TITLE/AUTHORS- Managing Agricultural Resources During Oil Spills: Case of the OSSA II Pipeline Spill in Bolivia, 2000. By: Charles D. Getter[1], Elliott Taylor[2], and Gavin Macgregor-Skinner[3] : *[1]Polaris Applied Sciences, Inc., PO Box 10638, Bainbridge Island, Washington 98110, USA, phone: 206-855-9197; fax: 425-696-0485; email: chuckgetter@aol.com ; [2]Polaris Applied Sciences, Inc., 755 Winslow Way East, Suite 302, Bainbridge Island, Washington 98110, USA, phone: 206-842-5667; fax: 206-842-2861; email:eteams@prodigy.net. [3]5 Scott Street, Murwillumbah, New South Wales, 2484, Australia, phone: ++61-266-721170; fax: ++61-266-728204; email: gavinjms@yahoo.com*

ABSTRACT-On January 30, 2000 an estimated 29,000 barrels of mixed crude oil and condensate were released into the Desaguadero River on the Bolivian Altiplano. The spill threatened the feeding and watering grounds for over 50,000 head of livestock, including sheep, cattle, llamas, and pigs. At the time, livestock were grazing in the hills above the watershed spill zone. Local ranchers were advised to avoid the spill area until cleanup and assessments had been completed to verify that pastures and waters were safe for livestock use. To address concerns by local ranchers and landowners, vegetation cutting was done in areas of oiled natural grasses and several million liters of water and over 400 tons of supplemental forage were provided. No livestock mortalities were attributable to the oil spill, although perceived and indirect losses to livestock value were estimated for compensation purposes. Animal health monitoring by licensed veterinarians showed that the incidence of illnesses was not significantly different from previous years, suggesting little if any direct adverse affects on livestock. In addition patches of oil were cleaned up in native pastures over more than 18,000 hectares. Direct and indirect effects of the spill on vegetation in the area included very sparse and non-continuous oiling of natural grasses and some crops, and isolated cases of reduced irrigation of cultivated forage crops and natural grasses. A vegetation cleanup program was conducted in response to local concerns despite evidence that toxic oil components were not present in oiled plants. Criteria for screening and cutting vegetation were developed for the natural forage grasses, primarily totora (reed) beds and kempara. This paper presents a brief summary of the methods and results of the protection of these resources during the course of this spill. It concludes with a discussion of recommended management practices for future spills.

INTRODUCTION- The rural Bolivian altiplano is a high altitude (over 3600 m), semi-arid (303 mm/yr), and cold (8-10 ºC average with frost approximately 180 days per year) region. The inhabitants are economically poor and highly dependent upon livestock. Demand in neighboring cities has created an intensive livestock industry with severe deficiencies in animal sanitation, feeding and shelter. Years of overgrazing has depleted the forage vegetation and degraded the livestock to underweight animals with low levels of meat and milk production. On January 30, 2000 29,000 barrels of oil were released and transported downstream and stranded along more than 200 km of riverbanks and flood plains, up to 6km wide (Figures 1 and 2). Oil was stranded in a range of water-saturated and dry conditions, including: mud point bars, channel margins, or mid-channel shoals; fine-sand point bars, channel margins and mid-channel shoals; vertical and/or eroding river-cut banks; vegetated flood-plain areas that initially were wet but later dried out; reed (totora) habitats, known locally as totorales, and over-bank vegetated areas (primarily short grasses). Table 1 gives the common species and their abundance in the effected area of the watershed. Floodwaters transporting oil entered areas where crops are cultivated, natural grass pastures for livestock food, and irrigation and watering canals many of which were the only source of water. Many of the canals were closed in time to protect them from oil.

METHODS- Cleanup began within hours eventually utilizing over 10,000 personnel in a multinational eleven-month cleanup effort. Within hours of arriving by plane to the location our spill response team was collecting data using video cameras, still photography, household surveys and community meetings, while traveling in boats, four-wheel drive vehicles and helicopters to speed this process. These projects collectively formed the database for livestock and forage management programs. A team of professional agronomists began working to characterize the extent of oiling in forage and crops. They helped characterize and develop criteria for determining which forage plants were to be removed developed for the protection of livestock, including:

1. The cutting of vegetation was limited since the cleanup itself could cause additional or even permanent damage to the plants. The vegetation cutting, therefore, was confined to marked areas where more than 10% of the stems had

un-weathered or sticky oil, or to areas where more than 30% of the stems had a weathered oil stain.

2. Red flags were placed in oiled areas to protect the forage and warn families not to graze livestock in contaminated forage.
3. Cleanup personnel were not to damage plant roots nor to dig or pull up plants. Cutting could spread the oil, so when it was discovered that the oil was spreading, cutting was stopped.
4. Vehicles and heavy equipment people were to be kept out of oiled vegetation. Agronomists familiar with the vegetation established new access points to help with this.
5. Vegetation cutting started after the water receded and ended when the rainy season started again.

Eleven full-time licensed veterinarians spent the next 11 months working throughout the affected communities. The veterinary teams were asked to provide:

1) Response to all reports of possible oil contamination affecting animals
2) Immediate treatment to sick livestock
3) Identification and documentation of the existing relationships between breeding and availability of food, water, and livestock management practices.
4) Establishment of the degree of impact on different domestic species. Alternative solutions to animal breeding and husbandry in areas impacted by the spill.
5) Technical support for livestock breeding
6) Identification of livestock diseases in the region and analysis of the frequency of clinical symptoms

7) Sampling of feces, blood, serum and organs from dead animals (post mortems). Where clinical information was not sufficient to assure a reliable diagnosis, samples were sent to certified veterinarian laboratories.
8) Follow-up on cases with apparent symptoms of intoxication caused by the ingestion of plants, as well as other cases presenting syndromes related to the problem.
9) Provide treatment to all animals that were sick regardless of the cause
10) Provide assistance to interdisciplinary activities carried out in the different zones regarding problems with breeding, husbandry and feeding.

Each veterinarian prepared a daily report of household visited including animals treated including the clinical signs. To calibrate field observations, field and clinical findings from the literature (Barber et al. 1987, Beck et al. 1977, Coppock et al. 1986, Coppock et al. 1995, Cosle 1947, Eaton 1943, Edwards and Zinn 1979, Monluz *et al.* 1971, Oehme 1977, Parker and Williamson 1951) were summarized to allow knowledge of expected symptoms of petroleum poisoning in livestock. A detailed review of this literature is provided in Getter et al. (in review).

Finally two commissions were formed consisting of federal, state and local government representatives joined by community and pipeline scientists. These were the forage and water commissions that were charged with overseeing the cleanup and monitoring of food and water (Comisión de Forraje (Forage Commission) (2000) and Comisión de Aqua (Water Commission) (2000).

RESULTS-The effect of the oil spill on the forage plants in the watershed was neglibable (Comisión de Forraje, 2000). Typically (99.9% of observations) oil was located in small, scattered spots on large plants such as the totora and kempara. In rare cases, oil patches reached young specimens of kempara and totora in sufficient concentration to suffocate them. Chiji, a low growing succulent, appeared visibly to be less vulnerable and had grown through small patches of oil. Oiling patterns in vegetation were typically found in one of three forms: fringe oiling along the other edges of vegetation concentrations, such as in totora; river edge, or riverine oiling along minor river channels and natural depressions; and overwash oiling resulting from receding water levels and oil stranding in vegetated areas (Figure 3).

Cleanup operations were completed along the river by early April, though vegetation cutting continued into December 2000. Environmental sampling after completion of cleanup showed that there was negligible oil remaining in the water and sediments with the exception of oil residues that did not meet cleanup recommendation criteria (Taylor and Getter, in review). No petroleum was found within the tissues of the plants, although plants at some locations had visible external oil (Comisión de Forraje, 2000). Even where the ground had surface oiling, forage plants like chiji, kempara, and totora continued to grow.

The veterinarian team made the following observations. A total of 413,827 animal visits were conducted during the 11-month period. Sheep dominate the area accounting for approximately 90% of all animals attended by the veterinarians. The number of animals requiring veterinary treatment in the area affected by the spill was normal (47,201 or 11%). Veterinarians working in this area expect a treatment incidence of around 12% for the young and 6% for adult livestock. The major illnesses during and after the spill were eye infections, digestive disorders, respiratory disorders, and caquexia (wasting away). Tables 2 and 3 give percentages before and after the spill and the treatment offered. The incidence of intoxication due to eating poisonous plants among animals requiring veterinary attention was 0.03%. Of the 355 samples submitted for analysis, 23 indicated signs of intoxication that may have been the result of ingesting toxic plants (for example, gold button (*Cotala sp.)* and garbancillo or woolly locoweed (*Astragalus garbancillo))*, lack of vitamins, or feeding with forage with oil. This represents less than 0.01% of the animals attended to in the region. Laboratory tests on 350 different animal samples were analyzed to confirm a diagnosis made on clinical signs and to determine a diagnosis for cases that were not obvious: Samples taken from animals in the north half of the spill zone indicated high rates of nutritional deficiency (34.8%) and gastrointestinal parasitosis (22.8%). Samples taken from animals in the south half of the spill zone indicated similarly high rates of nutritional deficiencies (25.9%) and gastrointestinal parasitosis in cows (14.6%), and also elevated respiratory illnesses in sheep (15.2%). Laboratory analyses of fecal matter showed that the high levels of intestinal parasitosis were mainly caused in sheep by roundworms; *Trichostrongylus* sp. (15.3%), *Strongylus* sp. (10.7%) and coccidiosis sp. (10.0%). In cows, the parasitosis is caused by *Trichostrongylus* sp. (16.3%), *Strongylus* sp. (10,1%) and coccidiosis (10.1%). No mortalities were documented due to the oil spill.

DISCUSSION-A review of the published literature found three other large oil spills and dozens of oilfield spills that had affected sheep, cows, and their forage and water supplies. These showed that sheep and other livestock are only affected in areas that are heavily oiled. An account of the effects of crude oil on sheep and their forage during the Braer spill in Scotland was published by Milne et al. (1997) and by Richie and O'Sullivan (1994). They reported only short-term sub-lethal effects even in areas of heavy oiling. Samples of the vegetation that the livestock grazed on did not contain volatile or semi volatile hydrocarbons, even in areas among the most heavily oiled. During the Arrow oil spill in Nova Scotia in 1970 one researcher fed seaweed and other forage from the spill to local sheep (MacIntyre, 1970). He concluded that there were no short term effects to sheep from that oil. The Sea Empress oil spill in a coastal area in Milford Haven, Wales impacted livestock and crops. Within 10 days of the original spill, grass samples taken from coastal and inland sites showed elevated PAH (polyaromatic hydrocarbons) Ten days later at selected sites, concentrations had fallen by an average of 40%. Analysis of tissue samples from sheep grazing in the coastal area showed hydrocarbon levels to be normal. The government then advised that the oil spill had resulted in no risk to the human food chain from the consumption of agricultural produce (SEEEC, 1996).

According to data corresponding to the previous year (1999) in the Bolivian altiplano, very similar cases of health problems to those reported in 2000 (the year of the spill) with the exception of a Foot and Mouth disease outbreak the previous year. These data are presented in Table 2. Comparison shows that the cases of diarrhea, eye problems including cataracts and conjunctivitis, and pneumonia were common in these communities. Before and after the spill, the most frequent illnesses noted were diarrhea, caquexia (diverse degrees of malnutrition due to poor quality feed), eye problems and pneumonia. These illnesses are normal for this time period in the altiplano, and especially in the areas of the river drainage that are heavily over-grazed**.** Factors other than oil that contribute to the predisposition to enteric illnesses like diarrhea and pneumonia are: lack of shelter for the animals, especially following birth; lack of proper birthing procedures; poor feeding; and the pre-existing condition of nutritional deficiency caused by insufficient forage that is reflected in differing degrees of malnutrition. This is reported in all major breeds of cattle.

Although there was no evidence of direct loss of forage from spilled oil impact, canal closures may have led to indirect drought-like damages. Therefore the Forage Commission recommended the provision of supplemental forage for livestock, approved the method of forage delivery and the types of forage delivered. In accordance with the Forage Commission recommendations, five deliveries were made for a total of 423.4 tons of supplemental forage from September to December 2000.

RECOMMENDATIONS-For those managing oil spill cleanup, damage assessments, or doing contingency planning the following action are recommended. Contingency planning for land oil spills should provide that veterinary expertise is readily available.

Conduct immediate and ongoing assessments of the distribution of oil with potential to affect livestock, forage and watering resources, and assess initial priorities with respect to human health and effects on food sources. Immediately identify all government agencies and livestock industry interests and organize them into a working group to make decisions and exchange information. Dedicate licensed veterinarians to the field to provide veterinary assistance to affected communities. Included in this program consider medicine, antibiotics and vitamins. Local veterinarians should be used since they are familiar with local practices and breeds. Monitor for acute symptoms of severe petroleum poisoning including: Pneumonia, smell of petroleum on breath; diarrhea, smell of petroleum in feces; and/or oil around mouth, nostrils and legs.

Treat livestock that have been exposed to oil. Because secondary infection may be important, animals known or suspected to have consumed oil should be were treated with broad-spectrum antimicrobials for >7 days (Figure 4). Immediately keep or move all livestock from affected (and potentially affected) areas by transporting them to areas that have no likelihood of impact upstream, upland and/ or inland areas and/or preventing livestock from reaching pools and larger patches of oil using herding practices, fences and warnings to people to keep their livestock away. Provide livestock with uncontaminated forage and water. Some regions have no established markets to purchase forage and water. In a large spill all regions will be taxed by new, large demands for supplemental forage and water. Preplan the distribution system including: the type of supplemental forage needed, the sources of forage and agricultural waters during different seasons, transportation options for water and forage and places to store forage and water.

Identify local environmental laws and standards and use them to establish cleanup criteria that are protective of water and forage resources. Consider that over-cleaning could lead to long-term damages to water and forage resources. Focus on immediate action to remove pools of oil that are available to livestock. The criteria used in the OSSA II spill was to manually remove all pooled oil and also patches of oil greater than 50x50 cm.

Develop and implement a comprehensive sampling program for water, soil, and forage. The program should include toxic component analysis (BTEX-benzene, toluene, ethylbenzene and xylene, and PAH-polyaromatic hydrocarbons). Develop cleanup endpoints protective of livestock. Continue selected, long-term monitoring of water and forage. Take and analyze flesh, urine and blood samples from livestock to determine their contaminant levels throughout the spill. Communication and education is essential in relation to livestock issues during oil spills. Sense of urgency is required to inform farmers and safeguarding the food chain as precautions to take, what action is being taken and interpretation of the results.

Establish and monitor realistic cleanup end points considering the following: The field and lab literature indicate that pure, pooled oil consumption has led to mortality of sheep and cattle. The spill literature verifies this indicating that livestock must consume pure, pooled oil to suffer mortalities. Getter et al (in review) reviews the literature on threshold levels based upon cattle body weight and determined that for weathered oil 8ml/kg or less is acceptable. In the Bolivian spill this equated to approximately a 50X50 cm pool of liquid oil, 1 cm thick (typical in clay). A 200 kg animal would have to drink one of these pools daily to suffer mortality. Return the livestock to affected areas once cleanup endpoints are met.

ACKNOWLEDGEMENTS-We thank Mr. Tony Henshaw, Dr. Gavin McGregor-Skinner, Ms. Vicky Copeman, Dr. Edward H. Owens, Dr. Corsino Huallata Ibarra, Dr. Eduardo Mena Orozco, Dr. Walter Vilela Zabaleta, Engineer Ricardo Ledo, Engineer Esteban Santos, Engineer José Soto, Engineer Mercedes Molina, Ms. Linda Z. Owens and Ms. Janet Arce.

REFERENCES

Barber D.L.M., Cousin D.A.H., Seawright D. 1987 An episode of kerosene poisoning in dairy heifers. Veterinary Record. 120: 462, 1987.

Beck B.E., Wood C.D., Whenham C.R. 1977. Triaryl phosphate poisoning in cattle. Veterinary Pathology 14: 128-137, 1977.

Comisión de Agua (Water Commission) 2000. Derrame de Petróleo Ossa 2 - Informe de la Comisión de Agua. Informe no Publicado al Ministerio de Agricultura, Ganadería, y Desarrollo Rural, La Paz, 5 Junio, 84 paginas y 8 Apéndices.

Comisión de Forraje (Forage Commission) 2000. Derrame de Petróleo Ossa 2 - Informe de la Comisión de Forraje. Informe no Publicado al Ministerio de Agricultura, Ganadería, y Desarrollo Rural, La Paz, 8 Junio, 61 paginas y 11 Apéndices.

Coppock, R.W., M.S. Mostrom, and D.L. Smetzer. 1986. Volatile hydrocarbons (solvents, fuels) and petrochemicals. Pp. 197-202. In: Kirk, R.W. 1986. Current Veterinary Therapy IX: Small Animal Practice. W.B. Saunders Company Publisher.

Coppock, R.W., M.S. Mostrom, E. Stair, and S.S. Semalulu. 1995. Toxicopathology of oilfield poisoning in cattle: a review. Vet. Human Toxicol. 38(1):36-42.

Cosle A.J. 1947. Drinking of crude oil by cattle. North American Veterinary Journal 28:221, 1947.

Eaton G. 1943. Paraffin poisoning in cattle. Veterinary Record 53:19, 1943.

Edwards, W.C. and L.L. Zinn. 1979. Diagnosis of petroleum hydrocarbon

TABLES

Table 1. Natural grasses and relative abundance within vegetated areas in the deltaic region of the Desaguadero River.

VARIETY	COVERAGE%
Totora (*Schoenoplectus totora*)	39
Quempara (*Baccharis junceae*)	20
Chiji (*Distlichis humilis*)	15
Mouse Tail (*Hordeum muticum*)	8
Cauchi (*Suaeda foliosa*)	4
Others	16

Table 2. Sheep and cattle illnesses diagnosed before and after the oil spill.

Eye problems	677	3.0%	Eye problems	2	0.4%
Diarrhea	265	1.2%	Diarrhea	44	9.1%
Pneumonia	135	0.6%	Pneumonia	1	0.2%

Cachexia	152	0.7%	Cachexia	43	8.9%
Intoxication		0.0%	Intoxication	0	0.0%
syndrome	29	0.1%	syndrome	0	0.0%
Carbunculo	1	0.0%	Carbunculo	0	0.0%
Skin Problems	1	0.0%	Skin Problems	0	0.0%
Trauma	1	0.0%	Trauma	0	0.0%
Abortions	2	0.0%	Abortions	0	0.0%
Leg Swelling	0	0.0%	Leg Swelling	1	0.2%
Total	22243	100%	Total	483	100%

Data from Comisión de Forraje (2000).

Table 3. Histopathology and treatment regimes applied by the veterinarian team of the pipeline company during the OSSA II oil spill.

Diagnosis	Clinical Signs	Cause-[1]	Treatment
Infectious diarrhea	Diarrhea, cachexia, abdominal pain	Enterotoxemias	Tetracyclines, soluble antibiotics
Nutritional diarrhea	Greenish diarrhea, dehydration, anorexia	Sudden nutritional changes	Sulfas
Respiratory infections	Cough, dyspnea, fever	Pathogenical bacterias	Tetracyclines, long action (LA) Oxitetracyclines
Gastrointestinal parasitosis	Atypical diarrheas, weight loss, anorexia	Gastrointestinal verminosis	Ivomec, Tehuelchi
Kerato-conjunctivitis	Blindness, tearing, lemma.	Conjunctivitis complications	Ophthalmic antibiotics
Nutritional syndrome	Weight loss, anorexia, weakness	Nutritional deficiency, lack of food, lack of vitamins	Vitamins ADE, B Complex, Serum with vitamins
Parasite syndrome	Weight loss, anorexia, weakness, cough.	Nutritional deficiency, lack of food, lack of vitamins	Antiparasites as prevention
Respiratory syndrome	Cough, nasal secretion, dyspnea	Exposure to dust, parasite migration, sudden temperature changes	Expectorants, antibiotics
Intoxication syndrome	Lack of coordination, profuse salivation, blackish diarrhea, high temperature, dyspnea	Ingestion of toxic plants, lack of vitamins, feeding with forage affected by petroleum	Antitoxil, hepatic protectors, Serum with vitamins

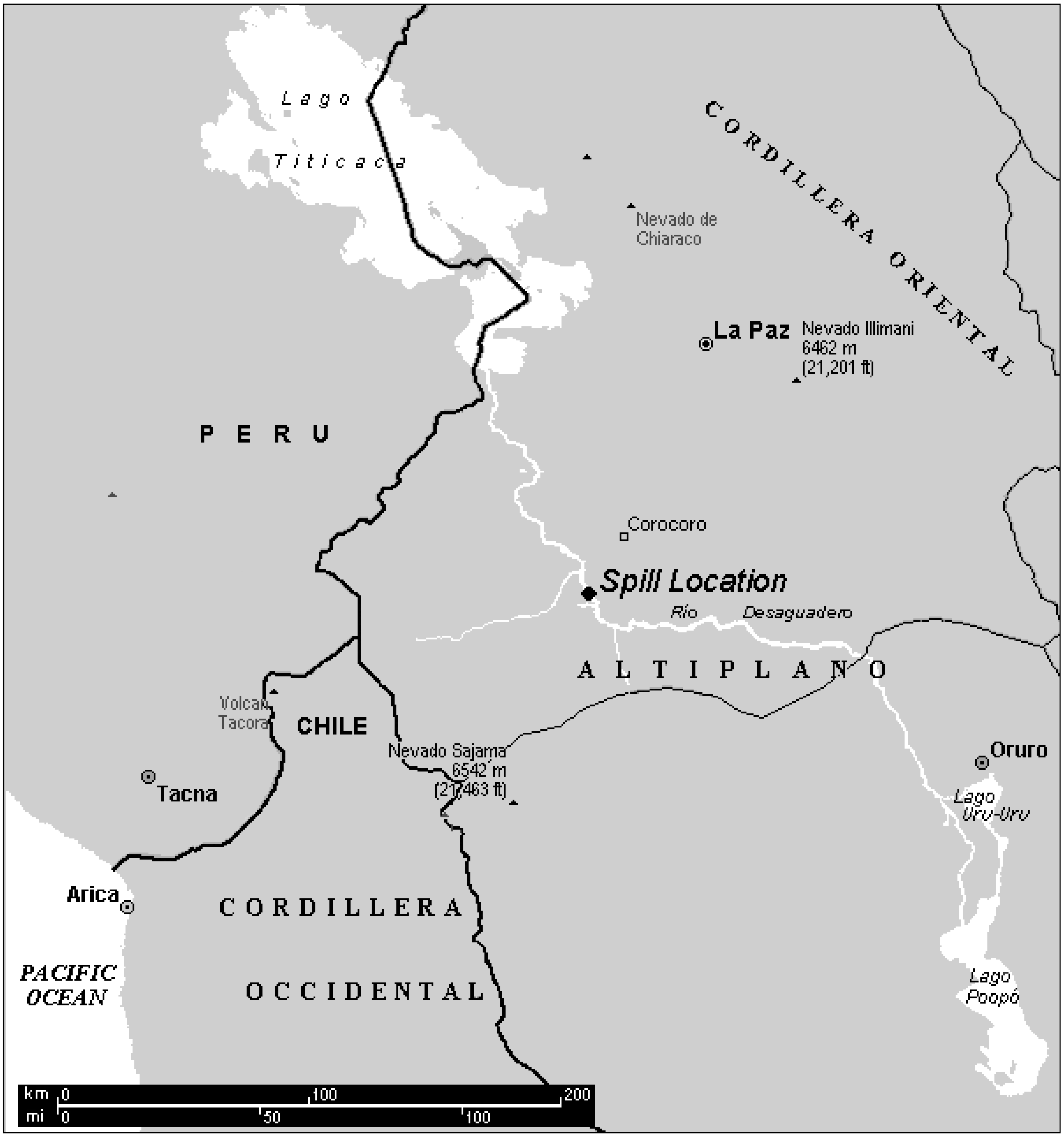

Figure 1. The Rio Desaguadero River originates in Lake Titicaca and ends in Lakes Uru-Uru and Poopo. Below the spill location is a broad vegetated delta of thousands of hectares of reeds that acted a s a filter keeping oil from the lakes to the south.

Figure 2. The Bolivian high plains is a high cold desert presenting hard conditions to all inhabitants. This area was lightly oiled in thin (1 m.) strips along contours that have subsequently been raked and naturally weathered.

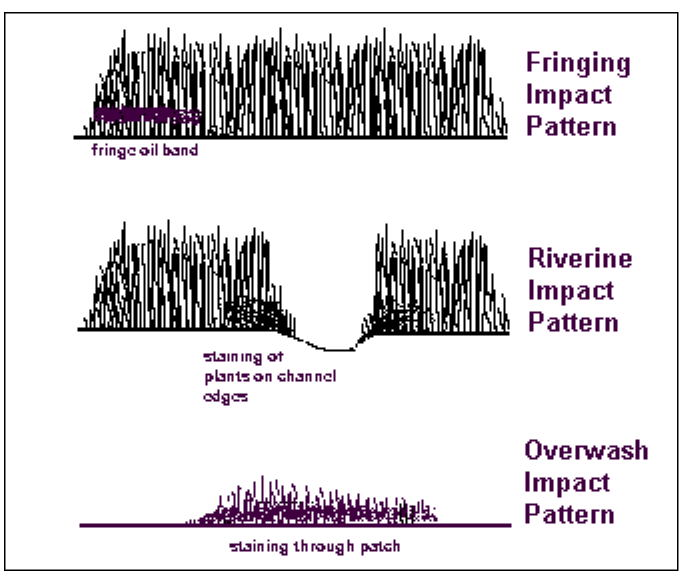

Figure 3. Typical oiling patterns in vegetation.

Figure 4. Veterinarians examined a total of 413,827 animal visits were conducted during the 11-month period providing inoculations where they were in areas of oiled forage.