%20risk%20factors

[34] Summary report for the ATSDR Soil-Pica Workshop, Atlanta, Georgia, 2000. Available from: URL: http://www.atsdr.cdc.gov/NEWS/soilpica.html

[35] Proposed Modifications To Identified Acute Toxicity-Based Soil Cleanup Target Level, December 1999, www.dep.state.fl.us/waste/quick_topics/ publications/wc/csf/focus/csf.pdf .

[36] For Example: El Paso Metals Survey, Appendix B,   www.atsdr.cdc.gov/HAC/PHA/**elpaso**/epc_toc.html.

(4) EPA (2011) now uses a cutoff of 1000 mg/d as the definition of pica. Note that this skews ingestion rates lower because any child ingesting over 1000 mg/d is assumed to be pica, and therefore can be removed from the 'normal' population.

7. Data from dermal adherence

Dermal adherence of soil is generally studied in relation to dermal absorption of contaminants, but soil on the hands and face can be ingested, as well. Although this body of literature is not typically used to estimate a quantitative contribution to soil ingestion, it can give relative estimates of soil contact rates between activities.

Two relevant papers from Kissel's laboratory are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm^2 for 6 children and an average of 58 mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66 mg/cm^2 and an upper bound for reed gatherers of >1 mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings, up to 27 mg/cm^2. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm^2), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm^2). Since reed gatherers, farmers, and gardeners had higher skin loadings, this is supporting evidence that these activities also have higher than average soil ingestion rates.

One factor that has not received enough attention is the grain size of adhering and ingested soil. Stanek and Calabrese (2000) said that variability in estimating soil ingestion rates using tracer elements was reduced when a grain size less than 250 um were excluded in order to reduce variability. Driver et al. (1989) found statistically significant increases in skin adherence with decreasing particle size, with particles above the sand-silt size division (0.075 mm) adhering less than smaller sizes. Average adherences of 1.40 mg/cm^2 for particle sizes less than 150 µm, 0.95 mg/cm^2 for particle sizes less than 250 µm and 0.58 mg/cm^2 for unsieved soils were measured (see EPA, 1992[37] for more details). Soil samples should be sieved and concentrations should be evaluated for sizes below 0.075 mm.

A consideration of grain size could affect the estimation of soil ingestion rates because the mineral and organic composition within a particular soil sample can vary with particle size and

[37] EPA (1992). Interim Report: Dermal Exposure Assessment: Principles And Applications. Office of Health and Environmental Assessment, Exposure Assessment Group. /600/8-91/011B

pore size. If soil adherence studies are conducted in a manner wherein sand is brushed off the hands while smaller grain sizes remain adhered, then tracer ratios could be altered, and would be different from the original unsieved soil. Soil loading on various parts of the body is collected with wipes, tape, or rinsing in dilute solvents, which would generally collect the smaller particle sizes[38]. Soil adherence rate is correlated to grain size; soil samples must be sieved, and data for particle size <0.044 cm (RAGSe, App. C, Table C-4) should be used for dose estimation. Inhalation is also related to particle size, so the dust resuspension estimate must also include particle size.

8. Data from washed or unwashed vegetables.

Direct soil ingestion also occurs via food, for example from dust blowing onto food (Hinton, 1992), residual soil on garden produce or gathered native plants, particles on cooking utensils, and so on. However, there is very little quantitative data about soil on vegetation as-gathered, as-prepared, or as-eaten, which is a separate issue from root uptake of soil contaminants into edible materials. However, there is information on interception rate of dust particles deposited onto leafy surfaces, and information on soil ingestion by pasture animals. For example, Beresford and Howard (1991) found that soil adhesion to vegetation was highly seasonal, being highest in autumn and winter, and is important source of radionuclides to grazing animals. Palacios et al. (2002) evaluated lead levels in the aerial part of herbage near a Superfund site. A water washing pre-treatment of the vegetal samples considerably diminished the concentration of lead.

Kissel et al. (2003) evaluated concentrations of arsenic and lead in rinsed, washed, or peeled garden vegetables. He found that concentrations of lead and arsenic in washed or peeled potatoes or lettuce were generally lower, as expected, although the concentration of lead in peeled potatoes was higher than in rinsed or washed potatoes.

9. Homesteader and Traditional Practitioner rationale for soil ingestion rate

[38] Soils are classified according to grain size (1mm = Very coarse sand; 0.5mm = Coarse sand; 0.25mm = Medium sand; 0.10mm = Fine sand; 0.05mm = Very fine sand; 0.002mm = Silt; <0.002mm = Clay). The Wentworth scale classifies particle sizes as ranges: sand = 1/16 to 2 mm; silt = 1/256 to 1/16 mm; clay = <1/256 mm.

In brief, the homesteader is a residential farming and ranching scenario with a kitchen garden, row crops, and hay production. The homesteader may leave the homestead for short hunting excursions, but the exposure frequency is left at 365 days per year as an upper bound. The traditional practitioner lives in the community but spends his snow-free days at developed or undeveloped camps hunting, fishing, and gathering.

The soil ingestion rate of 330 mg/d is based on the following points:

It conforms to EPA recommendations for higher soil contact situations.
Low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999).
This rate is lower than Simon estimate of 500 mg/d and lower than the recommendations of 3 g/d for indigenous children and 2 g/d for indigenous adults in arid environments. It is also lower than the 5 or 10 grams he estimated for purely aboriginal lifestyles.
This rate includes a consideration of the number of windy-dusty days, but without further quantification of air particulates.

10. Soil and Dust Ingestion Update (2017)

The emphasis of soil ingestion studies is on children, and rightly so. It is generally (but not always) true that setting cleanup levels based on children's exposures will also protect adults. But much less has been published for adults, so risk assessors may at times fail to recognize situations where adults have high exposures, and, lacking data, overlook or underestimate those exposures. A brief update of adult rates for use in risk assessment is given below.

The questions that the risk assessor must answer are: (1) Are there people who may have higher exposures and/or who are more sensitive, and (2) Is there data to describe a Central Tendency Exposure (CTE) and RME for these scenarios? For the Tribal Homesteader (residential farming and ranching) scenario and the Traditional Practitioner (non-residential hunting, fishing, gathering), which are quite different from the suburban lifestyles used to develop default values, the questions can be restated as, (1) Are the generic default exposure parameters reflective of a mean and 90th or 95th percentile for each of the two scenarios, and (2) Is professional judgment needed to justify a more appropriate set of exposure parameters?

EPA CERCLA baseline risk assessments are required to use exposure scenarios that are selected to reflect both "average" or Central Tendency Exposure (CTE) and Reasonable Maximum

Exposure (RME).[39] The document "Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final" originally dated EPA/540/1-89/002 December 1989 and re-posted in 2015[40] directs project managers to:

Review information on the site area to determine if any subpopulations may be at increased risk from chemical exposures due to increased sensitivity, behavior patterns that may result in high exposure, and/or current or past exposures from other sources. Those potentially at higher risk due to behavior patterns include children, who are more likely to contact soil, and persons who may eat large amounts of locally caught fish or locally grown produce (e.g., home-grown vegetables).

Recommendations are based on EPA's determination of what would result in an estimate of the RME. As discussed previously, a determination of "reasonable" cannot be based solely on quantitative information, but also requires the use of professional judgment. Accordingly, the recommendations below are based on a combination of quantitative information and professional judgment.

Contact rate reflects the amount of contaminated medium contacted per unit time or event. If statistical data are available for a contact rate, use the 95th percentile value for this variable. (In this case and throughout this chapter, the 90th percentile value can be used if the 95th percentile value is not available.) If statistical data are not available, professional judgment should be used to estimate a value which approximates the 95th percentile value. (It is recognized that such estimates will not be precise. They should, however, reflect a reasonable estimate of an upper-bound value.)

It is not clear what the current default soil ingestion rate should be, since EPA documents are constantly being updated and old documents are re-posted (presumably after review to ensure that they represent the latest policy), and are not always consistent with each other. For the purposes of CERCLA risk assessment, OSWER Directive 9200.1-120 February 6, 2014 ("Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors") uses a soil ingestion rate 100 mg/d for adults. Soil screening levels (OSWER 9355.4-24, 2002) are based on 100 mg/d for residential adults and 330 mg/d for short-term non-residential construction work, with the admonition that a full risk assessment should be more comprehensive.

[39] "Because of the uncertainty associated with any estimate of exposure concentration, the upper confidence limit (i.e., the 95 percent upper confidence limit) on the arithmetic average will be used for this variable. USEPA RAGS-A; https://www.epa.gov/sites/production/files/2015-09/documents/rags_a.pdf, page 6-19.
[40] https://www.epa.gov/sites/production/files/2015-09/documents/rags_a.pdf

USEPA's 2011 revision of the Exposure Factors Handbook ("EFH 2011") presents default values for national soil ingestion rates. Based primarily on reanalysis of older data plus three studies published after 1997, the current default soil ingestion rate for all adults, whether indoor resident or outdoor worker, appears to be 100 mg/d, with 50 mg/d for the indoor worker (USEPA 2015 (Human Health Evaluation Manual); EPA 1989 (RAGS A)), although EFH 2011 gives the central tendency of soil plus dust ingestion for adults as 50 mg/d based on the Davis and Mirick 2006 study. No upper percentile is given, leaving that to the risk assessors for a particular site. Thus, the questions are (1) is 100 mg/d or another number intended to be a number a 90th or 95th percentile, (2) why are the soil and soil + dust upper percentiles the same for children aged 3 to <6 years of age, and (3) are they even relevant to either tribal scenario if the tribal scenario is not a 'general population' lifestyle?

Table 5-1. Recommended Values for Daily Soil, Dust, and Soil + Dust Ingestion (mg/day)

	Soil[a]				Dust[b]		Soil + Dust	
Age Group	General Population Central Tendency[c]	General Population Upper Percentile[d]	High End Soil-Pica[e]	Geophagy[f]	General Population Central Tendency[g]	General Population Upper Percentile[h]	General Population Central Tendency[c]	General Population Upper Percentile[h]
6 weeks to <1 year	30				30		60	
1 to <6 years	50		1,000	50,000	60		100[i]	
3 to <6 years		200				100		200
6 to <21 years	50		1,000	50,000	60		100[i]	
Adult	20[j]			50,000	30[j]		50	

[a] Includes soil and outdoor settled dust.
[b] Includes indoor settled dust only.
[c] Davis and Mirick (2006); Hogan et al. (1998); Davis et al. (1990); van Wijnen et al. (1990); Calabrese and Stanek (1995).
[d] Özkaynak et al. (2011); Stanek and Calabrese (1995b); rounded to one significant figure.
[e] ATSDR (2001); Stanek et al. (1998); Calabrese et al. (1997b; 1997a; 1991; 1989); Calabrese and Stanek (1993); Barnes (1990); Wong (1988); Vermeer and Frate (1979).
[f] Vermeer and Frate (1979).
[g] Hogan et al. (1998).
[h] Özkaynak et al. (2011); rounded to one significant figure.
[i] Total soil and dust ingestion rate is 110 mg/day; rounded to one significant figure it is 100 mg/day.
[j] Estimates of soil and dust were derived from the soil + dust and assuming 45% soil and 55% dust.

USEPA (EFH 2011, chapter 5) discusses soil ingestion rates and uses one study (Davis and Mirick, 2006), supported by other studies (Hogan, Ozkaynak), to support the adult soil ingestion rate. The Davis and Mirick study used a mass balance method that measured quantities of specific elements present in feces, urine, food and medications. Thirty-three adults from a suburban area in southeast Washington during summer and fall months in 1988. This is a hot arid area, sometimes dusty, with summer temperatures sometimes exceeding 100 degrees. No garden vegetables were consumed. For the aluminum and silicon tracers, soil ingestion rates ranged from 23−92 mg/day (mean), 0−23 mg/day (median), and 138−814 mg/day (maximum), with an overall mean value of 52 mg/day for the adults in the study. The large range of maximum values suggests that there are some people even in suburban settings with significantly higher soil contact and ingestion.

The most commonly used soil ingestion values for occupational and outdoor exposures are 330 mg/d and 480 mg/d while the worker is engaged in those activities. Single high-contact events are not included.

Soil Ingestion Rate for Construction Worker - 480 mg/day (USEPA 1996, 2002)
Soil Ingestion Rate for Industrial Worker - 136 mg/day (USACE 1998)
Sediment Ingestion Rate for Sewer Maintenance Worker - 330 mg/day (USACE 1996, 2002)
Soil Ingestion Rate for Utility Worker - 480 mg/day (USEPA 1996, 2002)

EPA (2002) in the Soil Screening Levels Directive 9355.4-24, gives a soil ingestion rate for construction workers as 330 mg/d, and says that the soil ingestion rate was revised from the previous default ingestion rate of 480 mg/d, albeit without any new data. The activities for this receptor typically involve substantial on-site exposures to surface and subsurface soils. The construction worker is assumed to be exposed to contaminants via incidental soil ingestion, dermal absorption, inhalation of volatiles outdoors, and inhalation of fugitive dust. The default value of 330 mg/day (Stanek et al., 1997) replaces the previous default 95th percentile ingestion rate of 480 mg/day (Hawley, 1985). While the Hawley value was based on a theoretical calculation for adults engaged in outdoor physical activity, the revised default ingestion rate is based on the 95th percentile value for adult soil intake rates reported in a soil ingestion mass-balance study that was not in dusty or outdoor settings other than a suburban backyard.

Hawley (1985) used a set of assumptions to estimate total dust exposure (ingestion, inhalation, and dermal) while entering dusty attics (12 hrs/yr) and outdoor work (80 hrs/yr) based on skin adherence and surface area, the ratio of indoor to outdoor dust, and similar factors. These remain reasonable assumptions. Other investigators have studied dermal loading of soil residues in various activities such as children playing in the mud and adults playing rugby, gathering reed, or digging clams (Kissel et al., 1996; Shoaf et al., 2005). The Stanek et al, (1997) study administered measured soil aliquots in gelatin capsules to 10 volunteers and collected food and feces over 7-day intervals spread over several months, for a total of 280 collection days. No information is provided about the activities of the participants while they were collecting all of their fecal output.

The military follows EPA guidance on exposure factors if they are relevant to military situations (US Army, 2010). The National Research Council (2004) reviewed the Army's exposure parameters. In RD-230 (2003) an average soil ingestion was derived by assuming that soldiers have an equal number of high-contact days (at 480 mg/d) and low-contact days (50 mg/d), for an average of 265 mg/d. In RD-230 (2003), the US Army gives the rationale that the EPA recommendation for construction or landscaping was 480 mg/d at that time, and that soldiers' field activities may include digging or crawling on the ground. Following EPA's recommendation of using the high-contact rate for limited exposure frequencies, the Army averaged the two rates. Subsequently, the Army lowered the high-contact rate to 330 mg/d (US Army 2010).

Two recent papers have appeared that evaluate native peoples engaged in some traditional activities using a mass-balance approach consisting of measuring trace elements that are not well-absorbed in the intestinal tract in food and feces, and assuming certain intestinal absorption, and that any increase over expected values comes from other sources such as soil ingestion or possibly other consumer products.

The first study was a pilot study of 7 subjects living in British Columbia was conducted over a 3-week period (Doyle et al., 2012). During most of this time the subjects were conducting fisheries-related activities. Daily activities included clearing deadfall from spawning streams, collecting Sockeye salmon using traditional methods, such as “dip nets” or seine nets along the shore, weighing, bleeding and cleaning each fish, and storing the catch in a mixture of brine and ice. The late afternoon and evening involved scouting of new dip net locations by hiking up the shore of the river or fishing for Sockeye and Chinook salmon with rod and reel, in addition to routine camp activities (e.g., eating and clean-up, collecting and cutting firewood, etc.). All foods (breakfast, lunch, dinner and snacks) were provided. The study did not include ingestion related to “high contact” activities and/or ingestion of soil in traditional foods, and the authors state that soil ingestion studies for potentially higher soil contact activities (e.g., root digging, attending and/or participating in rodeos, plowing, etc.) are warranted. The mean soil ingestion rate estimated in this study using the 4 elemental tracers with the lowest food-to-soil ratios (i.e., Al, Ce, La, Si), was observed to be approximately 75 mg/d, the median soil ingestion rate was 50 mg/d, and the 90th percentile was 211 mg/d. The second paper (Irvine et al., 2014) recalculated the 90th percentile of the first study to 193 mg/d, all with very large standard deviations and vastly different rates for different tracers. It is a point of discussion whether this is an actual “wilderness” setting, as opposed to a rural setting with fisheries activities, and also whether so much water contact resulted in lack of adherence of soil to skin.

The second study was by the same investigators and evaluated 9 subjects over a 13 day period in Cold Lake, Alberta (Irvine et al., 2014). The purpose was to determine if soil ingestion in a community with a ‘wilderness’ lifestyle is greater than soil ingestion values used in Canadian human health risk assessments. The area has a humid continental climate, with a lower than average rainfall compared to other Canadian cities, and contains many unpaved roads that can contribute to airborne dust particles. An outdoor base camp was established and all participants remained at the base camp for the duration of the study, and engaged in a variety of outdoor wilderness activities during the day (e.g., fishing, hunting, food gathering). All food was provided and prepared for study participants, and the exact amount of food consumed by each participant was pre-weighed. Activities included hunting and setting traps and snares on the reserve, fishing and setting fishing nets, collection of medicinal plants on the reserve and surrounding traditional lands, and collection of foods and spices such as blueberries, bear berries, and mint. Although this study did not detect a statistically significant effect of activities on soil ingestion rate, the authors recommended follow-up studies that include higher soil contact activities (i.e., rodeo participation, root harvesting) and other seasons. This study found a mean (Al, Ce, La, Si) of 32 mg/d and a 90th percentile of 152 mg/d.

At the request of USEPA[41], the authors combined the results of the two studies for the two most commonly used tracers as follows (units in mg/d):

Tracer	*Mean*	*50th*	*90th*	*95th*
Al	37	19	155	213
Si	59	39	213	264
Average of Al and Si	48	29	184	239

The results from the Irvine report are reproduced below. The means are similar but not identical when calculated first by combining all data for each element (Table 5) or calculated per person first (Table 6). This may be a statistical artifact of the sequence of data combination. The trace elements Al and Si are generally used as the most suitable tracers according to generally accepted criteria of being poorly absorbed, having a low food/soil ratio, and being within accurate instrument measurement ranges. Even so, the variances are large considering that all the food was pre-weighed and analyzed, suggesting that either different participants had different behaviors, the sources were not homogeneous, or there were inconsistencies in fecal collection.

Table 5
Summary of soil ingestion rates calculated for each of the 12 elemental tracers examined. Soil ingestion rate is expressed as mg d^{-1}.

	Al	Ba	Ce	La	Mn	Si	Th	Ti	V	U	Y	Zr
Mean	36	318	12	12	1998	68	−378	3215	−183	196	−7	19
Standard deviation	117	1662	72	78	10,107	152	461	5622	238	626	145	407
Standard error	12	176	8	8	1071	16	49	597	25	66	15	43
Median	7	467	−4	−2	1034	37	−390	759	−185	143	−17	−30
90th percentile	165	1744	111	97	11,555	231	109	9325	111	1032	159	211
95th percentile	268	2405	132	156	18,226	361	217	16,459	169	1226	230	301
Upper 95% CI[a]	65	650	29	32	4075	104	−283	4662	−129	328	27	196
Lower 95% CI[a]	15	−26	−1	−1	−164	40	−479	2242	−230	69	−34	−34
n	87	87	87	87	87	87	87	87	87	87	87	87

[a] Upper and lower 95% confidence intervals are bootstrapped confidence intervals with 5000 bootstrapped replicates.

[41] M. Stifelman, Region 10 Office of Environmental Assessment and Review, March 9, 2017

Table 6
Soil ingestion rate values calculated for each participant. Mean, standard deviation (SD), median, and sample size are given for each participant over the study duration. Soil ingestion rate is expressed as mg d^{-1}.

Subject	Al	Ba	Ce	La	Mn	Si	Th	Ti	V	U	Y	Zr
A	18	384	19	16	2346	119	−244	5314	−197	117	16	64
B	−47	−1005	−41	−42	−2820	−19	−790	163	−400	−295	−157	−38
C	152	485	82	92	6665	267	−725	13,574	−352	260	78	616
D	32	37	−2	−1	−1697	3	−195	839	−185	−103	−60	−57
E	55	8	−8	0	−875	61	−544	1861	−179	290	27	−109
F	32	394	34	25	10,137	58	−406	2343	−252	166	25	−13
H	60	631	13	11	4714	72	−111	5055	−30	582	−15	−30
I	−11	620	−9	−7	1408	87	−349	443	45	54	−34	−38
J	6	1759	10	13	−7612	25	−307	719	−86	601	1	−12
Mean	33	368	11	12	1363	75	−408	3368	−182	186	−13	43
SD	55	725	34	36	5359	84	234	4277	144	292	67	220
Median	32	394	10	11	1408	61	−349	1861	−185	166	1	−30
n	9	9	9	9	9	9	9	9	9	9	9	9

One explanation for the vastly different input-output differences for some elements, such as titanium, has been that some elements are present in relatively high quantities in consumer products, since the content in foods were all accounted for. However, titanium (always high in excreta measurements) is a common food additive and is poorly absorbed in nanoparticle form (Cho et al., 2013), so it is possible that elements other than Al and Si may reflect unrecognized ingestion sources that might or might not be related to soil ingestion. For example, aluminum is poorly absorbed following either oral or inhalation exposure and is essentially not absorbed dermally. Approximately 1.5–2% of inhaled and 0.01–5% of ingested aluminum is absorbed. The absorption efficiency is dependent on chemical form, particle size (inhalation), and concurrent dietary exposure to chelators such as citric acid or lactic acid (oral), and is primarily excreted in the urine, with a lesser amount in the bile, but it binds to various ligands in the blood and distributes to every organ, with highest concentrations ultimately found in bone and lung tissues.[42] The general assumption that 100% of poorly-absorbed trace elements occurs within 24 hours may need to be revisited. Ultimately, titanium must be explained, along with inter-individual differences and the negative results for some subjects (assumed to be due to missed sample collection).

11. Grain or Particle Size

It has been known for decades that greater concentration of contaminants measured in smaller particles is due to increased surface area. For example, Parizanganeh (2008) found that the majority of trace elements were present in the 63 μm fraction. Zhao et al. (2003) found that particles with smaller grain size (<250μm) contributed more than 80% of the total metal loads in road runoff, while suspended solids with a grain size <44μm in runoff water accounted for greater than 70% of the metal mass in the total suspended solids. Sutherland (2003) found that sediment <63μm accounted for 51% of the total Pb load in road sediments. Wang et al. (2006) found that higher concentrations of anthropogenic heavy metals (Cu, Zn, Mo, As, Hg, Bi, Ag)

[42] https://www.atsdr.cdc.gov/toxguides/toxguide-22.pdf

are observed in the finest particle grain size fraction (i.e. < 45µm) of road dust. Some heavy metals (Se, Sb and Ba) behave independently of selected grain size fractions, but more than 30% of the concentrations for all anthropogenic heavy metals are contributed by the particle grain size fractions of 45–74µm and more than 70% of the concentrations for all heavy metals are contributed by the particle grain size fractions of 45–74 and 74–125µm.

The concern about health risks centers on adherence of small particles to the skin, where it is available for hand-to-mouth ingestion. Smaller grain sizes that comprise respirable fractions of dust whence they deposit in different areas of the respiratory system, including clearance by the mucociliary system and then swallowed. Air quality regulations focus on aerosols, PM10 (<10µm), PM 2.5, and recently on nanoparticles. Natusch et al. (1974) investigated the distribution of trace elements among fly ash grain sizes. Particles less than about 1 µm deposit predominantly in the alveolar regions of the lung where the absorption efficiency for most trace elements is 50 to 80 percent. Larger particles, on the other hand, deposit in the nasal, pharyngeal, and bronchial regions of the respiratory system and are removed by cilial action to the stomach. Natusch found that the size distribution of certain trace elements in ambient air can be influenced, at least in part, by their particle size distribution in the source emission, although this varies considerably between elements, and that the highest concentrations of many toxic elements are emitted in the smallest, lung-depositing particles. Particles larger than PM10 are intercepted in the nasopharyngeal area (Stuart 1984; Heyder et al. 1986).

The general cutoff for adherence is 63µm, the silt/sand boundary, with greater adherence of the smaller grain sizes, Soil adherence has been reviewed by EPA.[43] Grain size is the key parameter in dermal adherence, with moisture only a factor for very moist soils (Choate et al., 2006). These authors found that the adhered fractions of dry or moderately moist soils with wide distributions of particle sizes generally consist of particles of diameters <63 µm. Finer particles are less likely to be rejected/screened by the consumer (children). 63µm is the sand/silt break-point on the Wentworth scale[44] and is defined in the field based on oral "grittiness test". The clay/silt breakpoint is the first detection of grit when lightly ground between front teeth. Consequently, dermal absorption experiments using larger size fractions may be of limited relevance to actual situations of soil exposure.

Regardless of the source, due to gravity separation alone, finer particles are transported longer distances than larger particles. Finer particles are also less filterable via canopy, aquatic system, or household HVAC systems. Therefore, the nature and extent of the distribution of finer particles are much larger than coarser fractions, spreading contamination further. Finer particles

[43] https://www.epa.gov/sites/production/files/2015-09/documents/part_e_final_revision_10-03-07.pdf
[44] The simplified Wentworth scale is: Gravel gradations (>2mm); Sand gradations (62.5-125 µm); Silt (3.9–62.5 µm); Clay (0.98–3.9 µm). Soils are typed according to physical (e.g., grain size, color, moisture), chemical (e.g., minerals, pH), and biological attributes (e.g., organic matter).

are produced by more industrial sources (range from stack or tail-pipe air-emitters to sediment dischargers associated with mining)

One goal of the risk assessor is to employ an exposure point concentration that represents the pertinent pathway of interest (*direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact).* For example when evaluating ingestion of soils EPA recommends a particle size distribution (PSD) cutoff of 250µm because EPA believes this is the largest size that adheres to the hand which subsequently affects hand to mouth intake. This is not a conservative value.

Another goal is to employ an exposure point concentration that represent the thermodynamically effective (TDE) concentration of contaminants of concern associated with the particle size cutoff. The cutoff is directly related to: (1) the process that was responsible for genesis of the TDE contaminant, and (2) sorption of the contaminant on native particulates during transport. Native clay-sized materials (< 4µm) are the dominant media providing sites for active sorption. Falsely low values for exposure point concentrations occur when the incorrect cutoff is employed. For example, if an EPA defined size of 250µm (relatively coarse) is employed for ingestion of soils related to smelter stack emission exposure point concentration (an aerosol of 0.001µm to 100µm), the analytical result and exposure point concentration will be falsely low due to dilution of the aerosol-sized particle with larger naturally occurring materials occupying the greater than aerosol to 250µm range of the distribution. In other words, employing the larger cutoff relies on the assumption that TDE contaminants are homogenously distributed in the particle size distribution. This assumption is only valid for very rare cases where the particle size distribution of a manufacturing process is coincident with the 250µm cutoff.

Multiple pathways from multiple sources requiring different cutoffs for different thermodynamically effective contaminants, further complicate matters because sampling can become cumbersome and quite costly. In summary, for such situations, since wastes from manufacturing processes are governed by less-than particle size cutoffs associated with design of settling basins, air/water filtration, etc., the finer (<63 µm) fraction is present in all the aforementioned pathways (direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact), we recommend a much finer PSD cutoff of 63µm to represent all pathways. Employing a coarser cutoff of the particles sizes likely results in dilution of the exposure point concentration resulting in a falsely low exposure point concentration. Since quantitative estimates of risk are directly proportional to the exposure point concentration, risk is also estimated to be falsely lower than actual conditions.

For these reasons, we recommend sieving soil and dust samples along the sand/silt and silt/clay size boundaries, and using fractions <63µm for risk assessment.

12. Fugitive Dust

Fugitive dust may be an under-appreciated route of exposure for dust and soil. For example, asbestos can cause gastrointestinal tumors due to swallowing, and the clearance of coal dust by the mucociliary tract has been linked to gastric cancer.

Fugitive dust consists of geological material that is injected into the atmosphere by natural wind and by anthropogenic sources such as paved and unpaved roads, construction and demolition of buildings and roads, storage piles, wind erosion, and agricultural activities (Watson 1996). The largest sources of regional dust are roads and agriculture. There are more than 4 million miles of roads in the United States with about 2.5 million miles paved roads and 1.5 million miles unpaved. There are about 350 million acres of tilled farmland in the continental US and 188 million acres of range and pasture land.[45]

When administering federal Air Quality programs, states submit State Implementation Plans to EPA for Total Suspended Particulates (TSP) and other pollutants; the Idaho SIP[46] was approved in 1982. The Portneuf Valley was (2004 data) designated non-attainment for particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM10) and is now a maintenance area.[47,48] In 2004, the economy of the area was centered around agriculture and mineral products. Major agricultural crops are potatoes, sugar beets, and wheat. During winter, brisk southwesterly winds often persist for days or weeks. Spring months are normally wet and windy. Winds of 20 to 30 miles per hour (mph) may persist for days at a time. The Portneuf Valley is dominated by migratory weather disturbances that are greatly influenced by the complex terrain in the area.[6] The adjacent Fort Hall non-attainment area is specifically for the Astaris Idaho LLC facility (formerly FMC Corporation), which is no longer in operation.

Unpaved Roads

Nearly 50 percent of America's roads are unpaved, not counting private roads, agricultural roads, and parking lots.[49] The practice of converting paved roads to unpaved is relatively widespread; recent road conversion projects were identified in 27 states. These are primarily rural, low-volume roads that were paved when asphalt and construction prices were low. Those asphalt roads have now aged well beyond their design service life, are rapidly deteriorating, and

[45] https://www.westernwatersheds.org/watmess/watmess_2002/2002html_summer/article6.htm
[46] https://yosemite.epa.gov/r10/airpage.nsf/283d45bd5bb068e68825650f0064cdc2/22e835f0c66d125e88256f5f0001932c/$FILE/47%20FR%2032530.pdf 40CFR 80&81: 32530-32535 (July 28, 1982).
[47] http://www.deq.idaho.gov/air-quality/monitoring/attainment-versus-nonattainment/
[48] http://www.deq.idaho.gov/media/352079-portneuf_valley_SIP_plan_draft_2004.pdf
[49] www.equipmentworld.com/celebrating-80-years-of-better-roads (data from 2011).

are both difficult and expensive to maintain. Instead, many local road agencies are converting these deteriorated paved roads to unpaved as a more sustainable solution.[50]

Idaho dust control and road stabilization are necessary for the health and safety of rural residents, large and small communities. With over 23,000 miles of roads unpaved and Idaho's winds, dust control can be an issue.[51] Bingham County Idaho currently maintains more than 1,228 miles of road (56 % are paved). Bannock County Road & Bridge is a division of the Bannock County Public Works department that is tasked with maintaining 466 miles of road of which 300 miles are paved (note: these are county roads, not state or federal or private).

Nation-wide, counties spend approximately 31 percent of their budget on gravel road maintenance (Birst and Hough 1999). Gravel road maintenance includes roadside maintenance, grading, ditching, snow and ice control, signing, dust control, rehabilitation/regrading, and other steps. Results of a study conducted by *Better Roads*[52], identified that more engineers called dust their most serious gravel road maintenance problem than any other. A car traveling 35 mph on a moderately dusty road generates the concentration of silt-sized particles equal to that of about 100 times the pollution concentration in the air of an industrial city (Birst and Hough 1999). For every vehicle traveling one mile of unpaved roadway once a day, every day for a year, one ton of dust is deposited along a 1,000-foot corridor centered on the road (Sanders and Addo 1993).

Risk assessments often do not quantify the risk associated with soil inhalation. However, in areas with unpaved roads, this is a relevant exposure pathway. To determine the inhalation exposure, James et al. (2013) collected three size fractions of airborne particulate matter (total suspended particulates [TSP], particulate matter with an aerodynamic diameter less than 10µm [PM10], and particulate matter with an aerodynamic diameter less than 2.5µm [PM2.5]) before and after roads were paved. Road paving reduced the concentration of many airborne contaminants by 25 to 75% (James et al. 2012).

Off-road vehicles, such as might occur during homesteading activities, while perhaps trivial in a regional context, could be locally significant. Goossens and Buck (2009 a,b) examined the type of surface (sand, silt, gravel, drainage) with respect to dust emission from off-road use. As predicted by grain size, the increase in PM10 emission resulting from ATV use in arid areas are: for sandy areas, 30–40 g km^{-1} (PM10) and 150–250 g km^{-1} (TSP); for silty areas, 100–200 g km^{-1} (PM10) and 600–2000 g km^{-1} (TSP); and for mixed terrain, 60–100 g km^{-1} (PM10) and 300–800 g km^{-1} (TSP). These values are for the types of vehicles tested in this study and do not refer to cars or trucks, which produce significantly more dust (Goossens and Buck 2009 a,b).

[50] http://www.montana.edu/ltap/resources/publications/nchrp_syn_485.pdf (data from 2016).
[51] http://desertmtncorp.com/idaho-dust-control/
[52] http://www.equipmentworld.com/better-roads-magazine-archive/

Predictions of aeolian (wind-caused) erodibility can be made based on climate, wind speed[53], elevation, vegetative cover, slope, and soil type (USACE 2008), as well as grazing intensity (Goossens 2001).

Agricultural Dust Production

Tillage has been shown to be a significant source of dust (particles and any contaminants adsorbed onto them such as fertilizers and pesticides) as it is able to emit higher amounts of dust than wind erosion alone (Goossens et al., 2001; Clausnitzer and Singer, 1996; Cassel et al., 2016). A long history of research focusing on tillage and dust emission exists for the USA. On the local scale, wind erosion and agricultural activity remain the major sources of dust after vehicle driving on paved or unpaved roads. Tillage has been shown to be a significant source of dust as it is able to emit higher amounts of dust than wind erosion alone (Goossens et al., 2001). For example, the San Joaquin Valley of California is in non-attainment of National Ambient Air Quality Standards for PM10. The occurrence of 24-hour exceedences during periods of intense agricultural activity in the post-harvest months of October and November, as well as the composition of ambient PM10 at that time, indicates the importance of row crop agriculture in the region's air quality. Road dust and farming were the sources of the bulk of PM10 (Cassel et al., 2016). Clausnitzer and Singer (1996) measured respirable dust generated during agricultural operations related to corn, tomatoes, and wheat in the Sacramento Valley. The highest amount of respirable dust was generated form soil ripping and plant into dry surface soil, and the lowest was generated by disking corn stubble during the wet season. Approximately 64% of all operations were performed during the dry season and generated 83% of the respirable dust. Areas of abandoned agricultural land in the Antelope Valley, western Mojave (high) desert of California are recalcitrant to conventional tillage and revegetation strategies designed to suppress wind erosion of soil and transport of sediment and fugitive dust. These areas represented a continuing source of drifting sand and of coarse and respirable suspended particulate matter (Grantz et al., 1997).

Homesteading, farming, and ranching risk assessment must consider (1) past spread of mining-generated particles at the mine sites and much larger depositional areas, (2) newly generated particles during farming and ranching, and (3) particles generated as road dust, including a consideration of past spillage of mined materials onto haul roads.

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