Johnson
Pochop & Bartling
ATTORNEYS AT LAW

Stephanie E. Pochop
George F. Johnson
Amy R. Bartling
Kelsea K. Sutton

August 29, 2016

Secretary Steven M. Pirner
Dep't of Environment & Natural Resources
Feedlot Permit Program
Foss Building
523 E. Capitol Ave.
Pierre, SD 57501-3182

Re: Witness List & Exhibits

Dear Secretary Pirner,

Please find enclosed with this letter a disc containing the exhibits my client intends to offer at the contested case hearing in September. I additionally provide the enclosed list of witnesses we intend to call during the hearing.

We will provide hardcopies of the exhibits in the following manner: one set to Judge Duenwald prior to the hearing; one set to be marked as exhibits at the hearing; and one set to the hearing for Secretary Pirner.

Sincerely,

Kelsea K. Sutton

Kelsea K. Sutton
Attorney for Dakota Rural Action

Cc: Client
/Enclosures

Johnson Pochop & Bartling
office: (605) 835-8391

405 Main Street | PO Box 149
Gregory, South Dakota 57533

email: office@rosebudlaw.com
fax: (605) 835-8742

STATE OF SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

IN RE HEARING FOR REISSUING THE GENERAL WATER POLLUTION CONTROL PERMIT FOR CONCENTRATED ANIMAL FEEDING OPERATIONS	)))))))	**WITNESS DISCLOSURE**

Pursuant to the Procedural and Scheduling Order dated March 15, 2016, the Intervener Dakota Rural Action designates the following individuals as their expert witnesses and witnesses for the hearing scheduled for September 27-29, 2016.

1. Kathy Martin *expert curriculum vitae, disclosure and report attached*
2. Don Kelley *expert curriculum vitae and bibliography attached*
3. Glenn Mayer
4. Laura Krebsbach
5. Kennette Rogers

Interveners reserve the right to call additional witnesses or present any other exhibits to rebut any testimony which has not yet been disclosed.

JOHNSON POCHOP & BARTLING

/s/Kelsea K. Sutton

Kelsea K. Sutton
405 Main St. | PO Box 149
Gregory, SD 57533
(605) 835-8391
kelsea@rosebudlaw.com
Attorney for Intervener Dakota Rural Action

CERTIFICATE OF SERVICE

The undersigned certifies that on the 29th day of August 2016, she served a copy of this **Witness Disclosure, Exhibit Disclosure, Letter and Exhibit Disc** by U.S. First Class mail and email upon the following parties of record:

Steven M. Pirner
Secretary of the Dep't of Environment & Natural Resources
Foss Building
523 E. Capitol
Pierre, SD 57501-3182
Steve.Pirner@state.sd.us

Ellie Bailey
DENR Feedlot Permit Program
1302 E. Highway 14, Suite 1
Pierre, SD 57501-8501
Ellie.Bailey@state.sd.us

Anthony Helland
1013 W. 20th St.
Sioux Falls, SD57105
tony.helland@gmail.com

David & Lisa Nehring
27551 452nd Ave.
Parker, SD 57053
nehringd@crown.edu

George Bogenschutz
46135 222nd St.
Nunda, SD 57050
mtnmach@itctel.com

Meghan Jarchow
2523 Princeton Ave.
Vermillion, SD 57069
meghann.jarchow@usd.edu

Roger & Ann Loeschke
48464 155th St.
Milbank, SD 57252
arloe@tnics.com

South Dakota Cattlemen's Ass'n *and*
South Dakota Dairy Producers

WILKINSON & WILKINSON
103 Joliet Ave., SE | PO Box 29
De Smet, SD 57231
todd@wslawfirm.net
cc: sddairyproducers@gmail.com

South Dakota Pork Producers Council *and*
Sonstegard Food Company
DONAHOE LAW FIRM, P.C.
401 E. 8th St., Suite 215
Sioux Falls, SD 57103
brian@donahoelawfirm.com

William Powers
512 W. Main St.
White, SD 57276
wjp@swcp.com

/s/Kelsea K. Sutton
Kelsea K. Sutton

STATE OF SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

IN RE HEARING FOR REISSUING THE GENERAL WATER POLLUTION CONTROL PERMIT FOR CONCENTRATED ANIMAL FEEDING OPERATIONS	)))))))	**EXHIBIT DISCLOSURE**

Pursuant to the Procedural and Scheduling Order dated March 15, 2016, the Intervener Dakota Rural Action designates the following as their list of exhibits for the hearing scheduled for September 27-29, 2016.

1. 1999 Zoning Setback Waiver
2. 2008 Feedlot Expansion Building Permit & Variance/CUP Application
3. 2008 Planning & Zoning April 24th Meeting Minutes
4. Notice of Appeal of Planning & Zoning Decision
5. 2008 Board of Adjustment May 16th Meeting Minutes
6. 2008 Memorandum Decision *Mayers v. Buffalo County*, Civ. #08–08
7. 2008 Board of Adjustment November 6th Meeting Minutes
8. Odor Setback Radius Exhibit dated November 3, 2008
9. 2009 Court-Ordered Variance Filing
10. 2012 Lynn Mayer Animal Waste Management System Engineer Report/Expansion App.
11. L13-5-7 from Samp to DENR with Complaint to DENR dated September 7, 2012
12. Complaint to DENR dated September 7, 2012
13. L13-9-3 from DENR to Glenn Mayer with Inspection Reports
14. DENR Inspection Reports 2008-2012
15. L13-10-9 from Samp to Denver Regional EPA Office
16. L13-11-4 from Denver Regional EPA Office to Glenn Mayer
17. L14-6-4 from Denver Regional EPA Office to Samp
18. E12-8-14 from DENR to Glenn Mayer
19. Letters from DENR to Lynn Mayer 1998-2012
20. L15-8-27 from DENR to Glenn Mayer with Water License No. 7157-3
21. Application Form for 2011 Izaak Walton League Wildlife Habitat Award
22. Complaint to DENR dated June 1, 2008
23. Complaint to DENR dated October 24, 2008
24. Complaint to Buffalo County dated November 6, 2008
25. 2010 Signed Landowner Permission form for U.S. Geological Survey
26. 2010 Photos from EPA
27. E11-6-14 and E12-11-6 from EPA to Glenn Mayer

28. 2008 Water Sample Results from Crow Creek River
29. 2010 U.S. Geological Survey Water Samples from and near Glenn Mayer Ranch
30. SDSU Extension Extra: “Surface Water Pollution from Livestock Production”
31. L16-8-24 from Samp to EPA and DENR
32. Photograph, 3/23/10 Foam at Water Testing Location #3 (son taking sample)
33. Photograph, 3/17/11 Drainage from Glenn Mayer Dam Pipe to Crow Creek (looking north, overflow from first spring after dam construction)
34. Photograph, 4/8/11 Lynn Mayer Feed Yard, Testing Location #1 (looking northwest from road, visible standing water and algae)
35. Photograph, 4/8/11 Water Testing Location #1 (looking east from road, visible standing water and algae)
36. Photographs, 6/12/11 Fish Kill (right after dam was constructed and stocked)
    a. Close up fish and foam
    b. Distance fish and foam
    c. Close up fish and foam 2
    d. Distance fish and foam 2
    e. Close up fish
    f. Distance fish
    g. Shoreline and foam 1
    h. Shoreline and foam 2
37. Photographs, 6/17/11 Fish Kill (right after dam was constructed and stocked)
    a. Close up fish
    b. Distance fish
38. Photograph, 3/12/12 Aerial of Lynn Mayer Feedlot (taken sometime in 2012)
39. Photograph, 3/15/12 Big Dam (from beach area looking east, no cattails)
40. Photograph, 5/28/12 Dam Entry Point Water Testing Location #3 (visible algae)
    a. North side of the dam facing south
    b. Looking southwest from inlet of dam
41. Photograph, 7/4/12 Water Testing Location #3 (Inlet side of dam close up)
42. Photographs, 12/26/13-8/7/15 Dam Recreation
    a. Ice fishing
    b. Sledding
    c. Four wheeler paths
    d. Summer fishing
43. Photograph, 4/18/16 Water runoff from where second lagoon should be (looking northwest from road, visible standing water)
44. Photographs, 4/18/16 Water Testing Location #1 (water runoff and foam)
    a. Distance looking northwest from road
    b. Distance 2 looking northwest from road
    c. Close up west of road

    d. Close up 2 west of road
    e. Close up 3 west of road
45. Photograph, 5/30/16 Water Testing Location #3 (cattails in big dam close up)
46. Photographs, 7/30/16 Big Dam (sprayed cattails encompass entire dam)
    a. Northeast side of dam facing southwest (only other adjacent field, no runoff)
    b. Southeast corner of dam facing southwest
    c. Northeast side of dam facing southwest
    d. Northwest corner of dam looking west
47. Maps of Glenn and Lynn Mayer Property
    a. Points of Testing
    b. Seepage south of original lot (entire southeast draw full of water, dam is pure algae)
    c. Close up of Lynn's new lagoon (dark edges are cattails, turquoise is algae)
    d. Seepage on east side of lagoon and road
    e. Glenn's big dam (algae build up)
    f. Full feed lot (Lynn) and full dam (Glenn)
48. Kathy Martin Curriculum Vitae
49. Kathy Martin Expert Witness Testimony and Deposition History
50. Kathy Martin Report, SD Permit Comments
51. U.S. DEP'T OF HEALTH & HUMAN SERVICES, CENTERS FOR DISEASE CONTROL & PREVENTION, *Antibiotic Resistance Threats in the United States* (2013).
52. PEW COMM'N ON INDUSTRIAL FARM ANIMAL PRODUCTION, Silbergeld, E.K., Price, L., and Graham, J., *Antimicrobial Resistance and Human Health* (2008).
53. Food Marketing Institute, FMI Backgrounder, *Low-Level Use of Antibiotics in Livestock and Poultry* (2004).
54. Consumers Union: Policy & Action from Consumer Reports, "The Overuse of Antibiotics in Food Animals Threatens Public Health (2013), *available at* http://consumersunion.org/news/the-overuse-of-antibiotics-in-food-animals-threatens-public-health-2/.
55. Storteboom, H., Mazdak, A., Davis, J.G., Crimi, B. and Pruden, A., *Tracking Antibiotic Resistance Genes in the South Platte River Basin Using Molecular Signatures of Urban, Agricultural, And Pristine Sources*, ENVIRON. SCI. TECHNOL. Vol. 44 Issue 19, pp. 7397–7404 (2010).
56. Pruden, A., Mazdak, A., and Storteboom, H., *Correlation Between Upstream Human Activities and Riverine Antibiotic Resistance Genes*, ENVIRON. SCI. TECHNOL. Vol. 46 Issue 21, pp 11,541–11,549 (2012).
57. Amy R. Sapkota, Frank C. Curriero, Kristen E. Gibson, and Kellogg J. Schwab, *Antibiotic-Resistant Enterococci and Fecal Indicators in Surface Water and Groundwater Impacted by a Concentrated Swine Feeding Operation*, ENVIRON. HEALTH PERSPECTIVES Vol. 115 Issue 7, pp. 1040-45 (July 2007).

58. Deniza Gertsberg, *Antibiotic Resistance Threat and CAFOS*, GMO Journal: Food Safety Politics (Jan. 15, 2014), *available at* http://gmo-journal.com/2014/01/15/antibiotic-resistance-threat-and-cafos/.
59. Juan Li, Thanh Wang, Bing Shao, Jianzhong Shen, Shaochen Wang, and Yongning Wu, *Plasmid-Mediated Quinolone Resistance Genes and Antibiotic Residues in Wastewater and Soil Adjacent to Swine Feedlots: Potential Transfer to Agricultural Lands*, ENVIRON. HEALTH PERSPECTIVES Vol. 120 Issue 8, pp. 1144-49 (Aug. 2012).
60. Martin, M.J., Thottathil, S.E., and Newman, T.B., *Antibiotics Overuse in Animal Agriculture: A Call to Action for Health Care Providers*, AM. J. PUB. HEALTH Vol. 105 Issue 12, pp. 2409-10 (2015).
61. Gilchrist, M.J., Greko, C., Wallinga, D.B., Beran, G.W., Riley, D. G. and Thorne, P.S., *The Potential Role of Concentrated Animal Feeding Operations in Infectious Disease Epidemics and Antibiotic Resistance*, ENVIRON. HEALTH PERSPECTIVES Vol. 115 Issue 2, pp. 313–16 (Feb. 2007).
62. Burkholder, J., Libra, B., Weyer, P., Heathcote, S., Kolpin, D., Thorne, P.S., and Wichman, M., *Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality*, ENVIRON. HEALTH PERSPECTIVES Vol. 115 Issue 2, pp. 308-12 (Feb. 2007).
63. Willy Blackmore, "The Meat Industry Can't Stop Buying More and More Antibiotics," Takepart.com (Apr. 2015), *available at* http://www.takepart.com/article/2015/04/10/antibiotics-sales-livestock-rise.
64. Don Kelley Curriculum Vitae
65. Photograph, 3/6/15 Rogers Cattle
66. Photograph, 4/19/16
67. Photograph, 4/29/16
68. Photograph, 4/19/16
69. Photograph, 4/19/16
70. Photograph, 4/19/16
71. Photograph, 4/19/16
72. Photograph, 4/19/16
73. Photograph, 4/29/16
74. Photograph, Spring 15
75. Photograph, 4/19/16
76. 7/27/15 - Water Sample Test Results from SD Department of Health - North Dam
77. 7/27/15 Water Sample Test Results from the SD Department of Health - South Dam
78. 6/20/16 Water Sample Test Results from SD Department of Health - North Dam
79. Aerial View of Rogers and Waring Farm
80. Aerial View of Rogers and Waring Farm
81. Photograph, 7/4/16
82. Photograph, 4/4/15

83. Photograph, 11/3/15

Interveners reserve the right to call additional witnesses or present any other exhibits to rebut any testimony which has not yet been disclosed.

JOHNSON POCHOP & BARTLING

/s/Kelsea K. Sutton

Kelsea K. Sutton
405 Main St. | PO Box 149
Gregory, SD 57533
(605) 835-8391
kelsea@rosebudlaw.com
Attorney for Intervener Dakota Rural Action

CERTIFICATE OF SERVICE

The undersigned certifies that on the 29th day of August 2016, she served a copy of this **Witness Disclosure, Exhibit Disclosure, Letter and Exhibit Disc** by U.S. First Class mail and email upon the following parties of record:

Steven M. Pirner
Secretary of the Dep't of Environment & Natural Resources
Foss Building
523 E. Capitol
Pierre, SD 57501-3182
Steve.Pirner@state.sd.us

Ellie Bailey
DENR Feedlot Permit Program
1302 E. Highway 14, Suite 1
Pierre, SD 57501-8501
Ellie.Bailey@state.sd.us

Anthony Helland
1013 W. 20th St.
Sioux Falls, SD57105
tony.helland@gmail.com

David & Lisa Nehring
27551 452nd Ave.
Parker, SD 57053
nehringd@crown.edu

George Bogenschutz
46135 222nd St.
Nunda, SD 57050
mtnmach@itctel.com

Meghan Jarchow
2523 Princeton Ave.
Vermillion, SD 57069
meghann.jarchow@usd.edu

Roger & Ann Loeschke
48464 155th St.
Milbank, SD 57252
arloe@tnics.com

South Dakota Cattlemen's Ass'n *and*
South Dakota Dairy Producers

WILKINSON & WILKINSON
103 Joliet Ave., SE | PO Box 29
De Smet, SD 57231
todd@wslawfirm.net
cc: sddairyproducers@gmail.com

South Dakota Pork Producers Council *and*
Sonstegard Food Company
DONAHOE LAW FIRM, P.C.
401 E. 8th St., Suite 215
Sioux Falls, SD 57103
brian@donahoelawfirm.com

William Powers
512 W. Main St.
White, SD 57276
wjp@swcp.com

/s/Kelsea K. Sutton
Kelsea K. Sutton

Johnson
Pochop & Bartling
ATTORNEYS AT LAW

Stephanie E. Pochop
George F. Johnson
Amy R. Bartling
Kelsea K. Sutton

August 29, 2016

RECEIVED
SEP 01 2016
FEEDLOT PERMIT PROGRAM

Secretary Steven M. Pirner
Dep't of Environment & Natural Resources
Feedlot Permit Program
Foss Building
523 E. Capitol Ave.
Pierre, SD 57501-3182

Re: Witness List & Exhibits

Dear Secretary Pirner,

Please find enclosed with this letter a disc containing the exhibits my client intends to offer at the contested case hearing in September. I additionally provide the enclosed list of witnesses we intend to call during the hearing.

We will provide hardcopies of the exhibits in the following manner: one set to Judge Duenwald prior to the hearing; one set to be marked as exhibits at the hearing; and one set to the hearing for Secretary Pirner.

Sincerely,

Kelsea K. Sutton

Kelsea K. Sutton
Attorney for Dakota Rural Action

Cc: Client
/Enclosures

Johnson Pochop & Bartling
office: (605) 835-8391

405 Main Street | PO Box 149
Gregory, South Dakota 57533

email: office@rosebudlaw.com
fax: (605) 835-8742

Glenn Mayer Exhibits 1 through 47f

I hereby acknowledge that I have been advised by Lynn Mayer that he proposes to construct an animal feeding operation that may be within two or four miles of a residential site owned by me.

I hereby waive any objection to the construction of such operation and request that the Planning Commission and County Commission waive any restriction they may have in regard to location of such operation within any distance of my residence.

Dated: 4-1-99 Signed: Glenn J Mayer

BUFFALO COUNTY

APPLICATION #: 08-001

(Print or Type)
OWNER: Mayer Ranches Inc.

OWNER'S ADDRESS: 23438 Pheasant Ln Pukwana SD 57320

OWNER'S DAYTIME PHONE #: 605-844-4440

DATE OF BUILDING PERMIT REQUEST: 2/6/08

DESCRIPTION OF BUILDING PERMIT: Feed lot

REASON FOR BUILDING PERMIT DENIAL:

DATE OF DENIAL:

JOB ADDRESS:

LEGAL: NE-1/4

TOWNSHIP: 106-69 SECTION: 20

EXISTING USE OF PROPERTY: Farm land Ag

PRESENT ZONING CLASSIFICATION: Ag

PROPOSED ZONING CLASSIFICATION: Ag

SECTION OF ZONING ORDINANCE: 515

REASON FOR REQUEST: feed lot

LIST SPECIFIC HARDSHIPS:

X Variance Application

X Conditional Use Permit

__ Rezoning Permit

Applications will not be accepted nor acted upon until the following information has been provided by the applicant:

A) Detailed Site Plan (Refer to handout)
B) Location and Use of Adjacent Structures
C) Application Fee(s)

SCHEDULED FOR PLANNING COMMISSION ACTION (Date): 03-26-08

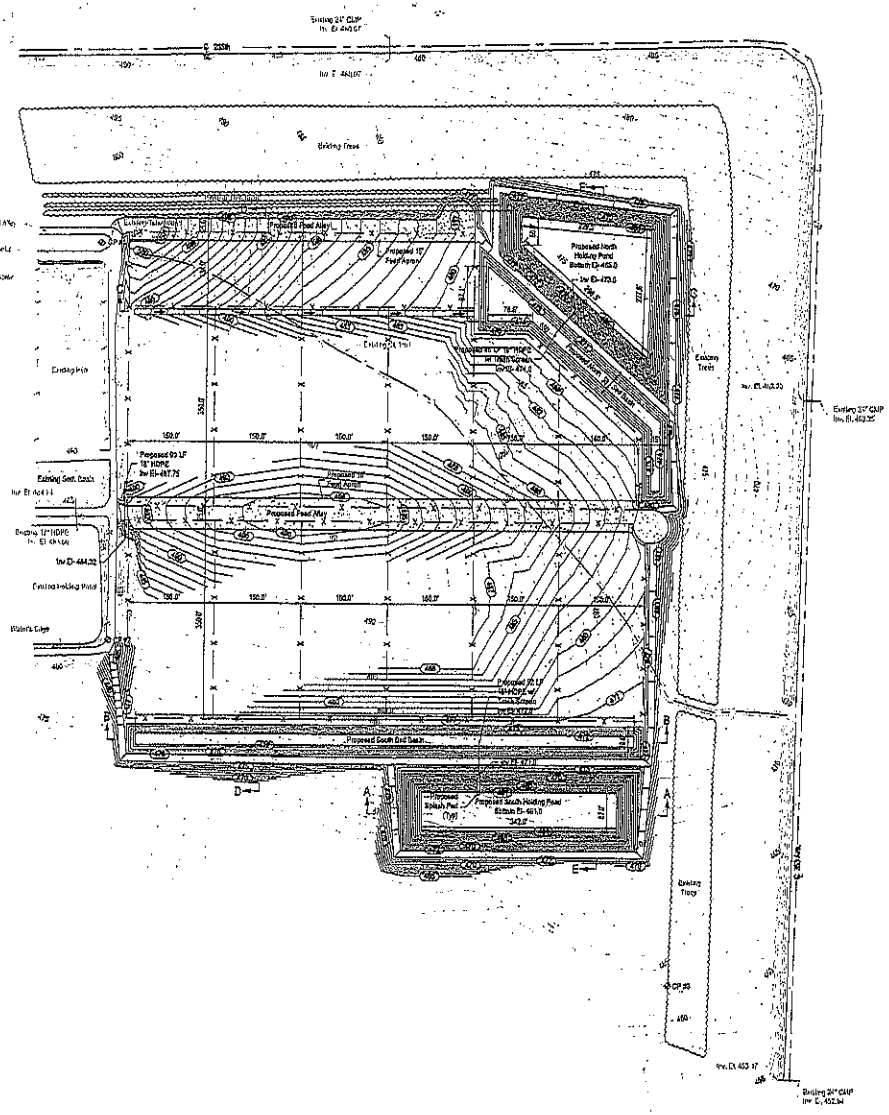
SCHEDULED FOR BOARD OF ADJUSTMENT ACTION (Date):

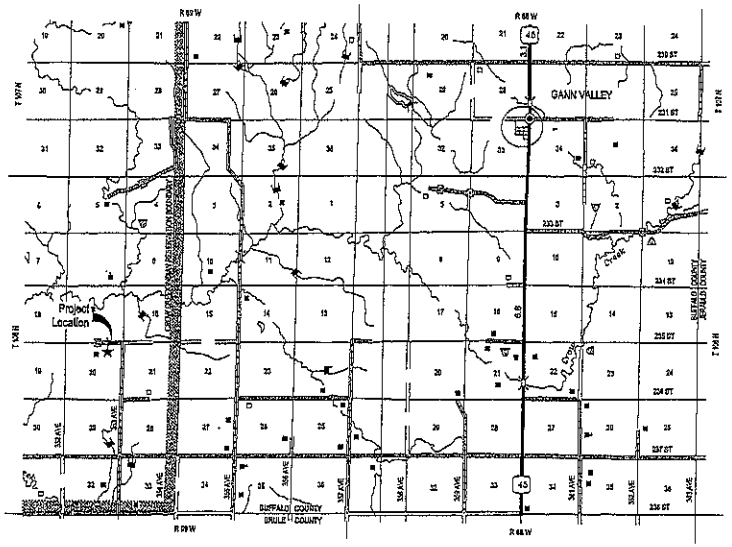
*TENTATIVE DATE (IF APPEALED): Final date announced at Planning Commission Meeting:

APPLICATION FEE: 10.00 CHECK #: 5866 RECEIPT #: 7301

The undersigned acknowledges/declares that all the facts and representations stated in this application are true and by signing, acknowledges the cost and the procedure for the processing of the application and certifies that the property described by the provided legal description, is not tax delinquent.

Name of Applicant/Owner	Date	Signature of Applicant/Owner	Date
Lynn Mayer	2/6/08	[signature]	2/6/08





Location Map

Scale: 1 inch = 1 mile

GRAPHIC SCALE

(IN FEET)
1 inch = 100 ft.

Legend

- Control Point
- Existing Fence
- Proposed Fence
- Existing Contour
- Proposed Contour
- Existing Trees
- Existing Concrete
- Existing Gravel
- Proposed Concrete
- Proposed Gravel

Control Table			
	Northing	Easting	Elev.
CP#1	10,000.00	20,000.00	500.00
CP#2	9,500.00	20,000.00	499.00
CP#3	9,000.00	20,000.00	485.00

Table of Estimated Quantities		
Item	Quantity	Units
Unclassified Excavation	29,021	CY
Unclassified Embankment*	41,177	CY
18" Clay Liner	6,819	CY
18" HDPE	180	LF
Concrete Splash Pad	7	CY
Trash Screen	2	EA

***Shrinkage Note:**
Cut and fill volume quantity figures of the earthwork construction quantities are determined by the Auditors land package. Based on available geotechnical data, fill quantities for this project have utilized a 30 percent shrinkage factor. Actual shrinkage factors will vary depending upon soil conditions, compaction equipment and construction techniques. The contractor is responsible for assembling available data and on-site conditions. Earthwork bid items shall be paid on a place specialty basis unless otherwise noted in the specifications.

Eisenbraun & Associates

Lynn Mayer Feedlot
Buffalo County, SD

Site Layout

Lynn Mayer Feedlot
NE 1/4, Section 20, T106N, R69W
Buffalo County, SD

Date	10/31/2006
Revised	10/31/2006
Drawn	SB
Reviewed	JAK
Approved	
Scale	04-Dec-0

SHEET NO. 1 of 3

BUILDING PERMIT APPLICATION

EACH BUILDING SITE MUST HAVE A SEPARATE SITE PLAN

OWNER

JOB ADDRESS

Applicant to complete numbered spaces only:

Job Address	RR1 Box 56 Pukwana S.Dak. 57370				
1. Legal Description	Township Par.	Section 20	Legal 106-69		
2. Owner	Mail Address		Zip	Phone	
Lynn Mayer	RI Box 56 Pukwana		57370	894-4440	
3. Contractor ?	Mail Address		Zip	Phone	
4. Architect or Designer	Mail Address		Zip	Phone	
Ken Real	520, 3rd Av. Brookings		57006	692-8754	
5. Use of Building					

6. Class of Work (Circle One) NEW ADDITION ALTERATION REPAIR MOVE REMOVE

7. Describe Work: Dept. of Environment and Natural Resources approval Acel lot Plan.

MAYER RANCHES, INC.
R.R. 1, BOX 56 PH. 605-894-4440
PUKWANA, SD 57370

78-4/914 188
1880136522

3347

DATE 3/18/99

PAY TO THE ORDER OF Buffalo Co. $ 10.00/100

Ten and 00/100 DOLLARS

Security features included. Details on back.

NORWEST BANKS
Norwest Bank South Dakota, N.A.
201 South Main
P.O. Box 209
Chamberlain, SD 57325

MEMO Zoning Permit Fee.

[redacted]

SAFETY PAPER

NOTICE

THIS PERMIT WILL EXPIRE IF WORK OR CONSTRUCTION AUTHORIZED IS NOT COMMENCED WITHIN (NINETY) 90 DAYS.

IF WORK OR CONSTRUCTION IS NOT SUBSTANTIALLY COMPLETED WITHIN (TWO) 2 YEARS OF ISSUANCE, THIS PERMIT WILL EXPIRE.

I HEREBY CERTIFY THAT I HAVE READ AND EXAMINED THIS APPLICATION AND KNOW THE SAME TO BE TRUE AND CORRECT. ALL PROVISIONS OF LAWS AND ORDINANCES GOVERNING THIS TYPE OF WORK WILL BE COMPLIED WITH WHETHER SPECIFIED HEREIN OR NOT. THE GRANTING OF A PERMIT DOES NOT PRESUME TO GIVE AUTHORITY TO VIOLATE OR CANCEL THE PROVISIONS OF ANY OTHER STATE OR LOCAL LAW REGULATING CONSTRUCTION OR THE PERFORMANCE OF CONSTRUCTION.

Signature of Contractor or Authorized Agent — Date

Signature of Owner (If Owner Builder) — Date

Type of Const.	Storm Water Certification
(Total) Sq. Ft.	No. of Stories
Use Zone	Animal Waste System Certification
No. of Dwelling Units	OFF-STREET PARKING SPACES: Covered Uncovered

FOR COUNTY OFFICIALS USE ONLY -
WHEN PROPERLY VALIDATED (IN THIS SPACE) THIS IS YOUR PERMIT

THE ABOVE APPLICATION IS HEREBY APPROVED

BUILDING PERMIT NUMBER:

Zoning Administrator or Authorized Representative — Date

BUFFALO COUNTY

Evelyn Wulff, Director of Equalization
P.O. Box 175
Gann Valley, SD 57341
PH. - 605/293-3286
FAX - 605/293-3240

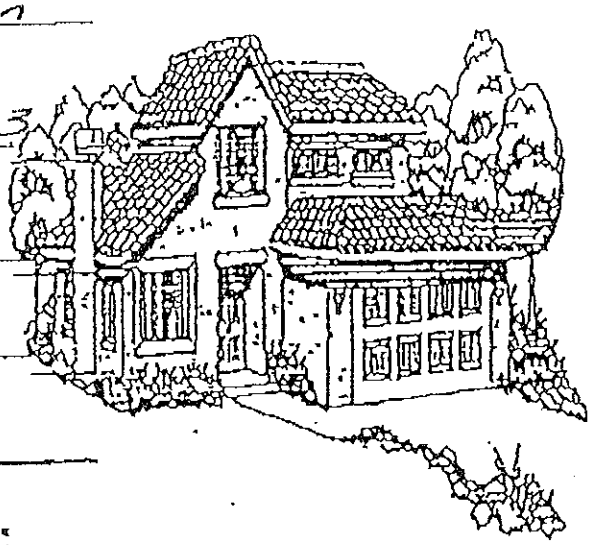
ATTN: A. J. Swanson

COMPANY: 605-743-2073

FROM: Evelyn

DATE: 6-5-08

NO. OF PAGES: 4
(incl. cover sheet)



MESSAGE:

Glenn Mayer requested that I fax those planning + zoning Commission minutes to you.

FAX COVER SHEET

MINUTES OF THE PLANNING AND ZONING BOARD, April 24, 2008.

Chairman Clayton Knippling brought the meeting to order with Board members Allen Fuegen, Jack Abernathy, Linda Ness and Lloyd Lutter present. Also attending were States Attorney Steven Fox and approximately twenty citizens present.

Lloyd Lutter explained purpose of meeting. States Attorney Fox explained rules and regulations of Zoning Board and stipulations of what they can do. The Board needs to approve or deny the requested conditional use permit and approve or deny a variance to allow a distance of below the two mile minimum to other residential dwellings.

Lynn Mayer presented feedlot expansion plans and showed maps of proposed feedlot and wind and odor projections. He explained methods of containing waste products and stated there is no drainage with system he is using. There is no shallow aquifer or water in area of feedlot. At the present time he does not have cattle in the feedlot during the summer months but is possible to do that.

Glenn Mayer stated he owns land with a house located within the two mile limit. He is very concerned that the value of his land would decrease with feed yards on two sides of his land. He is also concerned with the road traffic, what it will do to the county roads and regulations as per the Buffalo County Zoning Ordinance. His son raises pheasants and the neighboring feedlot would be a detriment to the sport recreation business. He indicated he has retained counsel and will do what he has to do to maintain his land value.

Other comments from the public present at the meeting included limiting a family to current practices would hinder county growth; liability and responsibility if regulations are not followed, and whether spreading manure needed neighbor's written agreement.

The Board discussed legal ramifications of their decision and whether approval variance affected future zoning requests.

The Planning and Zoning Commission specifically finds that public notice and all other notice was given as required under the zoning statutes and the public was fairly and fully informed of the hearing.

The Planning and Zoning Commission specifically finds that a written application for variance and conditional use was submitted and the applicant has demonstrated special conditions and circumstances, which exist, which are peculiar to the land involved and are not applicable to other land structures or buildings in the same district, that literal interpretation of the provisions of this ordinance would deprive the applicant of rights commonly enjoyed by other properties in the same district under the terms of this ordinance and that special conditions and circumstances do not result from the actions of the applicant and the granting of the variance or conditional use request will not confer on the applicant any special privilege that is denied by this ordinance to other lands in the same district.

After having considered all the factors, having found that those factors support the granting of the variance and the conditional use, and after having considered the testimony and the facts and the evidence offered the Commission finds the variance is justified, which would allow the animal waste facilities and/or feedlot closer that two miles to a residential dwelling of another landowner.

The Planning and Zoning Commission after having considered the testimony, the facts, and the evidence offered does hereby grant the variance subject to fulfilling all Section 515 requirements as set out below, allowing the feedlot application and particularly allowing it under facts where waste facilities would be closer than two miles to a residential dwelling of another landowner. A motion to grant the variance subject to the Section 515 condition was made by Allen Fuegen and seconded by Lloyd Lutter concerning the application of Lynn Mayer, d/b/a Mayer Ranches, Inc. Vote: Fuegen-Aye, Lutter-Aye, Abernathy-Aye, Ness-Aye, Knippling-Aye. Motion carried.

A motion to grant the conditional use subject to fulfilling all Section 515 requirements, after granting of the above variance was made by Lloyd Lutter seconded by Allen Fuegen concerning the application of Lynn Mayer, d/b/a Mayer Ranches Inc. and the Planning and Zoning Commission specifically finds from the testimony and the evidence and the facts offered that granting the application of conditional use is supported by the facts and the Planning and Zoning Commission has considered each of the applicable requirements in the Buffalo County Zoning Ordinance and all of the requirements set out in the zoning ordinance for Buffalo County that are required before the granting of the conditional use and such conditional use is granted after considering each of those issues and the facts and evidence presented at the hearing. Vote: Lutter-Aye, Fuegen-Aye, Abernathy-Aye, Ness-Aye, Knippling-Aye. Motion carried.

The granting of the variance and the conditional use are specifically done conditioned upon the applicant fulfilling the requirements of the Department of Natural Resources, including those set out in Section 515 of the Buffalo County Zoning Ordinance that each of the factors under Section 515 was discussed with the landowner and provisions have been made, will be fulfilled as required by the Department of Natural Resources, or are in the process of being made based upon the zoning conditional use being approved and variance being approved, and that the landowner understands and is aware that each of those requirements must be fully met as a requirement for conditional use approval and variance.

The Commission specifically finds and certifies compliance with the specific rules governing individual conditional uses and that satisfactory provision and arrangement has been made concerning all applicable subsections of Article 10, number 6, and specifically the variance and conditional use is in general compatible with adjacent properties and other properties in the district.

The Commission finds granting of the variance and the conditional use is based upon a finding that the strict application to the ordinance would produce undue hardship, such

hardship is not shared generally by other properties in the same zoning district and the same vicinity, the authorization of such variance and conditional use will not be substantial detriment to adjacent property and the character of the district will not be changed by granting the variance and conditional use, and the granting of such variance and conditional use is based upon reasons and facts presented at the hearing and the demonstration of exceptional hardship of the landowner including but not limited to the fact that adding to the present feedlot is the only environmental, feasible and reasonable way to proceed, that the use of the roads is reasonable, that there is no evidence of a meaningful change in the odor present or that odor would increase to the detriment of other landowners since there is presently odor from other operations or previously approved feedlots and the landowners own use of their property, and the Commission finds the variance is granted based on the facts as distinguished from purposes of convenience, profit and caprice or speculation and possible future use of other land in the area.

The Planning and Zoning Commission further finds the condition or situation of the property or the intended use of property concerned is not of so general or recurring nature as to make reasonably practical the formulation of a general regulation to be adopted as an amendment of the ordinance.

By granting this variance, the Commission finds that granting this variance does not confirm on anyone in the future the right to consider this variance as grounds for the recommendation or issuance or approval of any other future variances.

In granting the variance and this conditional use, the Commission finds that granting such variance and conditional use are not adverse to health, safety and welfare of others in the county based upon the facts and evidence presented to the Commission.

The Planning and Zoning Commission finds that it was and is empowered under the ordinance to recommend approval, approval with conditions, or denial of the conditional use or any variance. The Commission specifically finds its recommendation will not adversely affect the public interest.

A Board of Adjustment Meeting was scheduled for May 16, 2008, at 8:00 P.M.

Fuegen moved to adjourn the meeting, seconded by Lutter, motion carried, with all voting aye.

Elaine Wulff
Acting Secretary

We are appealing the decision of the zoning and planning board on April 24 concerning the Mayer Ranches feedyard expansion.

Glenn J Mayer
Delilah Mayer
Mary Mayer
Robin Mayer

BUFFALO COUNTY

Evelyn Wulff, Director of Equalization
P.O. Box 175
Gann Valley, SD 57341
PH. - 605/293-3286
FAX - 605/293-3240

ATTN: A. J. Swanson

COMPANY: 605-743-2073

FROM: Evelyn

DATE: 05-05-08

NO. OF PAGES: 4
(incl. cover sheet)

MESSAGE:

Final version of Board of Adjustments decision. May 16th meeting.
Correction made on motion one + two from second by Donita Loudner corrected to be second by Ronald Peterson

FAX COVER SHEET

MINUTES OF BOARD OF ADJUSTMENT MEETING, May 16, 2008

Chairman, Ronald Petersen called the meeting to order at 8:00 PM with members Donita Loudner and Lloyd Lutter present. Others attending were States Attorney Steven Fox and approximately twenty citizens.

Lynn Mayer d/b/a Mayer Ranches, Inc. presented information for their proposed feedlot expansion project located in the NE ¼ Sec. 20, Twp. 106 Rg 69.

Glenn Mayer and family presented their opposition against the proposed feed lot.

The Board of Adjustment specifically finds that public notice and all other notice was given as required under the zoning statutes and the public was fairly and fully informed of the hearing.

The Board of Adjustment specifically finds that a written application for variance and conditional use was submitted and that the applicant has demonstrated special conditions and circumstances, which exist, which are peculiar to the land involved and are not applicable to other land structures or buildings in the same district, that literal interpretation of the provisions of this ordinance would deprive the applicant of rights commonly enjoyed by other properties in the same district under the terms of this ordinance and that special conditions and circumstances do not result from the actions of the applicant and the granting of the variance or conditional use request will not confer on the applicant any special privilege that is denied by this ordinance to other lands in the same district.

After having considered all the factors, having found that those factors support the granting of the variance and the conditional use, and after having considered the testimony and the facts and the evidence offered the Board of Adjustment finds the variance is justified, which would allow the animal waste facilities and/or feedlot closer than two miles to a residential dwelling of another landowner.

The Board of Adjustment after having considered the testimony, the facts, and the evidence offered does hereby grant the variance subject to fulfilling all Section 515 requirements as set out below allowing the feedlot application and particularly allowing it under facts where waste facilities would be closer than two miles to a residential dwelling of another landowner. A motion to grant the variance subject to the Section 515 condition was made by Lloyd Lutter and seconded by Ronald Petersen concerning the application of Lynn Mayer, d/b/a Mayer Ranches, Inc. Vote: Lloyd Lutter-Aye, Donita Loudner-Aye, Ronald Petersen-Aye. Motion carried.

A motion to grant the conditional use subject to fulfilling all Section 515 requirements, after the granting of the above variance was made by Lloyd Lutter and seconded by Ronald Petersen concerning the application of Lynn Mayer, d/b/a Mayer Ranches, Inc., and the Board of Adjustment specifically finds from the testimony and the evidence and the facts offered that granting the application of conditional use is supported by the facts,

and the Board of Adjustment has considered each of the applicable requirements in the Buffalo County Zoning Ordinance and all of the requirements set out in the zoning ordinance for Buffalo County that are required before the granting of the conditional use and such conditional use is granted after considering each of those issues and the facts and evidence presented at the hearing. Vote: Lloyd Lutter-Aye, Donita Loudner, Aye, Ronald Petersen-Aye. Motion carried.

The granting of the variance and the conditional use are specifically done conditioned upon the applicant fulfilling the requirements of the Department of Natural Resources, including those set out in Section 515 of the Buffalo County Zoning Ordinance. That each of the factors under Section 515 was discussed with the landowner and provisions have been made, will be fulfilled as required by the Department of Natural Resources, or are in the process of being made based upon the landowner understands and is aware that each of those requirements must be fully met as a requirement for conditional use approval and variance.

The Board of Adjustment specifically finds and certifies compliance with the specific rules governing individual conditional uses and that satisfactory provision and arrangement has been made concerning all applicable subsections of Article 10, number 6, and specifically the variance and conditional use is in general compatible with adjacent properties and other properties in the district.

The Board of Adjustment finds granting of the variance and the conditional use is based upon a finding that the strict application to the ordinance would produce undue hardship, such hardship is not shared generally by other properties in the same zoning district and the same vicinity, the authorization of such variance and conditional use will not be a substantial detriment to adjacent property and the character of the district will not be changed by granting the variance and conditional use, and the granting of variance and conditional use is based upon reasons and facts presented at the hearing and the demonstration of exceptional hardship of the landowner including but not limited to the fact that adding to the present feedlot is the only environmental, feasible and reasonable way to proceed, that the use of the roads is reasonable, that there is no evidence of a meaningful change in the odor present or that odor would increase to the detriment of other landowners since there is presently odor from other operations or previously approved feedlots and the landowners own use of their property, and the Board of Adjustment finds the variance is granted based on the facts as distinguished from purposes of convenience, profit and caprice or speculation and possible future use of other land in the area.

The Board of Adjustment further finds the condition or situation of the property or the intended use of property concerned is not of so general or recurring nature as to make reasonably practical the formation of a general regulation to be adopted as an amendment of the ordinance.

By granting this variance, the Board of Adjustment finds that granting this variance does not confirm on anyone in the future the right to consider this variance as grounds for the recommendation or issuance or approval of any other future variances.

In granting the variance and this conditional use, the Board of Adjustment finds that granting such variance and conditional use are not adverse to health, safety and welfare of others in the county based upon the facts and evidence presented to the Board of Adjustment.

The Board of Adjustment finds that it was and is empowered under the ordinance to recommend approval, approval with conditions, or denial of the conditional use or any variance. The Board of Adjustment specifically finds its recommendation will not adversely affect the public interest.

A motion to allow Attorney Fox to advise Secretary Evelyn Wulff with the legal wording for the variance and conditional use motions was made by Lloyd Lutter and seconded by Donita Loudner. Vote: Lloyd Lutter-Aye, Donita Loudner-Aye, Ronald Petersen-Aye. Motion carried.

Donita Loudner made a motion to adjourn seconded by Lloyd Lutter. Vote: Donita Loudner-Aye, Lloyd Lutter-Aye, Ronald Petersen-Aye. Motion carried.

Evelyn Wulff
Secretary

First Judicial Circuit Court

Circuit Administrator
Kim L. Allison
Chief Court Services Officer
Francis McCabe
Circuit Assistant
Joan Novak

Bruce V. Anderson
Circuit Court Judge
P.O. Box 128
Lake Andes, SD 57356
Phone: (605) 487-7664
Fax: (605) 487-7615

Melissa A. Odens, RPR
Official Court Reporter
P.O. Box 36
Armour, SD 57313
Phone: (605) 724-2145
Fax: (605) 724-2508

Presiding Judge
Arthur L. Rusch
Circuit Judges
Glen W. Eng
Steven R. Jensen
Bruce V. Anderson
Timothy W. Bjorkman
Sean M. O'Brien
Magistrate Judges
Patrick W. Kiner
Tami A. Bern

COPY

September 26, 2008

Mr. Arvid J. Swanson, CEO
Arvid J. Swanson Law Office, PC
27452 482 Avenue
Canton, SD 57013

Mr. Albert Steven Fox
Sundall, Schaub & Fox, PC
PO Box 547
Chamberlain, SD 57325-0547

Re: Mayers v. Buffalo County – Buffalo County CIV. 08-08

Dear Gentlemen:

Enclosed each of you will find my Memorandum Decision and Order in the above-entitled case. Counsel for the Respondent shall prepare the appropriate Order and Judgment.

Sincerely,

Hon. Bruce V. Anderson
Circuit Court Judge

Encl.
cc: Doris Juhnke, Buffalo County Clerk of Courts (w/original decision for filing)

STATE OF SOUTH DAKOTA) IN CIRCUIT COURT
:SS
COUNTY OF BUFFALO) FIRST JUDICIAL CIRCUIT

* * * * * * * * * * * *

GLENN J. MAYER AND DELILAH MAYER,
Petitioners,
v.
BUFFALO COUNTY BOARD OF COMMISSIONERS
(ACTING AS THE BOARD OF ADJUSTMENT),
Respondent.

CIV. 08-8

MEMORANDUM DECISION

* * * * * * * * * * * *

This matter came before the Court for trial on the Petitioners' Petition for Writ of Certiorari on the 21st day of August, 2008, at 9:30 a.m. at the courthouse in Chamberlain, South Dakota. The Petitioners appeared with their counsel, A.J. Swanson, attorney at law of Canton, South Dakota. And the Respondents appeared with their attorney, Albert (Steven) Fox, attorney at law of Chamberlain, South Dakota.

FACTS

The Court makes the following Findings of Fact.

In 1997 Buffalo County adopted a Comprehensive Plan and Zoning Ordinance in accordance with South Dakota statutes. This ordinance was passed in response to fear that out-of-state interests were planning on purchasing, or had already purchased, land in the county in order to commence operation of large-scale animal feeding operations. Prior to 1997 Buffalo County had not passed any zoning or other land use controls.

The zoning ordinance that was passed was admitted into evidence as Exhibit 1. The Ordinance was amended in 1999 and those amendments are attached to the exhibit.

The Petitioners in this case, Glenn and Delilah Mayer, own and farm rural agricultural land adjacent to Glenn's brother, Lynn Mayer. Prior to the adoption of the Zoning Ordinance Lynn Mayer operated a cattle feeding operation on his property in the Northeast Quarter of Section 20, Township 106, Range 69 in Buffalo County, South Dakota. The Petitioners' property is located in the Southwest Quarter of Section 21 adjacent to the east of Lynn's property.

Shortly after passage of the Zoning Ordinance in 1998 Lynn Mayer proposed to build an animal feeding operation near his original feedlot area in Section 20. Glenn testified that this operation was something that was done so that Lynn could move his existing cattle feedlot out of the creek and that Lynn had obtained grant money for that purpose. To get this done Lynn was required to apply to the county zoning officials to obtain a building permit and other approval by the zoning authorities for the construction of the new feedlot. As part of his request Lynn submitted a signed statement from Glenn

Mayer whereby Glenn acknowledged that Lynn as going to construct an animal feeding operation within two or four miles of a residential site owned by Glenn and waived any objection to the construction of that feedlot. (See Exhibit A) The county officials granted Lynn's request to construct his feedlot in 1999.

Section 515 of the Buffalo County Zoning Ordinance provides regulations on commercial feedlot and animal feeding operations (hereinafter AFO). Among the various requirements for an AFO is that such facility shall not be located within a certain distance (hereinafter the "separation distance") from any residential dwelling. As to the above-mentioned separation distance, Section 515 f was amended in 1999 to read as follows:

> "Animal waste facilities shall be located no closer than four (4) miles from any residential dwelling for swine operations and two (2) miles for cattle feeding operations. One (1) dwelling unit is allowed on the facility site. The owner of a residential dwelling may request the planning commission to review the facility and the commission may, by variance, waive or decrease the required separation distance. The waiver must then be recorded with the county register of deeds in order that any future owners can be informed. The distance provided for herein shall be measured as a radius from the waste facility."

In 2008 Lynn commenced plans to expand his cattle feeding operations. On April 8, 2008 he filed an application for variance and conditional use permit with the county. (See Exhibit 4) Under Section 507 of the ordinance a conditional use permit may be granted in an agricultural district for an animal feeding operation. In the definition of terms on page one of the ordinance, animal feeding operation is defined and the proposed feedlot of Lynn Mayer fits within that definition. Under Section 1003, the Planning and Zoning Commission has the authority to "recommend for approval or denial" any request for a conditional use or variance as well as other special questions upon which the Planning and Zoning Commission is authorized by the ordinance to decide. Since Lynn Mayer's proposed feedlot required both a conditional use and a variance, the application that was filed (Exhibit 4) was heard by the Planning and Zoning Commission on April 24, 2008.

Lloyd Lutter, a Buffalo County commissioner and a member of the Planning and Zoning Commission testified that he attended the Planning and Zoning Commission hearing on the variance and conditional use request. He testified that there were a substantial number of people present at the meeting. He further testified that hey gave ample opportunity for all sides to express their positions in favor of and against the proposed feedlot expansion, and provide evidence to the commission supporting their positions. None of the participants on either side were limited, in any way, as to presentation of their positions. He testified that it was his opinion, based on a reading of the ordinance, that the commission could reduce the separation distance required in 515(f) by one of two ways, those being a written waiver by any owner of a residential dwelling within the separation distance, or by the commission granting a variance based upon a request of the landowner and on all of the circumstances.

Glenn Mayer also testified at trial in this matter as well as before the Planning and Zoning Commission in April and the Board of Adjustment in May. He testified that he was not limited or confined in any manner as to his comments or presentation of evidence on the issues before either the board or the commission. He testified that the new feedlot proposed by Lynn would be only 3,000 feet from his current residential property in Section 21. He further provided testimony that in 1972 he lived on the property in question but moved to Chamberlain so that his children could go to school there. However, he still continues to farm the land adjoining the feedlot; maintains residential buildings on the property; and spends a substantial amount of time there. There is also another residential dwelling that his hired hand resides in. There are phone lines, water, sewer, and other utilities for both residential buildings. Glenn applied for a building permit on April 8, 2008 in order to build a new home on the property in question, and testified it had been, and continues to be, his intent to build a permanent residential dwelling on his property. (See Exhibit D) Previously he had installed water and electric lines on the property in anticipation of building his new home.

There are two other large feedlots in the immediate area of Glenn's property, one being a 5,000-head operation that is exactly two miles from his property. The Planning and Zoning Commission also considered materials provided by Lynn from the DENR, plans, various maps, and the testimony from an air-quality expert from South Dakota State University in making its recommended approval.

Following the meeting of the Planning and Zoning Commission on April 24th the commission approved the conditional use and variance request. In their minutes (Exhibit 2) they stated their findings. Notable is the fact that the commission made, among others, the following findings:

> "Applicant has demonstrated special conditions and circumstances, which exist, which are peculiar to the land involved;
>
> ***
>
> Authorization of such variance and conditional use will not be substantial detriment to adjacent property and the character of the district will not be changed; and
>
> ***
>
> There is no evidence of a meaningful change in the odor present or that odor would increase to the detriment of other landowners since there is presently odor from other operations or previously approved feedlots and the landowners' own use of their property."

The commission further found that granting the variance was not adverse to the health, safety and welfare of others in the county based upon facts and evidence presented to the commission.

Immediately after approving Lynn Mayer's request the Planning Commission set a Board of Adjustment meeting for May 16, 2008. The Board of Adjustment met on the

date set. Once again, all of the parties involved were allowed to present their positions, including any evidence that they had. The Board of Adjustment made findings similar to the Planning and Zoning Commission.

At trial on this matter, Lloyd Lutter testified that it was his understanding of the ordinance that the Planning and Zoning Commission could hear variances and make recommendations to the Board of Adjustment. It should be noted that despite the fact that the Planning and Zoning Commission immediately set a hearing with the Board of Adjustment following its decision on Lynn's application, the Petitioners filed an appeal of the Zoning and Planning Board's decision on April 24th. (See Exhibit B) Glenn testified that he handed Exhibit B to the director of equalization within days following the Planning and Zoning Board's decision. He further testified that no one on behalf of the county has ever responded to the appeal letter set forth in Exhibit B. Moreover, the Board of Adjustment hearing was set for May 16th during the Commission hearing on April 24th prior to the time Glenn had filed Exhibit B.

Following the decision of the Board of Adjustment on May 16, 2008, Petitioners' filed this Petition for Writ of Certiorari.

DECISION

Appeals from boards of adjustment are considered by circuit courts under writs of certiorari, and therefore, judicial review is limited. *Elliot v. Board of County Commissioners of Lake County*, 2005 SD 92, 703 NW2d 361, 367 (see also SDCL 11-2-61 and SDCL 21-31-8). On a petition for certiorari the Court's review is limited to deciding whether the Board of Adjustment had jurisdiction over the matter and whether it pursued in the regular manner the authority conferred upon it. A Board's actions will be sustained unless it did some act forbidden by law or neglected to do some act required by law. *Jensen v. Turner County Board of Adjustment*, 2007 SD 28, 730 NW2d 411.

WAS PROPER PROCEDURE FOLLOWED BY THE COUNTY?

The ordinance in the present case provides that, as to commercial feedlots and animal feeding operations, certain performance standards must be met. Most important in this case is Section 515(f) that prohibits the construction or operation of a feedlot or animal waste facility for cattle feeding operations within two miles of a residential dwelling. This Court found on the record at trial that the property belonging to Glenn Mayer is considered a "residential dwelling" as contemplated by the ordinance.

The Planning and Zoning Commission has authority to hear and recommend for approval any request for a variance as per Section 1003 (B). Under Section 1107 (C) the Board of Adjustment has the power to hear requests for variances. Under the ordinance then the Board of Adjustment has the final authority and decision on any request for a variance. SDCL 11-2-53 provides that the Board of Adjustment shall hear and decide all appeals and authorize variances in specific cases. Section 1003 (A) of the ordinance grants the Planning and Zoning Commission the power to hear and make

recommendations on requests for conditional uses and recommend their approval or denial. SDCL 11-2-17.3 provides that a county zoning ordinance that authorizes a conditional use shall specify the approving authority to hear and decide requests for such conditional uses.

In the present case under South Dakota law the Board of Adjustment was required to hear and decide the variance request and the Planning Commission was authorized to hear and recommend approval or denial of the conditional use permit request. That is apparently what happened based upon the evidence that was presented in this case. The Planning Commission met on April 24, 2008, and took extensive evidence and public comment concerning the request for the conditional use permit and the variance. They approved both subject to certain safeguards and conditions being met. The Board of Adjustment then convened on May 16th and heard additional evidence and public comment. Thereafter the Board adopted the Commission's recommendation and approved the variance and adopted the recommendation of the Planning and Zoning Commission to approve the conditional use permit. This Court finds that according to the ordinance both Boards had jurisdiction and there is nothing illegal about the procedure that was followed, as the Board of Adjustment ultimately made the final decision on the variance request. This court sees nothing in South Dakota law that prohibits consideration of the conditional use by both boards as was done in this case.

Petitioners further claim that Section 1107(f) of the Zoning Ordinance is contrary to state law because it authorizes and appeal of the Board of Adjustment decision to the Buffalo County Commissioners. This ordinance has not been updated to comply with the legislative changes in 2000, which provided that appeals from the Board of Adjustment were to go to the Circuit Court by way of a Petition for Writ of Certiorari. (See SDCL §§11-2-61-62) Petitioners also claim that there is some confusion as to the original jurisdiction conferred upon either the Board of Adjustment or the Planning and Zoning Commission. This Court finds that the ordinance in question allows for the Planning and Zoning Commission to hear and make recommendations concerning variances and conditional use permits. The Board of Adjustment may "authorize upon appeal in specific cases such variance from terms of the ordinance as will not be contrary to the public interest." SDCL 11-2-53. Glenn Mayer had filed an appeal shortly after the Planning and Zoning Commission made its decision in April 2008.

The fact that the ordinance continues to provide for an appeal to the County Commissioners is of no consequence in this case because the Petitioners properly followed the revised statutes, particularly SDCL 11-2-61 & 62.

WHETHER GLENN WAS REQUIRED TO CONSENT TO THE VARIANCE BEFORE IT WAS GRANTED

The language in 515 (f) is difficult to interpret and this court stated on the record at trial it's opinion that it was poorly drafted. It generally provides that an animal feeding operation for cattle may not be located within two miles of a residential dwelling. It does provide for an exception by variance. The confusion arises from the language that

provides that "the owner of a residential dwelling may request the commission to review the facility and that the commission may, by variance, shorten the separation distance required".

The County argues that the ordinance provides that an animal feeding operation may not be located within a certain distance of a residential dwelling and that the Planning and Zoning Commission and the Board of Adjustment may, by variance, waive or decrease the required separation distance. The Petitioner claims that the language requires consent by a landowner who lives within the stated separation distance, that distance depending on whether the AFO is for swine or cattle.

In interpreting statutes the Court is confined to follow certain rules of construction and interpretation. The language expressed in the statute is the paramount consideration in determining a statute's meaning. *Goetz v. State*, 636 NW2d 675 (SD 2001). If the words and phrases in a statute have plain meaning and effect, the Court should simply declare their meaning and not resort to statutory construction. *Id.* The ordinance in question is vague and unclear. The Court is also required to consider the ordinance as a whole in its interpretation.

When considering Section 515 (f) of the Zoning Ordinance, the Court must determine if it is required that the owner of a residential dwelling located within the separation distance of two or four miles must request the Planning Commission to review this facility before a variance request can be considered, or if the County can simply consider a variance without an adjoining landowner having made a request. The Court must also determine if the language in the statute concerning "owner of a residential dwelling" includes a person such as Glenn Mayer or if it could include the owner of the feedlot, Lynn Mayer, who also resides within the separation distance. In the present case the County interpreted this ordinance in question to mean that a variance could be granted in one of two ways, the first being by consent of the neighbor, and the second being by the operator's request that the Commission consider the variance in the absence of such consent.

In the administrative agency context, decisions of an administrative agency concerning the interpretation of its own regulations need not be accepted if the interpretation is inconsistent with the statute under which the regulations were promulgated or plainly inconsistent with the wording of the regulation. *Oglala Sioux Tribe v. Andrus*, 603 F2d 707. However, the Court is unaware of any decisional authority or rule which would apply to a County's ability to interpret its own ordinance and whether or not the Court should give any deference to that interpretation.

When the Court considers the proposed interpretation by Petitioners, it would appear that the only way an AFO or animal waste facility could be located within the separation distance provided by 515(f) is if the neighbor "residential dwelling" owner requested the Commission to condnct a review of the facility to determine if a variance could be granted. Petitioners' interpretation of this statute requires that with respect to the phrase concerning "residential dwelling owner may request" be read conjunctively

with the phrase "the commission may, by variance waive or decrease" the separation distance. That is, the neighboring landowner would be required to request a review of the facility and the County would approve a variance. The words "and" or "or" are often misused in drafting statutes. *Sutherland* provides the following passage:

> "Where two or more requirements are provided in a section and it is the legislative intent that all of the requirements must be fulfilled in order to comply with the statute, the conjunctive "and" should be used. Statutory phrases separated by the word "and" are usually to be interpreted in the conjunctive. When a failure to comply with any of the requirement imposes liability, the disjunctive "or" should be used. Generally, courts presume that "or" is used in a statute disjunctively unless there is clear legislative intent to the contrary. *** While there may be circumstances which call for an interpretation of the word "and" and "or", ordinarily these words are not interchangeable. The terms "and" and "or" are often misused in drafting statutes. The inappropriate use of these words is found in many statutory enactments. The literal meaning of these terms should be followed unless it renders the statute inoperable or the meaning becomes questionable." 1A Sutherland Statutory Construction §21:14 (6th Ed.)

In this case using a conjunctive interpretation brings the meaning of the ordinance into question. The statute does not clearly show an intent that a neighboring landowner would have the right to veto a neighbor's use of his property. A reasonable interpretation of the ordinance would allow the owner of a proposed animal feeding operation to apply for a variance with or without the consent of the landowner. At least an owner of an AFO or animal waste facility should be able to initiate the process to obtain a variance as opposed to a neighboring residential dwelling owner requesting the Commission to "review the facility" before any action could be taken to exploit economic opportunity on the property.

This peculiar language does not indicate who may be considered the owner of a residential dwelling in the context of the entire Section 515(f). Many questions are left unanswered by this language such as what would happen if, such as in this case, there are multiple persons who own residential dwellings within the separation distance. Can any one of those multiple owners initiate the process for a variance request without the consent of the other adjoining residential dwelling owners? Can the proposed AFO owner, if he also has a residential dwelling in the separation distance, make the request? Could Lynn and Glenn Mayer's father, who lives in the separation distance, request the review to initiate the variance request process? It is worth noting, for interpretation purposes that "owner of residential dwelling" is stated in the singular as opposed to the plural, leading this court to believe that any residential dwelling owner in the separation distance could commence the process for a variance request. Once the process is commenced in such a fashion, it appears the Board has the authority to grant the variance. Based upon the language of 515(f) as a whole, the answer to the above questions would be in the affirmative. Consequently, this Court determines that Lynn Mayer, as the

owner of a residential dwelling in the separation distance is authorized to request the review of the facility.

This Court finds that the intent and interpretation of the ordinance is as proposed by the Respondent County in this case, and a variance may be obtained by being granted, following a hearing, by the Board of Adjustment, or by consent of the neighboring landowner who owns a residential dwelling within the separation distance. Consequently, the Court finds that the County had proper jurisdiction when it considered the variance request without the consent of Glenn Mayer and that it did not act improperly or illegally.

WHETHER THE FINDINGS OF THE COUNTY BOARD OF ADJUSTMENT AND THE PLANNING AND ZONING COMMISSION WERE SUFFICIENT

Petitioner also raises the issue that the minutes of the Planning Commission and the Board of Adjustment contained nothing more than legal conclusions. Further, the Petitioner argues that since the minutes are inadequate to show the County's reasoning and basis for granting the conditional use and variance, this Court is not able to properly review whether the actions of the County were proper.

There is nothing in South Dakota law that specifically provides what detail is to be included in the County's findings in granting a conditional use or a variance. This Court is of the opinion that the county officials present at the meeting were best suited to determine if the elements necessary to grant a variance or conditional use permit were properly presented at their hearings. Although a verbatim transcript of their discussion and findings as well as the evidence of the proponents and opponents to the proposed feedlot would be beneficial to the Court, such is not required under the current statutes of South Dakota, nor will it be required by this Court.

This court is prohibited from usurping the Board's administrative function and expertise in dealing with zoning problems of the community. *Cole v. Board of Adjustment of the City of Huron*, 616 N.W.2d 483,488 (SD 2000); and *Falvo v. Kerner*, 222 A.D. 289, 225 N.Y.S. 747, 749 (1927) (stating that "[t]he determination of the board was an administrative function, which should not be interfered with by the courts in the absence of proof that the board had abused the discretion with which it was clothed by the ordinance creating it."); *American Fletcher*, 205 N.E.2d at 324 (noting "it must be recognized by the trial court that the Board is an administrative body especially expertise in the zoning problems of its particular jurisdiction.").

The Board has wide discretion in deciding whether or not to grant a variance to a zoning ordinance, and in reviewing that decision, the circuit court may not substitute its discretion for that of the Board. *Cole.* This limitation on scope of review prevents "courts from usurping policy decisions from other branches of government." *Bell v. Township of Bass River*, 196 N.J.Super. 304, 482 A.2d 208, 212 (Ct.Law Div.1984). Thus, courts must not review the merits of a petition or evidence in the absence of a showing that the Board "acted fraudulently or in arbitrary or willful disregard of

undisputed and indisputable proof." Cole, 1999 SD 54, ¶ 10, 592 N.W.2d at 177 (citing *Willard*, 75 S.D. at 298, 63 N.W.2d at 801).

The Commission also found that both prongs of the variance and conditional use requirements were met, that being that granting the variance will not be contrary to the public interest and that special conditions existed under which a literal enforcement of the ordinance would cause unnecessary hardship. *Hines v. Board of Adjustment of the City of Miller*, 675 NW2d 231 (SD 2004). Furthermore, certiorari cannot be used to examine evidence for the purposes of determining the correctness of a finding. *Peters v. Spearfish ETJ Planning Commission*, 1997 SD 1005 ¶ 5, 567 NW2d 880, 883.

Consequently, the Court finds as to applying the appropriate law as well as the requirements of the Buffalo County Zoning Ordinance, the Board of Adjustment did not act illegally or in excess of its jurisdiction.

IS REMAND REQUIRED TO PROVIDE MORE DETAIL IN THE WAIVER TO COMPLY WITH SECTION 515(f)?

The Petitioner argued at the hearing in this matter that when it comes to AFO's, size and distance make a big difference. In this case they argue that the Board failed to comply with 515(f) because it failed to set a radius for the variance, failed to mention a specific size (as to total head allowed) for the feedlot, and failed to provide a proper resolution or waiver that could be recorded as required by such ordinance.

The ordinance is clear that the waiver must me made by radius and must be in a form that is recordable in the local Register of Deeds office. Such was not done in the present case. The County has not provided sufficient explanation or argument why they should not be required to comply with these requirements. Based upon the language of the minutes of the meetings of both the Planning Commission and the Board of Adjustment there is no way to determine the extent of the waiver, the extent of the conditional use permit as to the size of the feedlot allowed or the extent of the variance of the separation distance. By failing to so act the Board acted illegally in failing to do something they were required to do by law. Consequently, this matter is remanded to the Board of Adjustment with the directive that they enter the appropriate resolution, waiver and/or conditional use permit that shall:

1) set a specific limit on the size of the facility (number of head allowed) in accordance with the request made by the landowner and the ordinance;
2) set the appropriate waiver or variance radius required by 515(f); and
3) lay out the resolution or waiver/variance in appropriate form to be recorded in the Register of Deeds office.

975 ABOVE ORIGINAL

The Court has also considered all of Petitioners' other claims and denies the same.

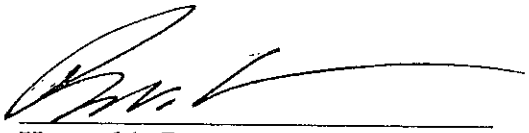
CONCLUSION

Based upon all of the above and foregoing, the Petitioners' request for certiorari is denied with the exception that it is granted as to the last section of this opinion and remanded in accordance therewith.

This Decision shall constitute the Court's Findings of Fact and Conclusions of Law in accordance with SDCL 15-6-52(a). Judgment will be entered accordingly.

Dated this 26th day of September, 2008.

BY THE COURT:



Honorable Bruce V. Anderson
Circuit Court Judge

ATTEST:

Clerk of Courts

MINUTES OF BOARD OF ADJUSTMENT MEETING
November 6, 2008

Chairman Ronald Petersen called the meeting to order at 2:30 P.M. with members Donita Loudner and Lloyd Lutter present. Others attending were State's Attorney Steven Fox, Auditor Elaine Wulff, Zoning Adm. Evelyn Wulff, Hwy Supt. Kenneth Wulff, Darla Viereck, Lynn Mayer, Glenn Mayer, Delilah Mayer and Adam Mayer.

State's Attorney Fox explained that a Memorandum Decision had been received for the Glenn J. Mayer and Delilah Mayer vs. County Board of Commissioners acting as the Board of Adjustment Court Case and while the original hearing was for a variance allowing an additional 975 head to the existing feedlot and the original hearing had a specific location of the feedlot to be constructed the Court had ordered the Board of adjustments to:

1. Set a specific limit on the size of the facility (number of head allowed);
2. Set the appropriate waiver or variance radius required by 515(f); and
3. Lay out the resolution or waiver/variance in appropriate form to be recorded in the Register of Deeds Office.

A letter was discussed from Attorney A. J. Swanson representing Glenn and Delilah Mayer and sent to Evelyn Wulff, Zoning Administrator, State's Attorney Fox and Board Members Petersen, Loudner and Lutter objecting to the Board of Adjustments acting on the application of Mayer Ranches, Inc. before the Court's decision has been formally entered.

A motion was made by Lloyd Lutter to set the limit of head of cattle at 975, the number requested at the hearing before the Board of Adjustment,(this is in addition to the 999 head approved for the feedlot in 1999) seconded by Donita Loudner. Vote: Lutter, aye; Loudner, aye; Petersen, aye. Motion carried.

The Board reviewed and discussed the distance/radius maps that were presented from Lynn Mayer and a University study on odor report that was

presented by Glenn Mayer. After a lengthy discussion a motion was made by Lloyd Lutter to set the radius at 2,640 feet from the corner of the proposed feedlot on the Mayer Ranches, Inc. property to any dwelling existing at the time of the application, seconded by Ronald Petersen. Vote: Lutter, aye; Loudner, aye; Petersen, aye. Motion carried.

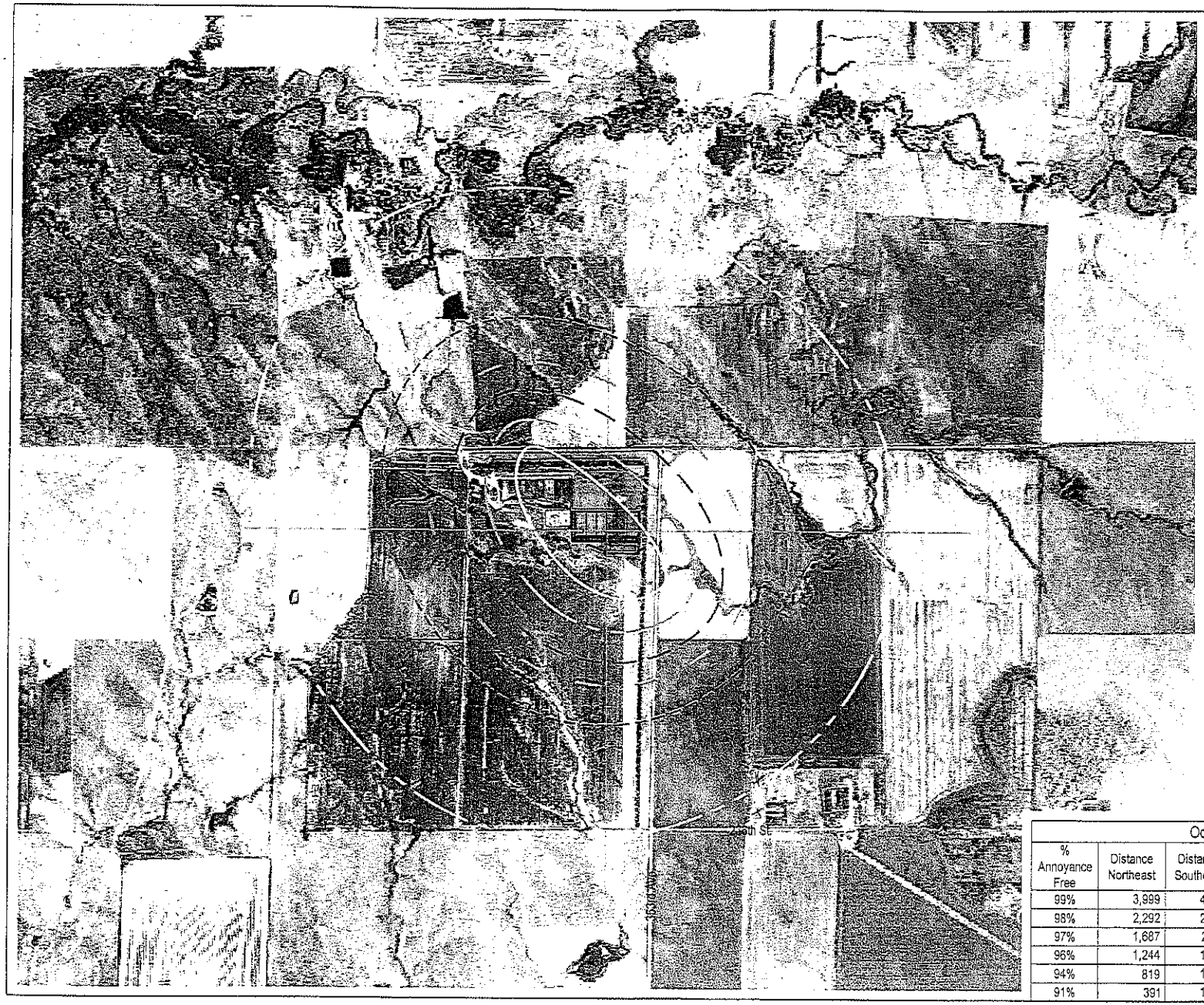
A motion was made by Donita Loudner to direct State's Attorney Fox to draw up an appropriate notice form that can be recorded in the Register of Deed's Office, seconded by Lloyd Lutter. Vote: Loudner, aye; Lutter, aye, Petersen, aye. Motion carried.

Next on the agenda was an application from First American Power LTD for a conditional use/variance to build two meteorological towers on designated property in Grey Hill Township. First American Power presented letters, maps, and tower information for the Boards review. Discussion followed. Donita Loudner felt that they should have specific site location before approval. Lloyd Lutter made a motion to approve this application for the sites listed in the application, seconded by Ronald Petersen. Vote: Lutter, aye; Petersen, aye; Loudner, nay. Motion carried.

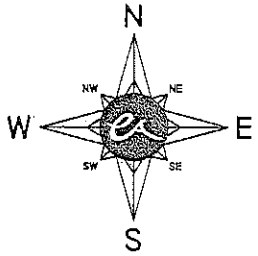
With no further business before the board Donita Loudner made a motion to adjourn seconded by Lloyd Lutter. Motion carried, with all voting aye.

Evelyn Wuff

Evelyn Wuff, Secretary



*Odor Setback Contours are calculated by utilizing the South Dakota Odor Footprint Tool (SDOFT) developed by Dr. Dick Nicolai of South Dakota State University.



Scale: 1 inch = 1/4 mile

Odor Setback					
% Annoyance Free	Distance Northeast	Distance Southeast	Distance Southwest	Distance Northwest	Line Type
99%	3,999	4,050	4,480	5,335	
98%	2,292	2,654	2,707	3,465	
97%	1,687	2,171	2,129	2,799	
96%	1,244	1,883	1,784	2,425	
94%	819	1,498	1,295	1,992	
91%	391	1,084	795	1,593	

Prepared By:
Eisenbraun & Associates
Professional Engineers & Surveyors
218 Walnut
Yankton, South Dakota 57078
605-665-6772
FAX 605-665-0523
www.eandaeng.com

Project Name: Lynn Mayer Feedlot Buffalo County, SD

Sheet Name: Odor Setback

Title: Odor Setback Map for the Lynn Mayer Feedlot Buffalo County, SD

Proj. No.: Y03167.D85
Dwg. No.: Odor Setback2
Layout No.: Odor
Drawn By: AKB
Drafting Review:
Engineering Review: JWR
Date: 03-Nov-08

SHEET NO. 1 OF 1 SHEETS

FILED FOR RECORD
STATE OF SOUTH DAKOTA BUFFALO COUNTY
2nd day of June 2009 at 1:00 P.M.
BOOK 14 OF MISC. RECORDS ON PAGE 219
Elaine J. Wulff REG. OF DEEDS

SEAL OF THE REGISTER OF DEEDS Buffalo County SOUTH DAKOTA

Recorded
Indexed
Grantor
Grantee
Fees

Prepared By:
Albert Steven Fox
States Attorney, Buffalo County
P.O. Box 547
Chamberlain, S.D. 57325
Tele: 605-734-6515

Buffalo County has granted a variance/waiver to operate a feedlot as indicated on the attached map with 1,974 animal unit in the Northeast Quarter of Section Twenty, Township One Hundred Six, Range Sixty-nine West of the Fifth Principal Meridian in Buffalo County, South Dakota. By this document notice of the location of that feedlot is registered in the Buffalo County Register of Deed's Office.

Dated this 28th day of May, 2009.

Evelyn Wulff

Evelyn Wulff, Zoning Administrator

State of South Dakota)
SS
County of Buffalo)

On this the 28th day of May, 2009, before me the undersigned officer, personally appeared Evelyn Wulff, known to me to be the person whose name is subscribed to the within instrument and acknowledged that she executed the same for the purposes therein contained.

In Witness Whereof, I have hereunto set my hand and seal.

Elaine J. Wulff

Elaine J. Wulff, Buffalo County Auditor

*Odor Setback Contours are Calculated by Utilizing the South Dakota Odor Footprint Tool Developed by Dr. Dick Nicolai of South Dakota State University

Odor Setback

Anonymous Rize	Distance Northeast	Distance Southeast	Distance Southwest	Distance Northwest	Line Type
99%	1,964	5,043	5,812	6,709	
99%	2,791	3,259	3,377	4,350	
97%	1,992	2,567	2,627	3,472	
95%	1,441	2,386	2,715	3,020	
90%	953	1,795	1,980	2,140	
10%	[illegible]	1,275	1,054	1,938	

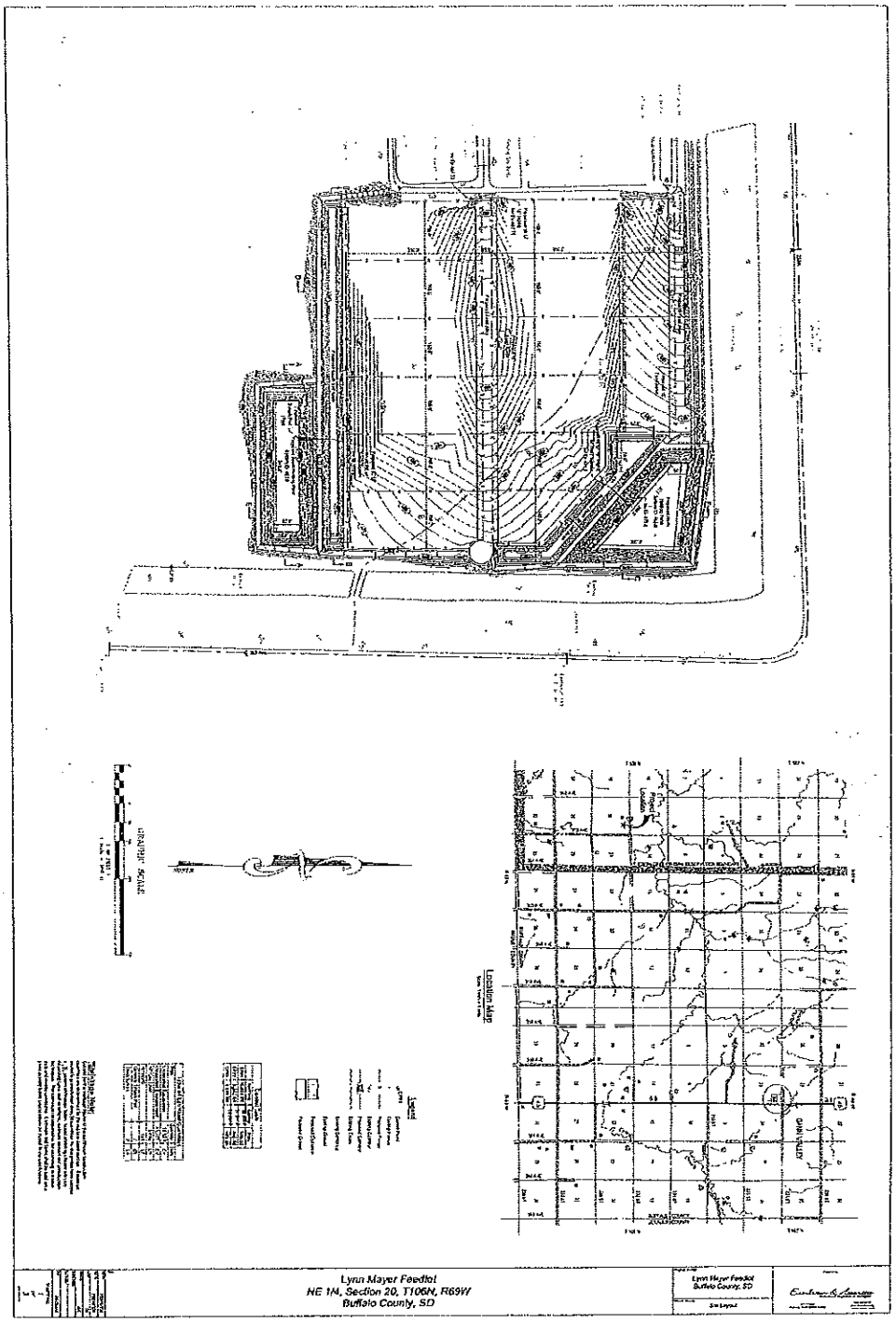
Odor Setback Map for the
Lynn Mayer Feedlot
Buffalo County, SD
NE 1/4, Sec 20, T106, R69W

Project Name: Lynn Mayer Feedlot Buffalo County, SD

Drawing Name: Odor Setback

Prepared by: Eisenbraun & Associates

Drawing No.: Odor Setback
Date: 10/12/2011
Drawn by: Odor
Checked by: JVS
Drawing Scale:
Engineering Scale:
Sheet No.: 1 of 1
Sheet Size: 8.5x11


Lynn Mayer Feedlot
NE 1/4, Section 20, T106N, R69W
Buffalo County, SD
Lynn Mayer Feedlot
Buffalo County, SD
Site Layout
Location Map
STRAIGHT SCALE
LEGEND

Animal Waste Management System Engineering Report

Lynn Mayer Feedlot

located in the
NE 1/4 of Section 20,
T106N, R69W,
Buffalo County, SD

RECEIVED
JUL 17 2012
SURFACE WATER PROGRAM

Designed by:

Eisenbraun & Associates
Professional Engineers & Surveyors

July 2012

E/A Project No. Y03167.D85

Eisenbraun & Associates
Professional Engineers & Surveyors
Innovative Solutions Long Term Value

RECEIVED
JUL 27 2012
SURFACE WATER PROGRAM

July 13, 2012
Revised: July 25, 2012

SD DENR
Surface Water Quality Program
Joe Foss Building
Attn: Kent Woodmansey
523 East Capitol
Pierre, SD 57501-3182

RE: Lynn Mayer Feedlot – Buffalo County, SD
E/A Project No: Y03167.D85

Mr. Woodmansey:

Enclosed are the plans, specifications, computation sheets, and revised CPA-7 for the revised permit application for Lynn Mayer. The facility is located in the NE ¼ of Section 20, T106N, R69W in Buffalo County. The contact information is as follows: Lynn Mayer, 23438 Pheasant Lane, Pukwana, SD 57370, (605) 894-4440.

The existing facility currently has permit coverage with the SD DENR. The proposed addition is for an additional 975 head pen system located east of the existing feedlot. The proposed improvements include pen space, two sediment basins and a holding pond. An 18" pipe will connect the existing holding pond to the proposed west sediment basin. There will be two valves installed on this pipe to prevent accidental release of liquids. The purpose of the pipe is to allow the operator to drain a portion of the west pond into the new pond (by way of the west sediment basin) when the system is being dewatered. The design of the east holding pond system accounts for minimal evaporation and has additional capacity. However, it is not the intent of the producer to utilize the new pond as a storage basin for both feedlot systems.

The revised CPA-7 was provided to us by Stacy Turgeon, SD NRCS in Chamberlain, SD. Her contact information is as follows: Stacy Turgeon, SD NRCS – Chamberlain Field Office, 200 S. Paul Gust Road, Suite 111, Chamberlain, SD 57325. Should you require additional information or have questions regarding the NMP, please contact Stacy.

If you require any additional information or clarification, please contact my office. It is the intent of the producer to complete construction this fall. Your timely review of the submittal is greatly appreciated. Thank you.

Sincerely,
EISENBRAUN & ASSOCIATES, INC.

LICENSED PROFESSIONAL ENGINEER
REG. NO. 9954
BRADLEY S. WOERNER
SOUTH DAKOTA
7/25/12

Brad Woerner, PE
Project Manager

215 Walnut Street
Yankton, SD 57078
Phone: 605-665-8092
Fax: 605-665-0523

Visit our web site or e-mail us @ www.eawebb.com
1-800-888-8307

TABLE OF CONTENTS FOR

LYNN MAYER FEEDLOT
DESIGN REPORT

Item	Description
1.	Cover Letter
2.	Design Computations
3.	Technical Specifications
4.	Site Plans and Details
5.	Nutrient Management Plan

RECEIVED
JUL 17 2012
SURFACE WATER PROGRAM

LICENSED PROFESSIONAL ENGINEER
REG. NO.
7954
BRADLEY S.
WOERNER
SOUTH DAKOTA
7/13/2012

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of South Dakota.

(signature) 7/13/2012 (date)

Bradley S. Woerner, PE
#7954

My license renewal date is February 28, 2013

Pages or sheets covered by this seal:
Items 1 through 4 as listed above.

Eisenbraun & Associates
Professional Engineers & Surveyors
Innovative Solutions Long Term Value

July 13, 2012

SD DENR
Surface Water Quality Program
Joe Foss Building
Attn: Kent Woodmansey
523 East Capitol
Pierre, SD 57501-3182

RECEIVED
JUL 17 2012
SURFACE WATER PROGRAM

RE: Lynn Mayer Feedlot – Buffalo County, SD
E/A Project No: Y03167.D85

Mr. Woodmansey:

Enclosed are the plans, specifications, computation sheets, and revised CPA-7 for the revised permit application for Lynn Mayer. The facility is located in the NE ¼ of Section 20, T106N, R69W in Buffalo County. The contact information is as follows: Lynn Mayer, 23438 Pheasant Lane, Pukwana, SD 57370, (605) 894-4440.

The existing facility currently has permit coverage with the SD DENR. The proposed addition is for an additional 999 head pen system located east of the existing feedlot. The proposed improvements include pen space, two sediment basins and a holding pond. An 18" pipe will connect the existing holding pond to the proposed west sediment basin. There will be two valves installed on this pipe to prevent accidental release of liquids. The purpose of the pipe is to allow the operator to drain a portion of the west pond into the new pond (by way of the west sediment basin) when the system is being dewatered. The design of the east holding pond system accounts for minimal evaporation and has additional capacity. However, it is not the intent of the producer to utilize the new pond as a storage basin for both feedlot systems.

The revised CPA-7 was provided to us by Stacy Turgeon, SD NRCS in Chamberlain, SD. Her contact information is as follows: Stacy Turgeon, SD NRCS – Chamberlain Field Office, 200 S. Paul Gust Road, Suite 111, Chamberlain, SD 57325. Should you require additional information or have questions regarding the NMP, please contact Stacy.

If you require any additional information or clarification, please contact my office. It is the intent of the producer to complete construction this fall. Your timely review of the submittal is greatly appreciated. Thank you.

Sincerely,
EISENBRAUN & ASSOCIATES, INC.

Brad Woerner, PE
Project Manager

LICENSED PROFESSIONAL ENGINEER
REG. NO. 7954
BRADLEY S. WOERNER
SOUTH DAKOTA
7/13/2012

215 Walnut Street
Yankton, SD 57078
Phone: 605-665-8092
Fax: 605-665-0523

Visit our web site or e-mail us @ www.caweb.com

1-800-888-8307

AWMS Computations for Open Feedlots

Producer: Lynn Mayer
Address: 23438 Pheasant Ln
Pukwana, SD 57370
Phone: (605) 894-4440

County: Buffalo
Location: NE 1/4, Section 20, T106N, R69W

E/A Project No. Y03167.D85 Date: 12-Jul-12

Average Annual Precipitation & Evaporation

NOAA Climatological Data Reports, Win TR-55 (USDA)

Average Normal Rainfall 19.46 inches

Percentage of May-Oct. Evaporation Considered: 30%

Potential Evaporation 35.88 inches

Evaporation Used 10.76 inches

25-year 24-hour Storm Event

25-yr/24-hr Rainfall Event 4.20 inches

Summary of Holding Pond Calculations

Annual Runoff Storage Requirements

Type	Area, SF	Area, AC	CN
Roof	0	0.000	98.0
Concrete	0	0.000	98.0
Farmstead	0	0.000	85.0
Earth	425,000	9.757	90.0
Drainage Area*	425,000	9.757	90.0 Weighted CN

Inside Top of Berm Area: 146,000 ft^2
NRCS Earthen Feedlot Runoff: 18.3%
NRCS Concrete Feedlot Runoff: 48.5%
Annual Precip Runoff Volume: 126,100 ft^3
Annual Precip On Pond Volume: 236,800 ft^3
Evaporation Surface Area @ 467.4 87,368 ft^2
Evaporation Volume: (78,400) ft^3
Net Annual Precipitation Volume: 284,500 ft^3

*Drainage area includes all drainage areas that ultimately flow into the holding pond

25yr/24hr Storage Requirements

NRCS Weighted 25yr/24hr Rainfall Runoff: 3.11 in.
25yr/24hr Rainfall Runoff Volume: 110,100 ft^3
25yr/24hr Rainfall on Pond Volume: 51,100 ft^3
Total 25yr/24hr Volume: 161,200 ft^3

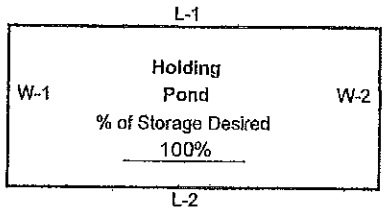
Holding Pond Requirements

	Volume Required	Volume Provided
Annual Precip & Runoff Volume:	284,500 ft^3	586,980 ft^3
25yr/24hr Storm Event Volume:	161,200 ft^3	235,190 ft^3
2nd 25yr/24hr Storm Event Volume:	161,200 ft^3	234,920 ft^3

	Elevation	Depth	
Solids Accumulation:	464.0	1.0	foot of pond bottom shall be for solids
Storage for Normal Runoff Precipitation	470.8	6.8	feet shall be included in the full marker
Storage for 25-yr, 24-hr Event of Pond:	473.0	2.2	feet for 25yr/24hr storm event
Minimum Freeboard:	475.0	2.0	feet for freeboard

Summary of Holding Pond Design

Bottom Length	varies feet
Bottom Width	varies feet
Bottom Elevation	463.0 feet
Storage Time	365 days
Cell 1: L-1 Side Slope	3 :1
Cell 1: L-2 Side Slope	3 :1
Cell 1: W-1 Side Slope	3 :1
Cell 1: W-2 Side Slope	3 :1



Summary of Key Elevations

	Holding Pond (feet)
<u>Solids Accumulation Depth</u> Elevation at Top of Solids Accumulation Level	464.0
<u>Normal Precipitation Storage Elevation</u> Elevation at Top of Annual Runoff Storage	470.8
<u>25-yr, 24-hr Rainfall Event Storage Elevation</u> Elevation at Top of 25yr/24hr Event	473.0
<u>Top of Freeboard (Top of Dike)</u> Elevation of Lowest Point on Dike	475.0

Volume Computation Summary
Holding Pond

Elev. (ft)	Depth from Bottom (ft)	Surface Area (sf)	Storage Volume (cu ft)	Volume Less Solids Accumulation (cu ft)
Pond Floor Elevation				
463.0	0.0	66,147	0	0
Solids Accumulation Level				
464.0	1.0	70,390	68,260	0
Mid-Point for Evaporation Elevation				
467.4	4.4	87,368	333,350	265,090
Full/Permanent Marker Elevation				
470.8	7.8	101,505	655,240	586,980
25yr/24hr Rainfall Event Storage Elevation				
473.0	10.0	112,366	890,430	822,170
Top of Freeboard/Lowest Top of Berm				
475.0	12.0	122,614	1,125,350	1,057,090

Storage Volume based on Prismoidal Equation:
Vol = h/6 x (B1 + B2 + 4xBh)

where h=height of liquid in pond
B1=area of bottom of pond
B2=area of top of pond
Bh=area of mid-point of pond

Lynn Mayer

E/A Project No: Y03167.D85

Holding Pond

	Elevation	Depth, FT	Area, SF	Volume, CF	Volume minus 1' Solids
Bottom	463.0	-	66,147	-	-
	463.1	0.1	66,571	6,630	-
	463.2	0.2	66,996	13,310	-
	463.3	0.3	67,420	20,030	-
	463.4	0.4	67,844	26,790	-
	463.5	0.5	68,269	33,600	-
	463.6	0.6	68,693	40,450	-
	463.7	0.7	69,117	47,340	-
	463.8	0.8	69,541	54,270	-
	463.9	0.9	69,966	61,250	-
Solids Accumulation	464.0	1.0	70,390	68,260	-
	464.1	1.1	70,824	75,320	7,060
	464.2	1.2	71,258	82,420	14,160
	464.3	1.3	71,692	89,570	21,310
	464.4	1.4	72,126	96,760	28,500
	464.5	1.5	72,560	103,990	35,730
	464.6	1.6	72,993	111,270	43,010
	464.7	1.7	73,427	118,590	50,330
	464.8	1.8	73,861	125,960	57,700
	464.9	1.9	74,295	133,360	65,100
	465.0	2.0	74,729	140,810	72,550
	465.1	2.1	75,171	148,300	80,040
	465.2	2.2	75,613	155,840	87,580
	465.3	2.3	76,055	163,420	95,160
	465.4	2.4	76,497	171,050	102,790
	465.5	2.5	76,940	178,720	110,460
	465.6	2.6	77,382	186,440	118,180
	465.7	2.7	77,824	194,200	125,940
	465.8	2.8	78,266	202,000	133,740
	465.9	2.9	78,708	209,850	141,590
	466.0	3.0	79,150	217,740	149,480
	466.1	3.1	79,603	225,670	157,410
	466.2	3.2	80,056	233,660	165,400
	466.3	3.3	80,509	241,680	173,420
	466.4	3.4	80,962	249,760	181,500
	466.5	3.5	81,416	257,880	189,620
	466.6	3.6	81,869	266,040	197,780
	466.7	3.7	82,322	274,250	205,990
	466.8	3.8	82,775	282,500	214,240
	466.9	3.9	83,228	290,810	222,550
	467.0	4.0	83,681	299,150	230,890
	467.1	4.1	84,603	307,560	239,300
	467.2	4.2	85,524	316,070	247,810
	467.3	4.3	86,446	324,660	256,400
Mid-Point for Evap	467.4	4.4	87,368	333,350	265,090
	467.5	4.5	88,290	342,140	273,880
	467.6	4.6	89,211	351,010	282,750

	467.7	4.7	90,133	359,980	291,720
	467.8	4.8	91,055	369,040	300,780
	467.9	4.9	91,976	378,190	309,930
	468.0	5.0	92,898	387,430	319,170
	468.1	5.1	92,898	396,710	328,450
	468.2	5.2	92,898	406,000	337,740
	468.3	5.3	92,898	415,290	347,030
	468.4	5.4	92,898	424,580	356,320
	468.5	5.5	92,898	433,870	365,610
	468.6	5.6	92,898	443,160	374,900
	468.7	5.7	92,898	452,450	384,190
	468.8	5.8	92,898	461,740	393,480
	468.9	5.9	92,898	471,030	402,770
	469.0	6.0	92,898	480,320	412,060
	469.1	6.1	93,373	489,630	421,370
	469.2	6.2	93,847	498,990	430,730
	469.3	6.3	94,322	508,400	440,140
	469.4	6.4	94,796	517,850	449,590
	469.5	6.5	95,271	527,360	459,100
	469.6	6.6	95,745	536,910	468,650
	469.7	6.7	96,220	546,510	478,250
	469.8	6.8	96,694	556,150	487,890
	469.9	6.9	97,169	565,840	497,580
	470.0	7.0	97,643	575,590	507,330
	470.1	7.1	98,126	585,370	517,110
	470.2	7.2	98,608	595,210	526,950
	470.3	7.3	99,091	605,100	536,840
	470.4	7.4	99,574	615,030	546,770
	470.5	7.5	100,057	625,010	556,750
	470.6	7.6	100,539	635,040	566,780
	470.7	7.7	101,022	645,120	576,860
Full Marker	470.8	7.8	101,505	655,240	586,980
	470.9	7.9	101,987	665,420	597,160
	471.0	8.0	102,470	675,640	607,380
	471.1	8.1	102,961	685,910	617,650
	471.2	8.2	103,451	696,230	627,970
	471.3	8.3	103,942	706,600	638,340
	471.4	8.4	104,433	717,020	648,760
	471.5	8.5	104,924	727,480	659,220
	471.6	8.6	105,414	738,000	669,740
	471.7	8.7	105,905	748,570	680,310
	471.8	8.8	106,396	759,180	690,920
	471.9	8.9	106,886	769,850	701,590
	472.0	9.0	107,377	780,560	712,300
	472.1	9.1	107,876	791,320	723,060
	472.2	9.2	108,375	802,130	733,870
	472.3	9.3	108,874	812,990	744,730
	472.4	9.4	109,373	823,900	755,640
	472.5	9.5	109,872	834,870	766,610
	472.6	9.6	110,370	845,880	777,620
	472.7	9.7	110,869	856,940	788,680
	472.8	9.8	111,368	868,050	799,790
	472.9	9.9	111,867	879,210	810,950
25yr/24hr Storm Event	473.0	10.0	112,366	890,430	822,170
	473.1	10.1	112,873	901,690	833,430
	473.2	10.2	113,380	913,000	844,740
	473.3	10.3	113,887	924,360	856,100

	473.4	10.4	114,394	935,780	867,520
	473.5	10.5	114,901	947,240	878,980
	473.6	10.6	115,408	958,760	890,500
	473.7	10.7	115,915	970,320	902,060
	473.8	10.8	116,422	981,940	913,680
	473.9	10.9	116,929	993,610	925,350
	474.0	11.0	117,436	1,005,330	937,070
	474.1	11.1	117,954	1,017,090	948,830
	474.2	11.2	118,472	1,028,920	960,660
	474.3	11.3	118,989	1,040,790	972,530
	474.4	11.4	119,507	1,052,710	984,450
	474.5	11.5	120,025	1,064,690	996,430
	474.6	11.6	120,543	1,076,720	1,008,460
	474.7	11.7	121,061	1,088,800	1,020,540
	474.8	11.8	121,578	1,100,930	1,032,670
	474.9	11.9	122,096	1,113,110	1,044,850
Lowest Top of Berm	475.0	12.0	122,614	1,125,350	1,057,090

Note: Areas in yellow were taken directly from AutoCAD output

	Elevation	Depth, FT	Area, SF	Volume, CF	Volume minus 1' Solids
Bottom	463.0	-	66,147	-	-
Solids Accumulation	464.0	1.0	70,390	68,260	-
Mid-Point for Evap	467.4	4.4	87,368	333,350	265,090
Full Marker	470.8	7.8	101,505	655,240	586,980
25yr/24hr Storm Event	473.0	10.0	112,366	890,430	822,170
Lowest Top of Berm	475.0	12.0	122,614	1,125,350	1,057,090

Settling Basin Computation Sheet

Producer: Lynn Mayer
Address: 23438 Pheasant Ln
Pukwana, SD 57370
Phone: (605) 894-4440

County: Buffalo
Location: NE 1/4, Section 20, T106N, R69W

E/A Project No. Y03167.D85 Date: 25-Jul-12

25yr/24hr Storm Event (Win TR55, USDA)

25-yr/24-hr Rainfall Event 4.20 inches

Summary of Settling Basin Calculations

Pen/Basin	# of Animals	Ave. Weight, lbs.	Confined days/year	Slope Factor	Lot Cleanings	Solids Volume, ft^3
West	540	900	365	0.25	6	3,696
East	435	900	365	0.25	6	2,977

$$V_s = \frac{(0.5ft^3) \times (\text{\# of 1000lb. Animals}) \times (\text{Confined days/year}) \times (\text{Slope Factor})}{(\text{Number of lot cleanings/year})}$$

Slope Factor	3% or less = 0.25		6%-10% = 0.75
	3%-6% = 0.50		over 10% = 1.00

REGISTERED PROFESSIONAL ENGINEER
REG. NO. 7954
BRADLEY S. WEGENER
SOUTH DAKOTA
7/25/12

RECEIVED
JUL 27 2012
SURFACE WATER PROGRAM

Lynn Mayer

E/A Project No: Y03167.D85

West Sed Basin

	Elevation	Depth, FT	Area, SF	Volume, CF
Bottom	480.0	-	9,157	-
	480.1	0.1	9,896	950
	480.2	0.2	10,634	1,970
	480.3	0.3	11,373	3,070
Solids Accumulation	480.4	0.4	12,111	4,250
	480.5	0.5	12,850	5,500
	480.6	0.6	13,588	6,820
	480.7	0.7	14,327	8,210
	480.8	0.8	15,065	9,680
	480.9	0.9	15,804	11,230
	481.0	1.0	16,542	12,840
	481.1	1.1	17,051	14,510
	481.2	1.2	17,560	16,250
	481.3	1.3	18,070	18,030
	481.4	1.4	18,579	19,860
	481.5	1.5	19,088	21,740
	481.6	1.6	19,597	23,680
	481.7	1.7	20,106	25,660
	481.8	1.8	20,616	27,700
	481.9	1.9	21,125	29,790
	482.0	2.0	21,634	31,920
	482.1	2.1	22,153	34,100
	482.2	2.2	22,673	36,350
	482.3	2.3	23,192	38,640
	482.4	2.4	23,711	40,980
	482.5	2.5	24,231	43,380
	482.6	2.6	24,750	45,830
	482.7	2.7	25,269	48,330
	482.8	2.8	25,788	50,880
	482.9	2.9	26,308	53,490
	483.0	3.0	26,827	56,150
	483.1	3.1	27,356	58,850
	483.2	3.2	27,885	61,620
	483.3	3.3	28,414	64,430
	483.4	3.4	28,943	67,300
	483.5	3.5	29,472	70,220
	483.6	3.6	30,001	73,190
	483.7	3.7	30,530	76,220
	483.8	3.8	31,059	79,300
	483.9	3.9	31,588	82,430
25yr/24hr Storm Event	484.0	4.0	32,117	85,620
	484.1	4.1	32,657	88,850
	484.2	4.2	33,196	92,150
	484.3	4.3	33,736	95,490
	484.4	4.4	34,275	98,890
	484.5	4.5	34,815	102,350
	484.6	4.6	35,354	105,860
	484.7	4.7	35,894	109,420
	484.8	4.8	36,433	113,040
	484.9	4.9	36,973	116,710
Lowest Top of Berm	485.0	5.0	37,512	120,430

*Note: Areas in yellow were taken directly from AutoCAD output

	Elevation	Depth, FT	Area, SF	Volume, CF
Bottom	480.0	-	9,157	-
Solids Accumulation	480.4	0.4	12,111	4,250
25yr/24hr Storm Event	484.0	4.0	32,117	85,620
Lowest Top of Berm	485.0	5.0	37,512	120,430

Lynn Mayer

E/A Project No: Y03167.D85

West Sed Basin

Sites Output

	West Sed Basin
Site Identification	W
Watershed Runoff Curve Number	90
Total Watershed Drainage Area (Acres)	5.3
Watershed Time of Concentration (Hours)	0.11
FBH or Storm Rainfall Total (Inches)	4.2
FBH or Storm Rainfall Duration (Hours)	24
FBH or Storm Inflow Peak (CFS)	24.5
Initial Reservoir Elevation (Feet)	480.4
Maximum WS FBH or Storm (Feet)	481.67
Storage at Max. WS FBH or Storm (Acre-Ft)	0.6
Top Dam (Feet)	481.67
PSH Drawdown (Days)	0.21
378 Drawdown (Days)	0.51
PS Crest (Feet)	480
PS Conduit Diameter (Inches)	18
PS Conduit Area (Sq. Feet)	1.77
PS Discharge at AS Crest (CFS)	7
PS Discharge FBH or Storm (CFS)	7.1
AS Crest (Feet)	481.66
Storage, AS Crest (Acre-Ft)	0.6
AS Width (Feet)	300
Uncontrolled Drainage Area (Acres)	5.3

Lynn Mayer

E/A Project No: Y03167.D85

East Sed Basin

	Elevation	Depth, FT	Area, SF	Volume, CF
Bottom	476.0	-	1,569	-
	476.1	0.1	1,993	170
	476.2	0.2	2,418	390
	476.3	0.3	2,842	660
	476.4	0.4	3,266	960
	476.5	0.5	3,691	1,310
	476.6	0.6	4,115	1,700
	476.7	0.7	4,539	2,130
	476.8	0.8	4,963	2,610
Solids Accumulation	476.9	0.9	5,388	3,130
	477.0	1.0	5,812	3,690
	477.1	1.1	6,360	4,290
	477.2	1.2	6,908	4,960
	477.3	1.3	7,456	5,680
	477.4	1.4	8,004	6,450
	477.5	1.5	8,552	7,280
	477.6	1.6	9,099	8,160
	477.7	1.7	9,647	9,100
	477.8	1.8	10,195	10,090
	477.9	1.9	10,743	11,130
	478.0	2.0	11,291	12,240
	478.1	2.1	11,887	13,390
	478.2	2.2	12,482	14,610
	478.3	2.3	13,078	15,890
	478.4	2.4	13,673	17,230
	478.5	2.5	14,269	18,620
	478.6	2.6	14,864	20,080
	478.7	2.7	15,460	21,600
	478.8	2.8	16,055	23,170
	478.9	2.9	16,651	24,810
25yr/24hr Storm Event	479.0	3.0	17,246	26,500
	479.1	3.1	17,781	28,250
	479.2	3.2	18,315	30,050
	479.3	3.3	18,850	31,910
	479.4	3.4	19,385	33,820
	479.5	3.5	19,920	35,790
	479.6	3.6	20,454	37,810
	479.7	3.7	20,989	39,880
	479.8	3.8	21,524	42,000
	479.9	3.9	22,058	44,180
Lowest Top of Berm	480.0	4.0	22,593	46,410
	480.1	4.1	22,404	48,650
	480.2	4.2	22,216	50,890
	480.3	4.3	22,027	53,100
	480.4	4.4	21,839	55,290
	480.5	4.5	21,650	57,470
	480.6	4.6	21,461	59,620
	480.7	4.7	21,273	61,760
	480.8	4.8	21,084	63,880
	480.9	4.9	20,896	65,970
	481.0	5.0	20,707	68,060

*Note: Areas in yellow were taken directly from AutoCAD output

	Elevation	Depth, FT	Area, SF	Volume, CF
Bottom	476.0	-	1,569	-
Solids Accumulation	476.9	0.9	5,388	3,130
25yr/24hr Storm Event	479.0	3.0	17,246	26,500
Lowest Top of Berm	480.0	4.0	22,593	46,410

Lynn Mayer

E/A Project No: Y03167.D85

East Sed Basin

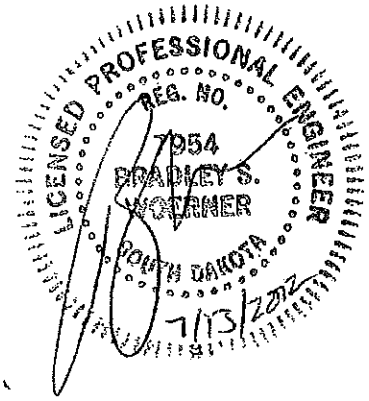
Sites Output

	East Basin
Site Identification	E
Watershed Runoff Curve Number	90
Total Watershed Drainage Area (Acres)	4.397
Watershed Time of Concentration (Hours)	0.11
FBH or Storm Rainfall Total (Inches)	4.2
FBH or Storm Rainfall Duration (Hours)	24
FBH or Storm Inflow Peak (CFS)	20.1
Initial Reservoir Elevation (Feet)	476.9
Maximum WS FBH or Storm (Feet)	477.12
Storage at Max. WS FBH or Storm (Acre-Ft)	0.1
Top Dam (Feet)	478.12
PSH Drawdown (Days)	0
378 Drawdown (Days)	0.51
PS Crest (Feet)	475
PS Conduit Diameter (Inches)	18
PS Conduit Area (Sq. Feet)	1.77
PS Discharge at AS Crest (CFS)	16.4
PS Discharge FBH or Storm (CFS)	16.3
AS Crest (Feet)	477.12
Storage, AS Crest (Acre-Ft)	0.1
AS Width (Feet)	300
Uncontrolled Drainage Area (Acres)	4.397

ANIMAL WASTE MANAGEMENT SYSTEMS

TECHNICAL SPECIFICATIONS
FOR
HOLDING POND CONTAINMENT

RECEIVED
JUL 17 2012
SURFACE WATER PROGRAM



PREPARED BY
EISENBRAUN AND ASSOCIATES

TECHNICAL SPECIFICATIONS
FOR
ANIMAL WASTE MANAGEMENT SYSTEMS

DIVISION 1 - General Requirements

****

DIVISION 2 - Site Work

Section	Title
205	Preparation and Maintenance of the Construction Site
221	Unclassified Excavation
235	Holding Pond Construction

****

Division 3 - Concrete

330	Concrete Work

DIVISION I

GENERAL INFORMATION AND REQUIREMENTS

SECTION 101 PROVISIONS AND REQUIREMENTS. All provisions and requirements of the Contract Documents, as well as those contained in the plans apply to the work that is specified within these technical specifications.

SECTION 102 SITE CONDITIONS AND PROJECT EVALUATION. The CONTRACTOR must satisfy himself by personal examination of the construction site as to all local conditions affecting the performance of his contract. The CONTRACTOR is deemed to accept such conditions as found to exist. All CONTRACTOR activities shall be confined to the project site. Construction easements, as needed, will be or have been obtained by the OWNER. If additional area is needed, it shall be the CONTRACTOR's responsibility to obtain said area.

The CONTRACTOR shall be responsible to adequately acquaint himself with all existing conditions, utilities, improvements, and other factors that would affect his bid, and shall examine the project plans and specifications of the foregoing and existing conditions. No extra compensation will be allowed unless specifically set forth in the contract documents and included in the Bid Form.

SECTION 103 MEASUREMENT AND PAYMENT OF INCIDENTAL WORK. Prices bid for bid item shall represent full compensation for all labor, materials, equipment, supervision and other incidental items necessary for the performance and completion of each item of work in place, in strict accordance with the Contract Documents. Payment for said item shall therefore include all work which may be reasonably inferred from the contract documents as being necessary to produce the intended results. All items of work necessary to produce the intended results not specifically contained in the Bid Form shall be considered incidental work to the bid item, and no allowance for separate, additional compensation shall be made.

SECTION 104 INTERRUPTION OF UTILITY SERVICE. The CONTRACTOR shall make every possible effort to minimize the downtime of any utilities which may be directly or indirectly affected by Work performed on this project. The CONTRACTOR shall at all times conduct his Work in such a manner as to cause minimum interference with routine daily use.

The CONTRACTOR shall notify residents affected by his proposed action at least twenty-four (24) hours in advance of such interruptions in residential, commercial and industrial areas.

SECTION 105 EXISTING FACILITIES. The CONTRACTOR shall take complete field measurements affecting all existing constructions in the Work, and he shall be solely responsible for proper fit between his Work and existing structures. He shall examine all work to which he will connect; and if any misalignment is found he shall so arrange his Work that the misalignment is corrected. Any dimensions given on the Drawings related to existing structures are based on available records and it shall be the responsibility of the CONTRACTOR to verify the accuracy of these dimensions. Any discrepancies shall be brought to the attention of the OWNER prior to start of new construction.

SECTION 106 PROTECTION OF EXISTING STRUCTURES. The CONTRACTOR will be held responsible for any damage to existing structures, work, materials, or equipment because of his operations and shall repair or replace any damaged structures, work, materials, or equipment to the satisfaction of, and at no additional cost to the OWNER. The CONTRACTOR shall be responsible for all damage to streets, roads, curbs, sidewalks, highways, shoulders, ditches, embankments, culverts, bridges, or other public or

private property which may be caused by transporting equipment, materials, or men to or from Work, or by performance of the Work. The CONTRACTOR shall make satisfactory and acceptable arrangements with the agency having jurisdiction over the damaged property concerning its repair or replacement.

SECTION 107 **PROTECTION OF EXISTING UTILITIES.** It is the sole responsibility of the CONTRACTOR to verify the exact location of any and all existing utilities. Locations of any utility shown on the drawings are for informational purposes only and may not represent the exact location, size, type, or depth of said utility. The CONTRACTOR shall give notice to the owners of any such lines or obstructions in order that they may have time to take necessary precautions for protecting their property. Existing utilities shall be protected from damage during excavation and backfilling operations and if damaged, shall be promptly repaired by the CONTRACTOR at his expense. The CONTRACTOR shall be responsible for any injuries to persons and property, for all damages to any pipe, conduit, sewer or other structure injuriously affected by the Work and shall save harmless the OWNER, ENGINEER, and state and federal agencies from any liability thereof.

SECTION 108 **CONSTRUCTION STAKING, PRESERVATION OF STAKES AND MONUMENTS.** Construction staking shall be provided by the OWNER in accordance with General Condition 4.4 and the plans and technical specifications. The CONTRACTOR shall be responsible for carefully preserving all benchmarks, construction stakes, reference points and monuments. Should destruction of same occur, the CONTRACTOR will bear the expense of their replacement and shall be held responsible for any mistake or loss of time that may be caused. Permanent benchmarks or monuments which must be removed or disturbed shall be protected until properly referenced for relocation.

SECTION 109 **PROJECT MANAGEMENT.** The CONTRACTOR shall be responsible for scheduling and coordinating the Work of his own crews as well as those of all his Subcontractors and others involved in order to maintain acceptable progress and assure timely completion in accordance with the contract time frame. The CONTRACTOR shall be responsible for complete supervision, control, and progress of his Subcontractors as though they were his own forces. Notice to the CONTRACTOR shall be considered as notice to all affected subcontractors. Prior to the start of construction, the CONTRACTOR shall supply to the OWNER a complete list of all subcontractors and suppliers with whom he proposes to contract. The name, address, and telephone number of each shall be provided along with the intended work or items to be furnished by each. Subcontractors and suppliers are subject to the review and approval of the OWNER.

SECTION 110 **CONSTRUCTION METHODS.** The CONTRACTOR alone shall be responsible for the safety, adequacy, and efficiency of his plant, equipment, and construction methods. The CONTRACTOR shall inform the OWNER in advance concerning his plans for carrying on each part of the Work. However, review by the OWNER of any plan or method of Work proposed by the CONTRACTOR shall not relieve the CONTRACTOR of any responsibility therefore, and such review shall not be considered as an assumption of any risk or liability by the OWNER or ENGINEER, or any officer, agent, or employee thereof. The CONTRACTOR shall have no claim on account of the failure or inefficiency of any plan or method so reviewed. Any method of Work suggested by the OWNER or ENGINEER, but not specified, shall be used at the risk and responsibility of the CONTRACTOR, and the ENGINEER and OWNER will assume no responsibility therefore.

SECTION 111 **ADVERSE CONSTRUCTION CONDITIONS.** In the event of unsatisfactory weather, wet ground, or other unsuitable construction conditions, the CONTRACTOR shall confine his operations to those portions of the Work which will not be adversely affected. No portion of the Work shall be constructed under conditions which would compromise the quality required unless special precautions are taken by the CONTRACTOR to perform the Work in a satisfactory manner.

SECTION 112 **QUALITY CONTROL.**

112.1 **Laboratory Testing.** Certain tests and inspection will be necessary for quality control as specified for this project. The OWNER has arranged for and employ, at his expense, an independent testing lab to perform the tests and inspections utilizing recognized standard procedures and criteria. Retests required due to initial test failures will be paid for by the CONTRACTOR. Location and frequency shall be as specified in these specifications.

The CONTRACTOR shall furnish all sample materials required for these tests and shall deliver same without charge to the OWNER when and where directed by these specifications. Any additional tests necessary beyond those required under this specification may be ordered by the ENGINEER to settle disagreements with the CONTRACTOR regarding quality of work done. If the work is defective, the CONTRACTOR shall pay all costs of the extra tests and shall correct the work.

If work is satisfactory, the OWNER will pay for extra tests. Quality testing shall include, but not necessarily be limited to, concrete testing, aggregate testing, soils testing, compaction testing, and the like.

112.2 **Factory Testing.** Factory tests of any materials relative to performance, capacity, rating, efficiency, function, or special requirements shall be conducted in the factory or shop for each item when this type of test is specified. These tests shall be performed in accordance with applicable standards and test codes.

Factory tests shall be set up and accomplished by the equipment manufacturer who shall provide all shop space, tools, equipment, instruments, personnel, and other facilities required for the satisfactory completion of each test. Test data and results shall be submitted to the OWNER.

The cost of factory tests shall be included in the bid price of the contract and no additional payment will be made for factory testing.

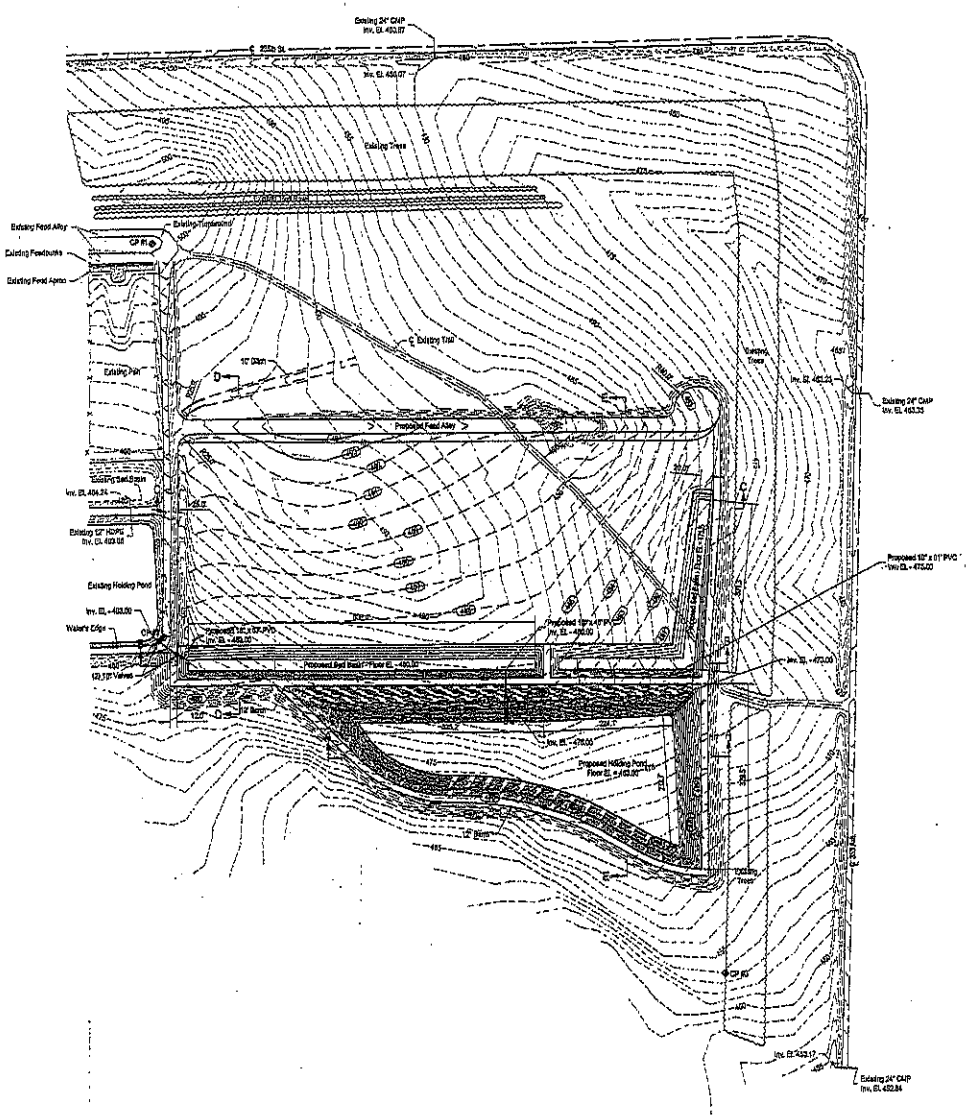
SECTION 113 **SALVABLE EQUIPMENT AND MATERIAL.** Any equipment or materials removed during construction which is deemed salvable shall remain the property of the OWNER and shall be carefully preserved by the CONTRACTOR.

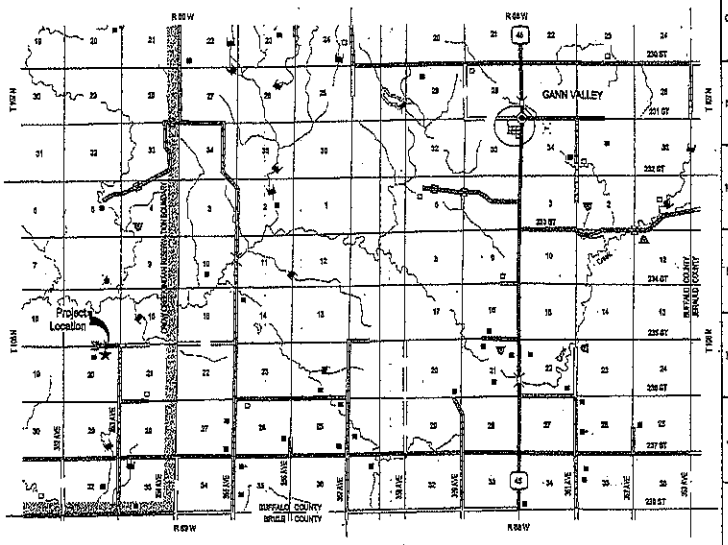
SECTION 114 **TEMPORARY CONSTRUCTION FACILITIES.** Site facilities which are necessary for construction shall be provided by and paid for by the CONTRACTOR. These may include but are not necessarily limited to material storage and/or waste areas, utility costs, office space, toilet facilities, storage buildings for the protection of materials and equipment, or other services. All such field office, storage sheds, and the like shall remain the property of the CONTRACTOR and shall be removed after completion of the Work and the site restored to its original condition.

When necessary, the CONTRACTOR shall make his own arrangements for electrical power and telephone service at the construction site. Obtaining water for construction purposes shall also be the responsibility of the CONTRACTOR.

The CONTRACTOR shall contact the OWNER to inquire about possible storage areas aud material waste areas. However the CONTRACTOR shall be responsible for securing these areas.

SECTION 115 **RECORD COPY OF CONTRACT DOCUMENTS.** The CONTRACTOR shall maintain a careful up-to-date record of all changes on the Drawings during construction. Upon completion of the Work, and prior to acceptance by the OWNER, the CONTRACTOR shall file with the ENGINEER one set of complete Drawings with all changes and CONTRACTOR's field construction notes neatly and legibly recorded thereon. Such Drawings shall include the exact routing, if changed from Drawing location, of sewer, water, gas, fuel oil tanks and lines, buried electrical feeder lines, changes to routing of conduit runs which are buried or concealed in concrete slabs, and any other major buried utility lines. Such information may be used to prepare record Drawings for the OWNER.





Location Map

Scale: 1 inch = 1 mile

GRAPHIC SCALE

(IN FEET)
1 inch = 100 ft.

Legend

- CP#1 — Control Point
- Existing Fence
- Proposed Fence
- 400 — Existing Contour
- 420 — Proposed Contour
- Existing Pipe (Size & Type)
- Proposed Pipe (Size & Type)
- Existing Trees
- Existing Concrete
- Existing Gravel
- Proposed Concrete
- Proposed Gravel

Control Table			
	Northing	Easting	Elev.
CP#1	10,000.00	20,000.00	000.00
CP#2	9,999.08	20,017.99	488.08
CP#3	9,999.91	20,037.96	470.96

Table of Estimated Quantities		
Item	Quantity	Units
Unclassified Excavation	67,800	CY
Unclassified Embankment*	41,400	CY
Safety Fence	1,320	LF
18" Clay Liner	8,882	CY
Grass Seeding	1.0	AC
18" Gate Valve	2	EA
18" PVC	160	LF
Trash Screen	2	EA
Concrete Splash Pad	10	CY

***Shrinkage Note:**
Cut and borrow yardage volumes of the earthwork construction quantities are determined by the in-place bank yardage. Based on available geotechnical data, if operations for this project have utilized a 20 percent shrinkage factor. Actual shrinkage factors will vary depending upon soil conditions, moisture content and construction techniques. The contractor is responsible for assembling available data and on-site conditions. Earthwork bid items shall be paid on a plans quantity basis unless otherwise noted in the specifications.

RECEIVED
JUL 17 2012
SURFACE WATER PROGRAM

Prepared by
Eisenbraun & Associates
Innovative Solutions - Long Term Value
Rapid City, SD
Yankton, Mitchell, Aberdeen, Davis

REGISTERED PROFESSIONAL ENGINEER
STATE OF SOUTH DAKOTA
17954
BRADLEY G. HUBBARD
7/13/12

CONSULTANTS

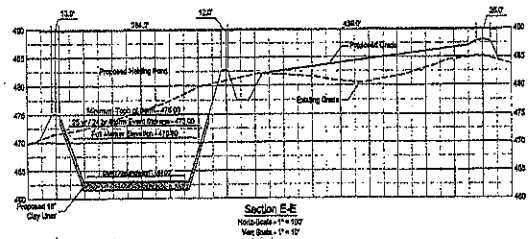
Lynn Mayer Feedlot
Buffalo County, SD
Lynn Mayer
Gann Valley, SD

MARK	DATE	REMARKS

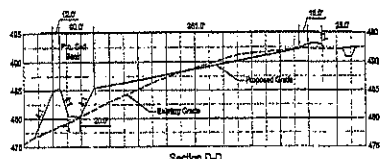
PROJECT NO: 1103107.000
CAD DWG FILE: C-GP10-00107
DRAWN BY: CAG
REVIEWED BY: BGH
COPYRIGHT: 2012 EISENBRAUN & ASSOCIATES, INC.

SHEET TITLE
PLAN VIEW

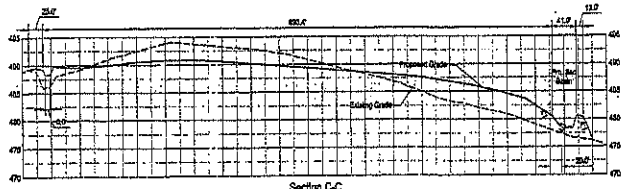
C-101
SHEET 1 OF 1



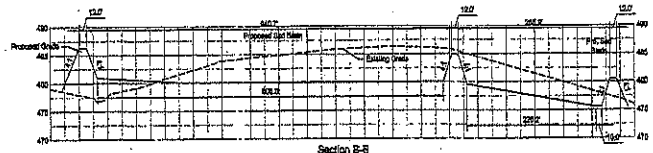
Section E-E
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'



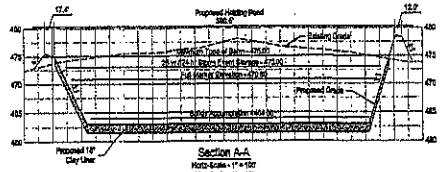
Section D-D
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'



Section C-C
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'



Section B-B
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'



Section A-A
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'

RECEIVED
JUL 13 2012
WATER RIGHTS PROGRAM

Prepared By
Eisenbraun & Associates
Transportation Solutions - Long Term Value
215 Fifth Ave
Torting SD 57063-2003
605.256.6570
605.256.6572
Eisenbraun@Sioux.com

SIGNED PROFESSIONAL ENGINEER
REG. NO.
JOHN DOUGLAS EISENBRAUN
SOUTH DAKOTA
7/12/2012

CONSULTANTS

Lynn Mayer Feedlot
Buffalo County, SD
Lynn Mayer
Gann Valley, SD

MARK	DATE	REMARKS

PROJECT No: 1031157.000
CAD DWG FILE: C-CP1A0201.DWG
DRAWN BY: DAG
REVIEWED BY: BBN
COPYRIGHT: 2012 EISENBRAUN & ASSOCIATES, INC.

SHEET TITLE
CROSS SECTIONS

C-301

SHEET 3 OF 3

Stacey R. Hennen
Associate
shennen@samplaw.com

Samp Law Offices
Rollyn H. Samp

Counselor at Law

2101 West 41st Street
Suite 2000
P.O. Box 495
Sioux Falls, South Dakota 57101

(605) 339-1020
TELEFAX: (605) 334-6630
rsamp@samplaw.com
MOBILE: (605) 366-1535 *24 Hrs.*

7 May 2013

Mr. Jason Williams
DENR PMB 2020
Joe Foss Building
523 East Capital
Pierre, South Dakota 57501-3182

Re: Mayer v Mayer

Dear Mr. Williams:

On September 7, 2012 my client filed the enclosed complaint with DENR.

Since then, he's had several phone calls from different persons promising action on this but nothing has transpired.

I find it amazing that DENR had no problem putting one of my clients out of business shutting down a multi-million-dollar feed lot but in this case can't seem to follow through on investigation or action.

I would like a letter summarizing the action taken by DENR to date and a position on this complaint.

Thank you.

Sincerely yours,

Rollyn H. Samp

RHS/ma
Enclosure
✓bcc: Glenn Mayer (letter only)

DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES
PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
denr.sd.gov

Received Sept. 7, 2012
from Glen Mayer
Complaint on Mayer Ranch
Feedyard

Vicki Murray,
Exec Assistant
DENR

STATE OF SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
COMPLAINT FORM

South Dakota law provides that:

"No inspection or other action pursuant to sections 34A-2-40, 34A-2-44 or 34A-2-45 that is based on, or is the result of a complaint or the provision of information by a member of the general public may be carried out unless the person making the complaint or providing the information signs the complaint. The complaint shall remain confidential with the board and the secretary." (South Dakota Codified Laws 34A- 2-111).

In conformity with the provisions of SDCL 34A-2-111, I, Glenn J. Mayer, hereby register the following complaint regarding the violation of our state Water Pollution Control Act:

LOCATION OF VIOLATION (please print):

Feed yard located NE 1/4; Sec 20; 106-69 Buffalo County owned by Lynn Mayer, Mayer Ranches, Inc.

FACTS ALLEGED TO CONSTITUTE THE VIOLATION (use back of page or second sheet if you need more room – please print):

Complaint and exhibits attached and incorporated herein

By signing this form, I certify that the information included on this form is, to the best of my knowledge and belief, true, accurate, and complete.

I declare and affirm under the penalties of perjury that this claim (petition, application, information) has been examined by me, and to the best of my knowledge and belief, is in all things true and correct.

Dated on September 5, 2012 at Chamberlain, South Dakota.

Glenn J. Mayer
Complainant Name (please print)

605-734-6526 or 605-730-1281
Complainant telephone Number (required)

Complainant Signature

PURSUANT TO SDCL 1-27-3 AND 34A-2-111 THIS DOCUMENT IS NOT A PUBLIC RECORD SUBJECT TO OPEN INSPECTION AND SHALL BE SEPARATELY MAINTAINED AND HELD CONFIDENTIAL.

GLENN MAYER

Complainant/Petitioner

vs

SOUTH DAKOTA DEPARTMENT
OF ENVIRONMENTAL AND
NATURAL RESOURCES

COMPLAINT AND OBJECTION

COMES NOW Glenn Mayer of 606 Merrill Street, Chamberlain, South Dakota 57325, individually and by and through his attorney, Rollyn H. Samp, 2101 W 41st Street, Suite 2000, Sioux Falls, SD 57105, who hereby file his complaint and objections to a proposed feedlot as follows:

FACTS

Lynn Mayer d/b/a Mayer Ranches, Inc., 23438 Pheasant Lane, Pukwana, SD 57870 is the owner of an animal feeding operation, to-wit:

> "The northeast one quarter (NE ¼) of Section 20, Township 106 North, Range 69 West in Buffalo County, South Dakota."

Owner has been operating an animal feeding operation of up to 999 head and has given Notice of Intent to Construct as of August 8, 2012 to 1,974 head of beef cattle.

That owner has completed an animal waste system management report and filed same with the South Dakota Department of Environmental and Natural Resources (DENR) as of July 17, 2012.

COUNT ONE

That petitioner Glenn Mayer hereby files a complaint and objections for polluting the following real property by owner, to-wit:

East one half (E ½) of Northwest one quarter (NW ¼) and Northeast one quarter (NE ¼) Section 21, Township 106, Range 69, Buffalo County, South Dakota.

Petitioner/Complainant believes feed lot runoff from owner is damaging real property, wildlife, recreation and stock dam of petitioners with its present operations.

That said pollution is documented as follows:

A. Complaint to the South Dakota Department of Environmental and Natural Resources (DENR) dated October 24, 2008, with report from Nancy Thiex, South Dakota State University;

B. Complaint to the South Dakota Department of Environmental and Natural Resources (DENR) dated June 1, 2008, with report of Nancy Thiex, South Dakota State University;

C. Water quality tests report(s) of Nancy Thiex, South Dakota State University dated May 20, 2009;

D. Water quality tests report(s) from the South Dakota Department of Health, Public Health Laboratories, as submitted by the Crow Creek Environmental Office. dated December 1, 2008;

F. Complaint filed with Buffalo County Director of Equalization on November 6, 2008, with attachments including those from David German dated May 22, 2008;

G. Water quality test reports from the United States Geological Survey, Huron, SD:
   1. Report dated May 31, 2010
   2. Report dated April 12, 2010
   3. Report dated July 2, 2010

H. Water quality test reports from Geotek Engineering and Testing Services, Inc.
   1. Report dated August 17, 2009
   2. Report dated March 30, 2010
   3. Report dated July 12, 2010
   4. Report dated April 19, 2011
   5. Report dated May 24, 2011
   6. Report dated June 22, 2011
   7. Report dated November 11, 2011
   8. Report dated April 4, 2012

That petitioner's complaints beginning in 2008 have gone unabated.

COUNT TWO

That approval of the proposed animal waste plant will put additional manure on land which is either adjacent to petitioner or drains onto petitioner's real property; same to increase damages already occurring to petitioner.

COUNT THREE

That DENR has statutory duty for enforcement of water quality laws in the state of South Dakota and has failed to act within its statutory authority to petitioner's complaints.

WHEREFORE, petitioner/complainant requests DENR take the following steps against owner:

1. Investigate the complaint filed by the petitioner/complainant;

2. Commence such actions as required by law to stop owner's current pollution of petitioner/complainant real property;

3. Begin remedial action as provided by law to abate past and present pollution;

4. Bring such administrative and legal actions as necessary to stop current pollution by owner;

5. Hold a hearing on owner's animal waste management system proposal to determine its environmental impact on petitioner/complainant's real property;

6. Conduct a public hearing so evidence may be heard on owner's proposed plan as to compliance of state law;

7. Pursue such other legal remedies as would mitigate the damages to petitioner/complainant; and

8. Require owner to comply with SDCL 34A-2-44.

Glenn Mayer
606 S Merrill St
Chamberlain, SD 57325
Complainant/Petitioner

Subscribed and sworn to before me
this 5th day of September, 2012.

Notary Public—South Dakota
My commission expires: 7/9/2016

(SEAL)

SAMP LAW OFFICE
for Rollyn H. Samp
P.O. Box 495
Sioux Falls, SD 57101
605-339-1020
Attorney for Complainant/Petitioner

Public Notices . . . Public

NOTICE OF PUBLIC HEARING FOR A CONDITIONAL USE PERMIT

The Chamberlain Planning Commission will hold a public hearing on Aug. 23, 2012 at 6 p.m. at 715 North Main Street in the Chamberlain City Council Chambers to hear testimony regarding an application for conditional use by J. D. Heinrich to operate a day care center for up to 12 children at 186 River Run Road, Chamberlain, SD. The legal description of the property is Tract 5A out of Tract 5 in the NW1/4 of Section 35, T104N, R71W, City of Chamberlain, Brule County. For additional information, please contact the city at 605-234-4401.

Those needing assistance to reach the meeting room should contact the finance office by phone or in writing by 5 p.m. the day of the meeting.

(Published one week, August 8, 2012, at a total approximate cost of $7.81.)

(August 8)

NOTICE OF INTENT TO CONSTRUCT AN ANIMAL FEEDING OPERATION

Notice is hereby given that the South Dakota Department of Environment and Natural Resources has received an application for an expanding animal feeding operation from:

Lyon Mayer
Mayer Ranches, Inc.
23438 Pheasant Lane
Pukwana, SD 57370-9625

The animal feeding operation is located in the Northeast 1/4 of Section 20, Township 106 North, Range 69 West in Buffalo County, approximately 12 miles north and two miles east of the Town of Pukwana. The operation will expand from 999 head of beef cattle to 1,974 head of beef cattle. The proposed expansion to the manure management system will consist of constructing two sedimentation basins and an additional holding pond. The manure management system will have at least 365 days of storage capacity. The manure will be land applied to fields located in portions of the following sections in Buffalo County:

Sections 8, 17, 20, 21, 28, 29, 30, 32 and 33 in Township 106 North, Range 69 West.

Information about the manure management system for the proposed operation may be obtained from Troy Roth with the Department of Environment and Natural Resources, Joe Foss Building, Pierre, SD 57501-3181, phone 605-773-3351.

Steven M. Pirner
Secretary

(Published one week, August 8, 2012, at a total approximate cost of $13.39.)

(August 8)

File No. 12-14

NOTICE TO CREDITORS AND NOTICE OF INFORMAL PROBATE AND APPOINTMENT OF PERSONAL REPRESENTATIVE

State of South Dakota
County of Brule

In Circuit Court
First Judicial Circuit

Kimball, SD 57355
Brule County Clerk of Courts
300 South Courtland Street
Chamberlain, SD 57325
605-734-4580

David V. Natvig
P.O. Box 167
Kimball, SD 57355
605-778-6316

(Published three consecutive weeks, July 25, 2012, August 1, 2012 and August 8, 2012, at a total approximate cost of $38.49.)

(July 25/August 1/August 8)

File No. 12-9

NOTICE TO CREDITORS AND NOTICE OF INFORMAL PROBATE AND APPOINTMENT OF PERSONAL REPRESENTATIVE

STATE OF SOUTH DAKOTA)
:ss.
COUNTY OF LYMAN)

IN CIRCUIT COURT
SIXTH JUDICIAL CIRCUIT

ESTATE OF
BEULAH D. PECHAL,
DECEASED.

Notice is given that on May 30, 2012, First Dakota National Bank, whose address is 500 East Norway, P.O. Box 1306, Mitchell, South Dakota 57301, was appointed as personal representative of the estate of BEULAH D. "Polly" PECHAL.

Creditors of decedent must file their claims within four (4) months after publication of this notice or within sixty days after the date this notice was mailed to them, whichever is later or their claims may be barred.

Claims may be filed with the personal representative or may be filed with the clerk and a copy of the claim mailed to the personal representative.

Dated this 30th day of July, 2012.
FIRST DAKOTA NATIONAL BANK
By JEAN A. KOEHLER, CTFA
Vice-President/Trust Officer
500 East Norway P.O. Box 1306
Mitchell, SD 57301
605-995-7906

CLERK OF COURTS
P.O. BOX 235
KENNEBEC, SD 57544
605-869-2277

STEVEN R. SMITH
P.O. BOX 746
CHAMBERLAIN, SD 57325
605-734-9000

(Published three consecutive weeks, August 8, 2012, August 15, 2012 and August 22, 2012, at a total approximate cost of $44.49.)

(August 8/August 15/August 22)

Pro. No. 12-15

NOTICE TO CREDITORS AND NOTICE OF INFORMAL PROBATE AND APPOINTMENT OF PERSONAL REPRESENTATIVE

STATE OF SOUTH DAKOTA)
:ss
COUNTY OF BRULE)

IN CIRCUIT COURT

Page 2

Public Notices . . . Public

NOTICE OF PUBLIC HEARING FOR A CONDITIONAL USE PERMIT

The Chamberlain Planning Commission will hold a public hearing on Aug. 23, 2012 at 6 p.m. at 715 North Main Street in the Chamberlain City Council Chambers to hear testimony regarding an application for conditional use by J. D. Heinrich to operate a day care center for up to 12 children at 106 River Run Road, Chamberlain, SD. The legal description of the property is Tract 5A out of Tract 5 in the NW1/4 of Section 35, T104N, R71W, City of Chamberlain, Brule County. For additional information, please contact the city at 605-234-4401.

Those needing assistance to reach the meeting room should contact the finance office by phone or in writing by 5 p.m. the day of the meeting.

(Published one week, August 8, 2012, at a total approximate cost of $7.81.)

(August 8)

NOTICE OF INTENT TO CONSTRUCT AN ANIMAL FEEDING OPERATION

Notice is hereby given that the South Dakota Department of Environment and Natural Resources has received an application for an expanding animal feeding operation from:

Lynn Mayer
Mayer Ranches, Inc.
23438 Pheasant Lane
Pukwana, SD 57370-9625

The animal feeding operation is located in the Northeast 1/4 of Section 20, Township 106 North, Range 69 West in Buffalo County, approximately 12 miles north and two miles east of the Town of Pukwana. The operation will expand from 999 head of beef cattle to 1,974 head of beef cattle. The proposed expansion to the manure management system will consist of constructing two sedimentation basins and an additional holding pond. The manure management system will have at least 365 days of storage capacity. The manure will be land applied to fields located in portions of the following sections in Buffalo County:

Sections 8, 17, 20, 21, 28, 29, 30, 32 and 33 in Township 106 North, Range 69 West.

Information about the manure management system for the proposed operation may be obtained from Troy Roth with the Department of Environment and Natural Resources, Joe Foss Building, Pierre, SD 57501-3181, phone 605-773-3351.

Steven M. Pirner
Secretary

(Published one week, August 8, 2012, at a total approximate cost of $13.39.)

(August 8)

File No. 12-14
NOTICE TO CREDITORS AND NOTICE OF INFORMAL PROBATE AND APPOINTMENT OF PERSONAL REPRESENTATIVE

State of South Dakota
County of Brule

In Circuit Court
First Judicial Circuit

Kimball, SD 57355
Brule County Clerk of Courts
300 South Courtland Street
Chamberlain, SD 57325
605-734-4580
David V. Natvig
P.O. Box 167
Kimball, SD 57355
605-778-6316

(Published three consecutive weeks, July 25, 2012, August 1, 2012 and August 8, 2012, at a total approximate cost of $38.69.)

(July 25/August 1/August 8)

Pro. No. 12-9
NOTICE TO CREDITORS AND NOTICE OF INFORMAL PROBATE AND APPOINTMENT OF PERSONAL REPRESENTATIVE

STATE OF SOUTH DAKOTA)
:ss.
COUNTY OF LYMAN)

IN CIRCUIT COURT
SIXTH JUDICIAL CIRCUIT

ESTATE OF
BEULAH D. PRCHAL,
DECEASED.

Notice is given that on May 30, 2012, First Dakota National Bank, whose address is 500 East Norway, P.O. Box 1306, Mitchell, South Dakota 57301, was appointed as personal representative of the estate of BEULAH D. "Polly" PRCHAL.

Creditors of decedent must file their claims within four (4) months after publication of this notice or within sixty days after the date this notice was mailed to them, whichever is later or their claims may be barred.

Claims may be filed with the personal representative or may be filed with the clerk and a copy of the claim mailed to the personal representative.

Dated this 30th day of July, 2012.

FIRST DAKOTA NATIONAL BANK
By JEAN A. KOEHLER, CTFA
Vice-President/Trust Officer
500 East Norway P.O. Box 1306
Mitchell, SD 57301
605-995-7906
CLERK OF COURTS
P.O. BOX 235
KENNEBEC, SD 57544
605-869-2277
STEVEN R. SMITH
P.O. BOX 746
CHAMBERLAIN, SD 57325
605-734-9000

(Published three consecutive weeks, August 8, 2012, August 15, 2012 and August 22, 2012 at a total approximate cost of $44.49.)

(August 8/August 15/August 22)

Pro. No. 12-15
NOTICE TO CREDITORS AND NOTICE OF INFORMAL PROBATE AND APPOINTMENT OF PERSONAL REPRESENTATIVE

STATE OF SOUTH DAKOTA)
:ss
COUNTY OF BRULE)

IN CIRCUIT COURT

DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES
PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182

denr.sd.gov

September 3, 2013

Glenn Mayer
606 South Merrill Street
Chamberlain, SD 57325

Dear Mr. Mayer:

Thank you for contacting the Department of Environment and Natural Resources and submitting complaint forms for your water pollution concerns about the Mayer Ranches feedlot. The purpose of this letter is to respond to the complaint information submitted by you and your attorney, Mr. Rollyn H. Samp.

As you are aware, Mayer Ranches is a feedlot located in the Northeast ¼ of Section 20, Township 106 North, Range 69 West, in Buffalo County, South Dakota. Mayer Ranches currently has coverage under South Dakota's *General Water Pollution Control Permit for Concentrated Animal Feeding Operations* (general permit) for a maximum of 999-head of beef cattle. In South Dakota, large concentrated animal feeding operations feeding 1,000-head or more of beef cattle are required to obtain coverage under the general permit.

Mayer Ranches has voluntarily obtained general permit coverage for a 999-head beef cattle feedlot by submitting a permit application and constructing and operating a manure containment system meeting the requirements of the general permit. The manure containment system is designed to contain all the runoff from the feedlot in a clay-lined holding pond. Mayer Ranches is required to land apply manure from the facility to fields in its approved nutrient management plan following the requirements of the general permit. Permitted facilities are required to keep manure application records documenting their compliance with the nutrient management planning requirements of the general permit.

Mayer Ranches is located on land where both the Environmental Protection Agency (EPA) and the State of South Dakota claim jurisdiction. If EPA jurisdiction is asserted and Mayer Ranches obtains permit coverage from EPA, South Dakota will terminate its general permit coverage for the feedlot. For information on EPA's requirements please contact Amy Clark with EPA Region 8, at (303) 312-7014.

As you are also aware, the department has approved plans and specifications for an expansion of the feedlot to increase the number of cattle at the feedlot to a maximum of 1,974-head of beef

cattle. As you requested, enclosed is a copy of the approval letter for the expansion of the feedlot. The feedlot has not yet submitted a Notice of Completion indicating construction is complete so permit coverage can be issued for the expansion.

The information you and your attorney submitted to the department indicates you believe the Mayer Ranches feedlot is causing water pollution. The submitted information includes water quality sample results which you indicate provide evidence of pollution caused by the feedlot.

The department has inspected the Mayer Ranches feedlot in response to your complaints. The department has also conducted operation and maintenance inspections of the feedlot. During the inspections, the department has not documented evidence of manure runoff from the feedlot or manure containment system. Enclosed with this letter is a copy of the department's inspection reports.

The department's Surface Water Quality Standards staff has reviewed the submitted water sample results and based on their review, the department does not believe the sample results show water pollution is occurring from the Mayer Ranches feedlot.

You also inquired about a public hearing for the approved expansion of the Mayer Ranches feedlot. As your attorney discussed with Rich Williams with the South Dakota Office of the Attorney General since the feedlot is applying for coverage under the general permit there is not a public hearing available on the permit application. The general permit process provided the opportunity for a hearing prior to the issuance of the general permit, but does not provide for a hearing when applications for general permit coverage, such as the application from Mayer Ranches, are received by the department.

Thank you for contacting the department. If you have any questions, please feel free to contact me at (605) 773-3351.

Sincerely,

Kent R. Woodmansey, PE, Administrator
Feedlot Permit Program

cc: Rollyn H. Samp, Samp Law Offices
2101 West 41st Street, Suite 2000
P.O. Box 495
Sioux Falls, SD 57101

Rich Williams, Office of the Attorney General

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
Operation & Maintenance Inspection Report

1. **Background Information:**

Facility: Mayer Ranches, Inc. **Contact:** Lynn Mayer
Date of Inspection 9/25/12 **Phone Number:** 894-4440 **Permit Number: SDG-01**00014
Permitted Number/Type Animals: 999 beef cattle
Current Animal Number During Inspection: 0 - cattle

2. **On Site:**

	Yes	No	If No – Explanation	Or see #7
Copy of General Permit	☒	☐		☐
Copy of Nutrient Management Plan	☒	☐		☐
Are lease agreements current? ☐ NA	☒	☐		☐
Training Verification	☒	☐		☐

3. **Records Reviewed:**

	Yes	No	If No – Explanation	Or see #7
Manure Land Application Records				
All Soil Tests				
- 0-2 foot samples	☒	☐		☐
- 2-4 foot samples ☐ - 0-2 foot samples pre & post harvest ☐	~~☐~~	~~☐~~		☐
All Manure Tests				
-Tested for Total Nitrogen	☒	☐		☐
-Tested for Inorganic Nitrogen	☒	☐		☐
Rate Calculations				
Applied at Calculated Rate or Lower	☒	☐		☐
Applied to land in NMP	☒	☐	Applied to field 9	☐
Land Application Dates Documented	☒	☐		☐
Land Application Times Documented	☐	☐		☐
Method of Application Documented	☒	☐		☐
Inspection Records (Documentation)				
Daily Land Application	☒	☐		☐
Weekly Manure Containment Structure	☒	☐		☐
Precipitation Records	☒	☐		☐

4. **Ground Water Discharge Permit and Ground Water Monitoring:**

Was a ground water discharge permit required at this facility?	☐ Yes ☒ No: Permit #:
Is ground water monitoring required at this facility?	☐ Yes ☒ No :
Has required monitoring frequency and sampling been followed and documentation submitted?	☒ NA ☐ Yes ☐ No: Explanation –

5. Any Other Comments: No visible evidence of pollution observed.

6. Do you currently have any contagious livestock disease(s) at your facility – ☐ Yes ☒ No If yes, please provide more information on the type of disease. _____

7. Waste Containment System Observations:

Permanent Marker ☐ NA - Liquid level above permanent marker – ☐ Yes ☒ No
Description of Containment Structure Liquid Level: Pond is mostly dry
Marker Condition and Location: Steel post on center of North berm
☐ Discharge to surface waters since last inspection? ☐ Yes ☐ No: When and Why?
☐ NA - Was it reported to DENR within 24 hours? ☐ Yes ☐ No: Why not?

Check the box below if any of the following items were noted during the inspection.

☐ a. Seepage from the Structure	☐ b. Piping Problems	☐ c. Adverse Vegetation on Dikes
☐ d. Evidence of Livestock In or Around Lagoon	☐ e. Rodent Problems	☐ f. Structural Integrity Problems
☐ g. Erosion	☐ h. Liner Damage	☐ i. Vegetation in Ponds
☐ j. Cracks in Concrete	☐ k. Tank Corrosion	☐ l. Unapproved System Modifications
☐ m. Monitoring Well Integrity	☐ n. Other -	

Problems Noted:	Schedule and Action:

☐ Observations Continued on Next Page

8. Permit Violation Summary, Schedule, and Required Action:

Permit Violations:	Schedule and Required Action:

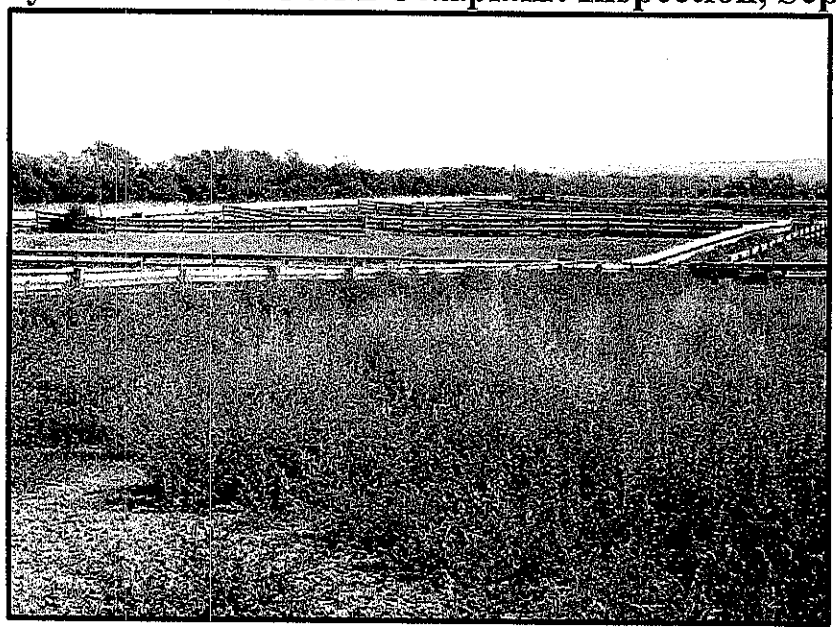
☐ Permit Violation Summary Continued on Next Page

Inspector Signature/Date: Jason A. Rogow 9/25/12 9-25-12

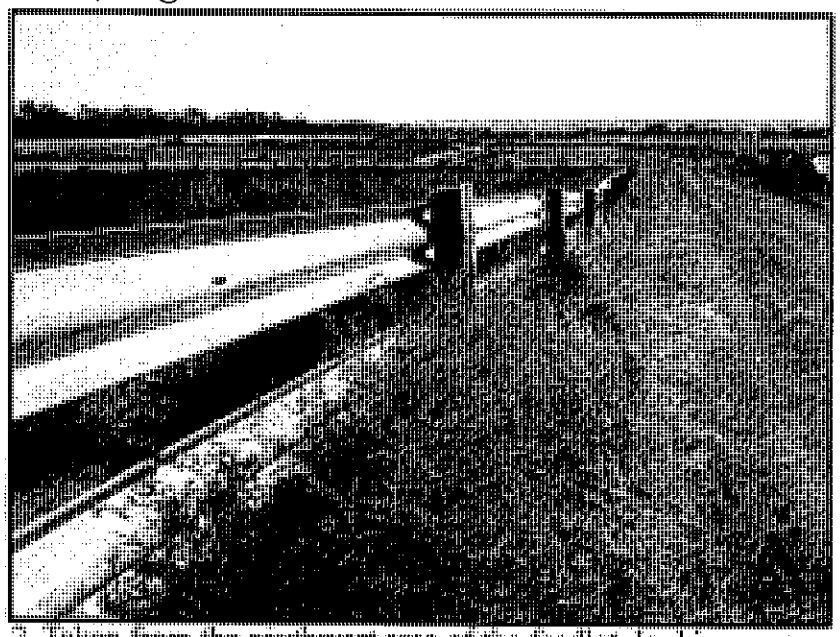
Owner or Operator Signature/Date: 9/25/12

NOTE: Producers and inspectors are required to sign and date this form. Signatures indicate that the inspector and the producer have discussed operational compliance and the comments written on this document and a copy of the inspection form was left with the producer on the day of the inspection.

Mayer Ranches - O&M/Complaint Inspection, September 25, 2012, Page 1 of 2

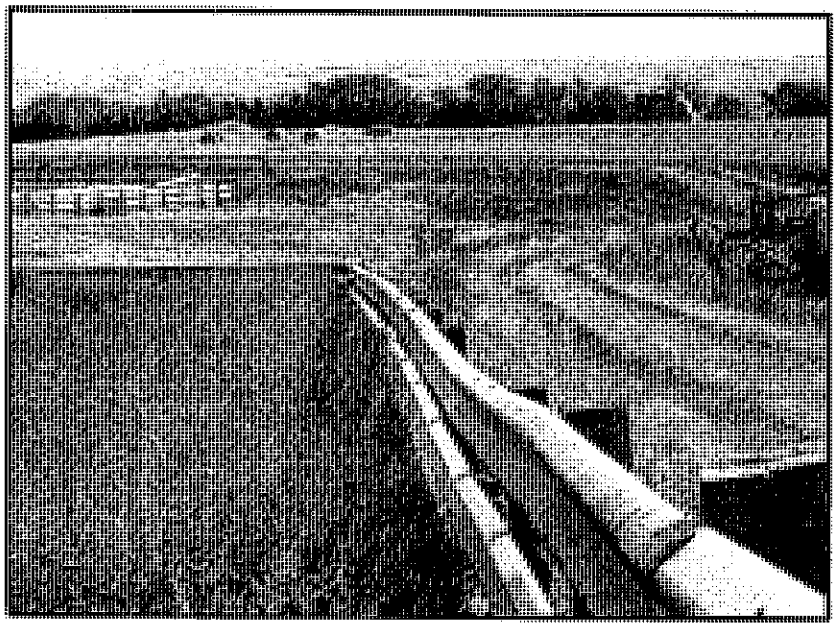


1. Taken from the southwest area of the feedlot, looking northeast.

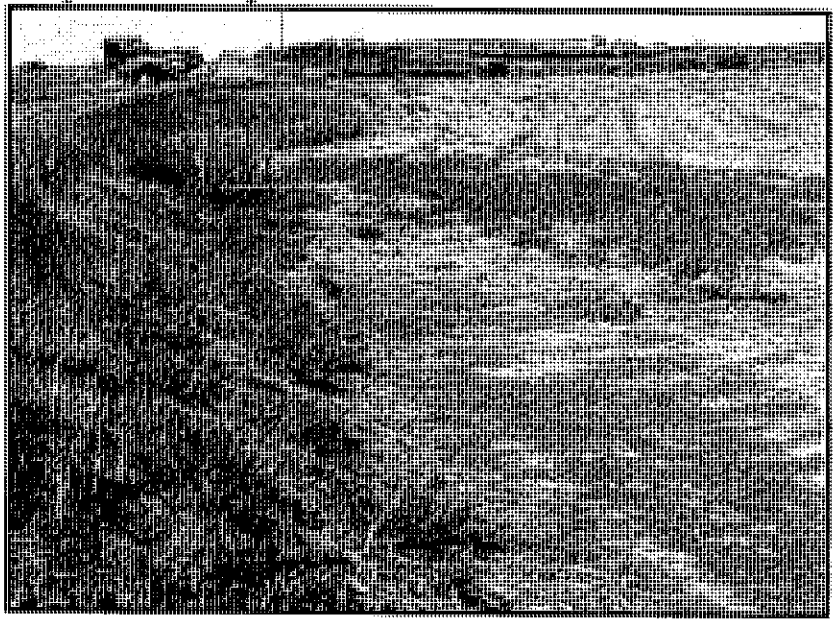


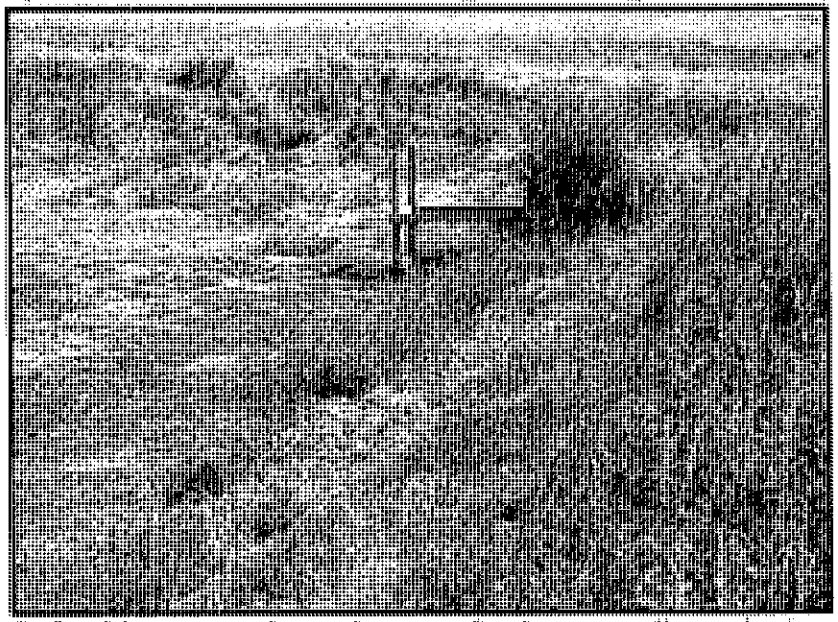
2. Taken from the southwest area of the feedlot, looking northeast-east at the feedlot.

3. Looking east at the sediment basin from the southwest area of the feedlot.



4. Standing at the sediment basin, looking west-northwest. The trash screen for the west sediment basin pipeline is seen in the left portion of the picture.

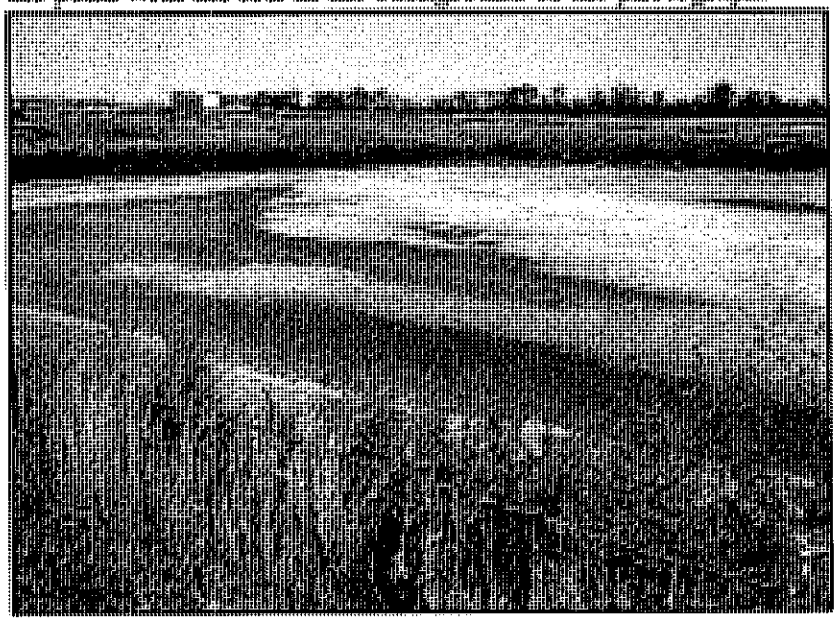




5. Looking east at the trash screen for the east sediment basin pipeline.

6. Standing approximately midway on the north berm of the holding pond, looking southeast across the pond.

7. Looking northwest across the holding from the south berm of the pond with the lots in the background of the photograph.



DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
Operation & Maintenance Inspection Report

1. **Background Information:**

Facility: Mayer Ranches Inc **Contact:** Lynn Mayer Cell 650-0056
Date of Inspection 12/6/11 **Phone Number:** 605, 994, 4446 **Permit Number: SDG-0** 100014
Permitted Number/Type Animals: 999 - beef cattle
Current Animal Number During Inspection: 740 beef cattle

2. **On Site:** last inspection 1-29-09

	Yes	No	If No – Explanation	Or see #7
Copy of General Permit	☒	☐		☐
Copy of Nutrient Management Plan	☒	☐		☐
Are lease agreements current? ☐ NA	☒	☐		☐
Training Verification	☒	☐		☐

3. **Records Reviewed:**

	Yes	No	If No – Explanation			Or see #7
Manure Land Application Records			2009	2010	2011	
All Soil Tests						
- 0-2 foot samples	☒	☒	T70 F2 T68 F5 - 08"	T60 F5	T68 F5	☐
- 2-4 foot samples ☐ - 0-2 foot samples pre & post harvest ☐	☐	☐	—	—	—	☐
All Manure Tests						
-Tested for Total Nitrogen	☒	☐	ok	ok	ok	☐
-Tested for Inorganic Nitrogen	☒	☐	ok	ok	ok	☐
Rate Calculations						
Applied at Calculated Rate or Lower	☒	☐	ok	ok	ok	☐
Applied to land in NMP	☒	☐	ok	ok	ok	☐
Land Application Dates Documented	☒	☐	ok	ok	ok	☐
Land Application Times Documented	☐	☐	—			☐
Method of Application Documented	☒	☐	ok	ok	ok	☐
Inspection Records (Documentation)						
Daily Land Application	☒	☐	ok	ok	ok	☐
Weekly Manure Containment Structure	☒	☐	ok	ok	ok	☐
Precipitation Records	☒	☐	ok	ok	ok	☐

4. **Ground Water Discharge Permit and Ground Water Monitoring:**

Was a ground water discharge permit required at this facility?	☐ Yes ☒ No: Permit #:
Is ground water monitoring required at this facility?	☐ Yes ☒ No :
Has required monitoring frequency and sampling been followed and documentation submitted?	☒ NA ☐ Yes ☐ No: Explanation –

Mayer Ranches, Inc.

5. Any Other Comments: _____

6. Do you currently have any contagious livestock disease(s) at your facility – ☐ Yes ☒ No If yes, please provide more information on the type of disease. _____

7. Waste Containment System Observations:

Permanent Marker ☐ NA - Liqnid level above permanent marker – ☐ Yes ☒ No
Description of Containment Structure Liquid Level: 3' below marker
Marker Condition and Location: Rusted and bent
☐ Discharge to surface waters since last inspection? ☐ Yes ☒ No: When and Why?
☒ NA - Was it reported to DENR within 24 hours? ☐ Yes ☐ No: Why not?

Check the box below if any of the following items were noted during the inspection.

☐ a. Seepage from the Structure	☐ b. Piping Problems	☐ c. Adverse Vegetation on Dikes
☐ d. Evidence of Livestock In or Around Lagoon	☐ e. Rodent Problems	☐ f. Structural Integrity Problems
☐ g. Erosion	☐ h. Liner Damage	☐ i. Vegetation in Ponds
☐ j. Cracks in Concrete	☐ k. Tank Corrosion	☐ l. Unapproved System Modifications
☐ m. Monitoring Well Integrity	☐ n. Other -	

Problems Noted:	Schedule and Action:

☐ Observations Continned ou Next Page

8. Permit Violation Summary, Schedule, and Required Action:

Permit Violations:	Schedule and Required Action:
0-3" test for ammonia	Sample from 0-2' for all Rule 15

☐ Permit Violation Summary Continued on Next Page

Inspector Signature/Date: [signature] 12-6-11

Owner or Operator Signatnre/Date: [signature]

NOTE: Producers and inspectors are required to sign and date this form. Signatures indicate that the inspector and the producer have discussed operational compliance and the comments written on this document and a copy of the inspection form was left with the producer on the day of the inspection.

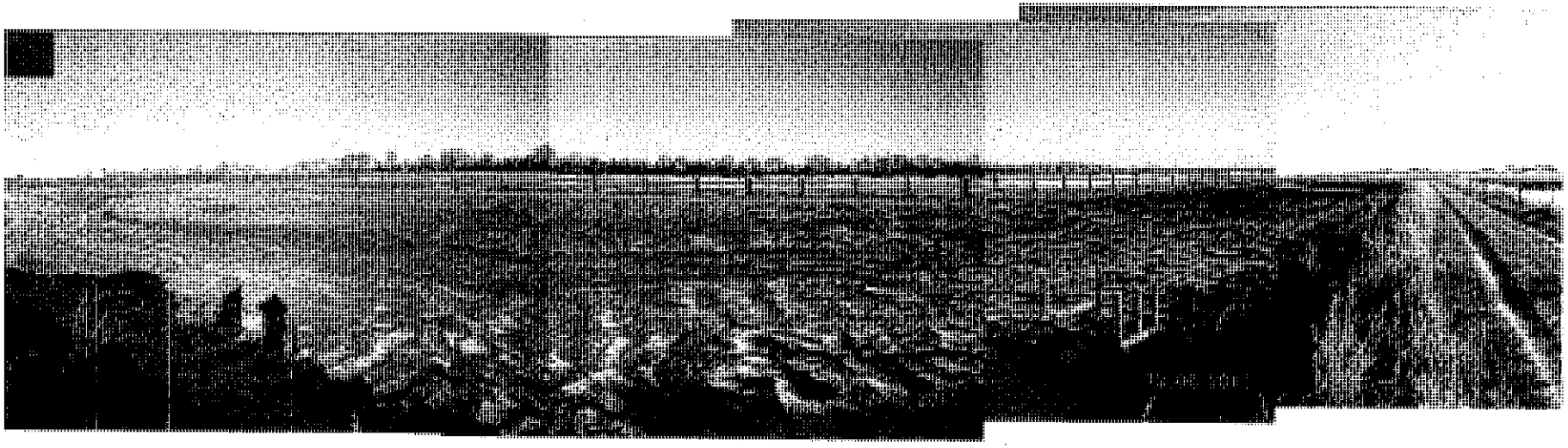


Photo 1, Composite Photo – Looking west to east (L to R) across the sediment basin. Basin had recently been cleaned and graded.

Photo 2, Composite Photo – Looking northeast across the holding pond from the southwest corner. Producer puts a pump in at this corner to pump down the pond.

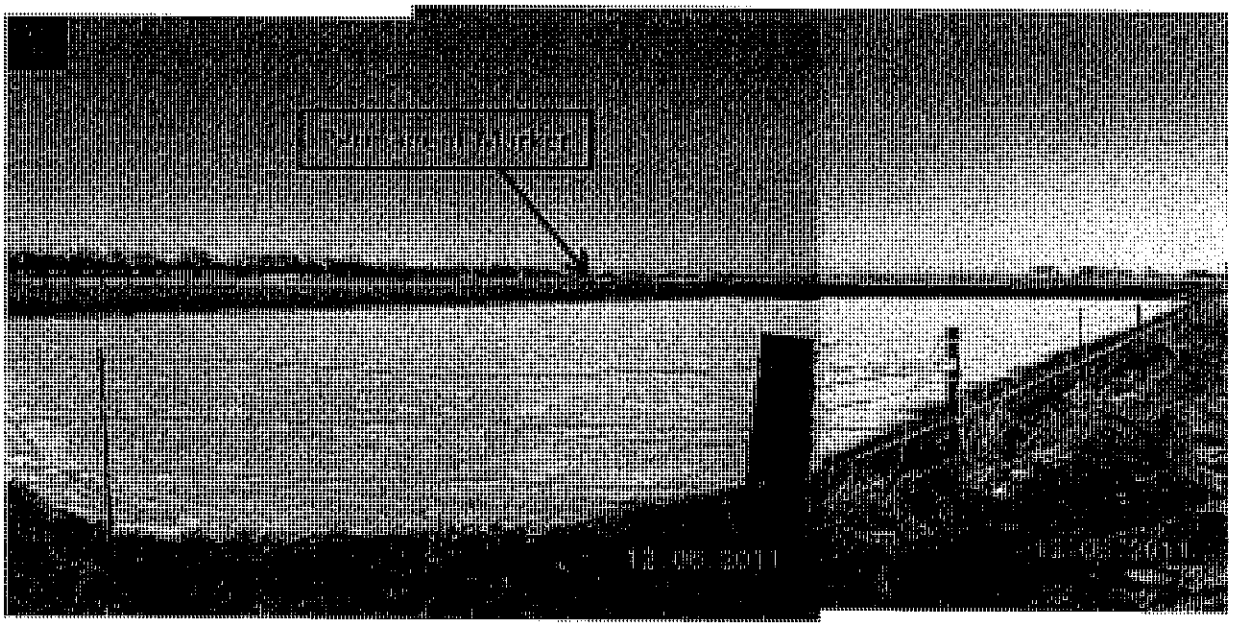
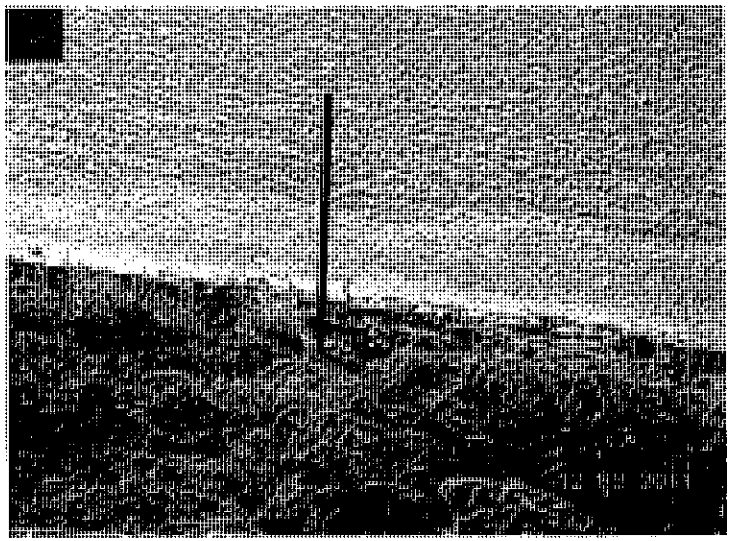
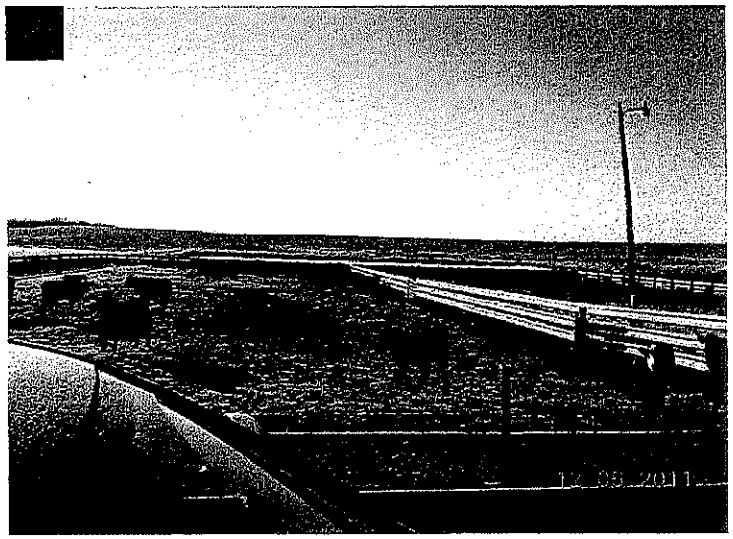
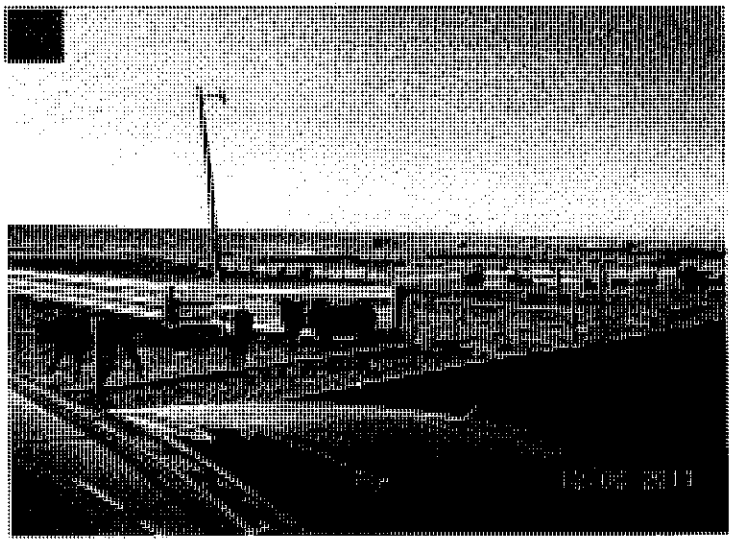


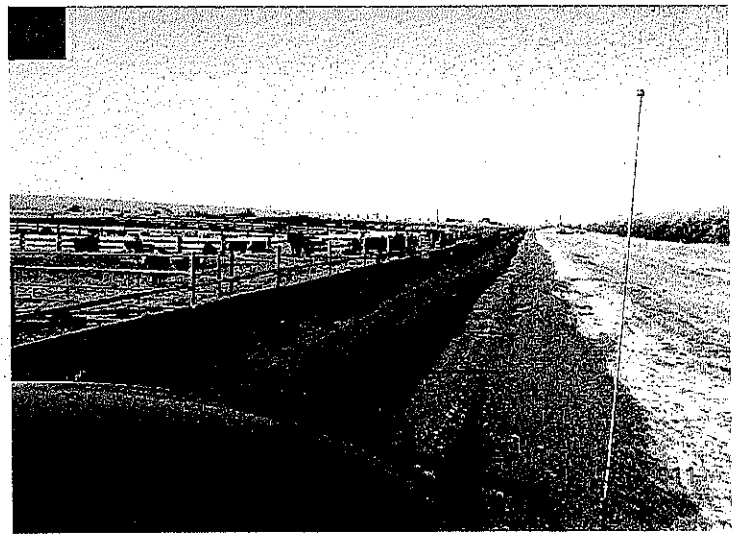
Photo 3 – Looking south at the permanent marker in the north berm. At the time of inspection the liquid level was approximately 3 feet below the marker.

Photos 4, 5, 6 – Looking south to east across the pen areas. At the time of inspection the lots were populated to 740 head.









DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
Operation & Maintenance Inspection Report

1. **Background Information:**

Facility: MATER RANCHES **Contact:** LYNN MATER
Date of Inspection 1/29/09 **Phone Number:** 994 4440 **Permit Number: SDG-0** 1 0 0 0 1 4
Permitted Number/Type Animals: 999 BEEF CATTLE
Current Animal Number During Inspection: 680 BEEF CATTLE

2. **On Site:**

	Yes	No	If No – Explanation	Or see #7
Copy of General Permit	☒	☐		☐
Copy of Nutrient Management Plan	☒	☐		☐
Are lease agreements current? ☐ NA	☐	☐		☐
Training Verification	☒	☐		☐

3. **Records Reviewed:**

	Yes	No	If No – Explanation			Or see #7
Manure Land Application Records			2006	2007	2008	
All Soil Tests						
- 0-2 foot samples	☐	☐		OK	OK	☐
- 2-4 foot samples ☐ - 0-2 foot samples pre & post harvest ☐	☐	☐	NO APPLICATION	NA	NA	☐
All Manure Tests						
-Tested for Total Nitrogen	☐	☐		OK	OK	☐
-Tested for Inorganic Nitrogen	☐	☐		OK	OK	☐
Rate Calculations						
Applied at Calculated Rate or Lower	☐	☐		YES	YES	☐
Applied to land in NMP	☐	☐		W 1/2 S20-106-69	NE S30-106-69	☐
Land Application Dates Documented	☐	☐		OK	OK	☐
Land Application Times Documented	☐	☐		OK	OK	☐
Method of Application Documented	☐	☐		OK	OK	☐
Inspection Records (Documentation)						
Daily Land Application	☐	☐		OK	OK	☐
Weekly Manure Containment Structure	☐	☐	←	CHECKED, NOT MEASURED	⊛ →	☐
Precipitation Records	☐	☐	OK	OK	OK	☐

4. **Ground Water Discharge Permit and Ground Water Monitoring:** ⊛ EXPLAINED REQUIREMENTS

Was a ground water discharge permit required at this facility?	☐ Yes ☒ No: Permit #:
Is ground water monitoring required at this facility?	☐ Yes ☒ No :
Has required monitoring frequency and sampling been followed and documentation submitted?	☒ NA ☐ Yes ☐ No: Explanation –

5. Any Other Comments: _____

6. Do you currently have any contagious livestock disease(s) at your facility – ☐ Yes ☒ No If yes, please provide more information on the type of disease. _____

7. Waste Containment System Observations:

Permanent Marker ☐ NA - Liquid level above permanent marker – ☒ Yes ☐ No
Description of Containment Structure Liquid Level: 6" BELOW MARKER
Marker Condition and Location: NORTH EDGE STEEL POST
☐ Discharge to surface waters since last inspection? ☐ Yes ☒ No: When and Why?
☒ NA - Was it reported to DENR within 24 hours? ☐ Yes ☐ No: Why not?

Check the box below if any of the following items were noted during the inspection.

☐ a. Seepage from the Structure	☐ b. Piping Problems	☐ c. Adverse Vegetation on Dikes
☐ d. Evidence of Livestock In or Around Lagoon	☐ e. Rodent Problems	☐ f. Structural Integrity Problems
☐ g. Erosion	☐ h. Liner Damage	☐ i. Vegetation in Ponds
☐ j. Cracks in Concrete	☐ k. Tank Corrosion	☐ l. Unapproved System Modifications
☐ m. Monitoring Well Integrity	☐ n. Other -	

Problems Noted:	Schedule and Action:

☐ Observations Continued on Next Page

8. Permit Violation Summary, Schedule, and Required Action:

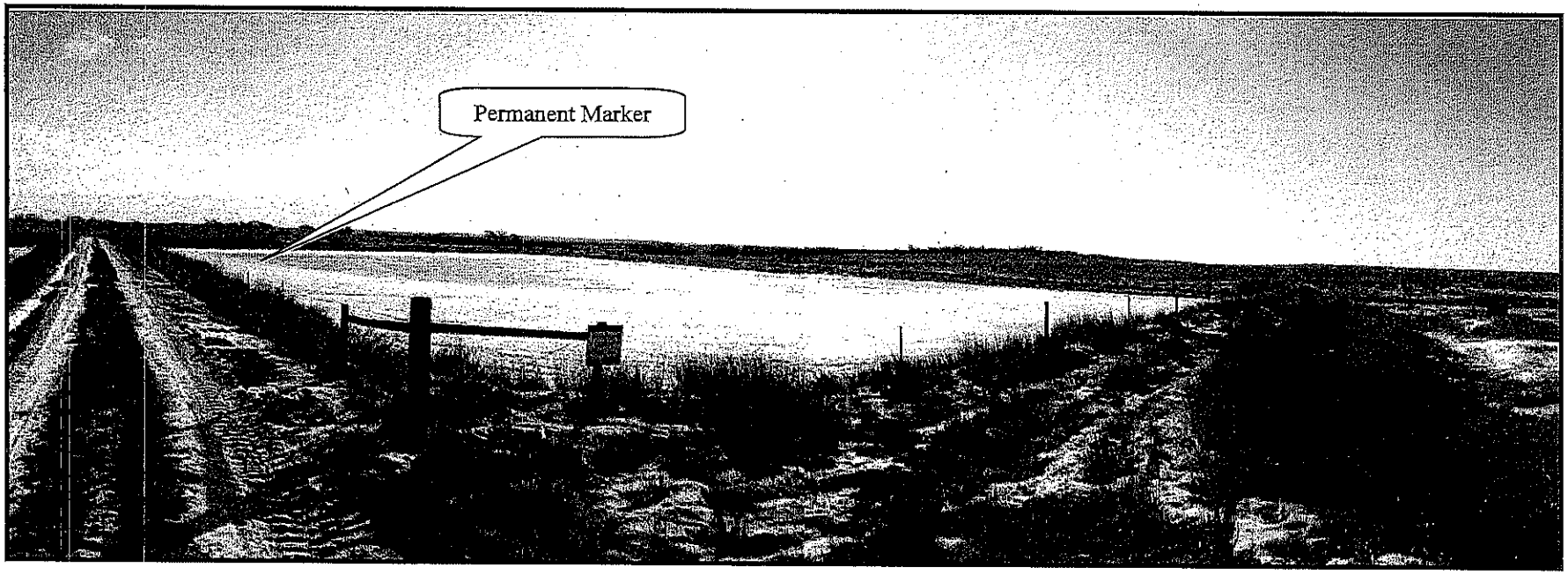
Permit Violations:	Schedule and Required Action:
POND LEVELS NOT DOCUMENTED	DOCUMENT POND LEVEL ONCE PER WEEK

☐ Permit Violation Summary Continued on Next Page

Inspector Signature/Date: 1/29/2009

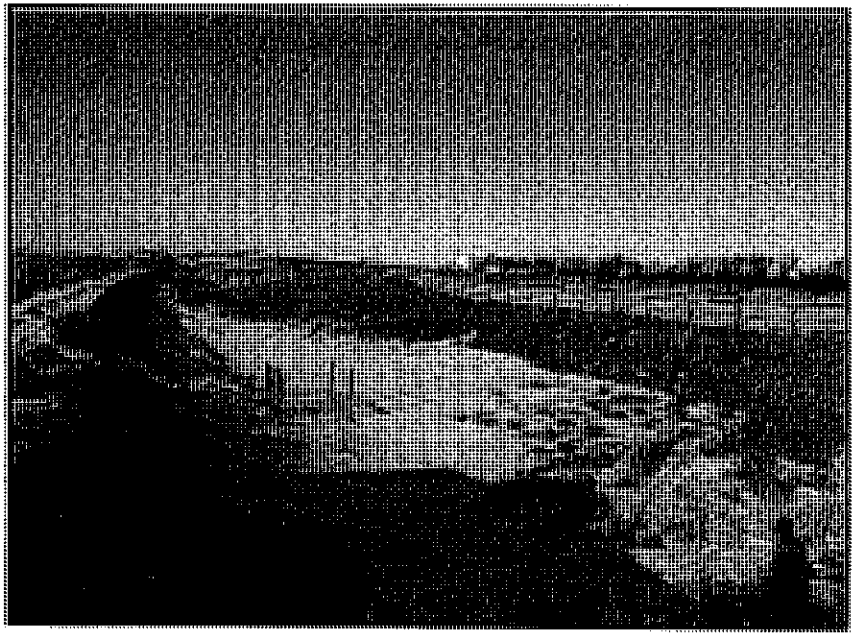
Owner or Operator Signature/Date: 1/29/09

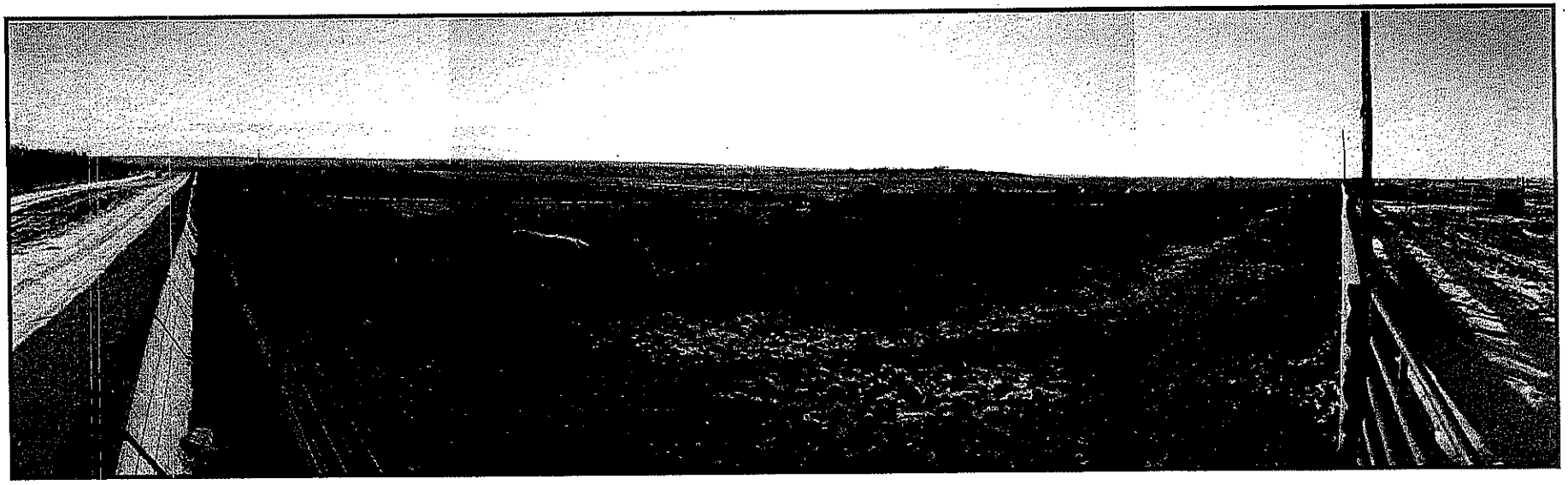
NOTE: Producers and inspectors are required to sign and date this form. Signatures indicate that the inspector and the producer have discussed operational compliance and the comments written on this document and a copy of the inspection form was left with the producer on the day of the inspection.



1. Looking southeast across holding pond.
2. Permanent Marker.

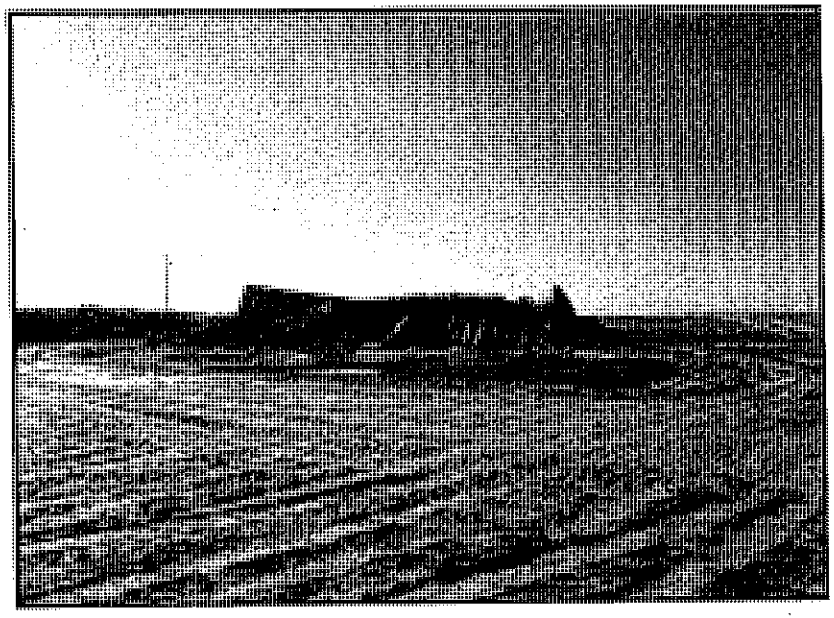
3. Looking west across sediment basin.



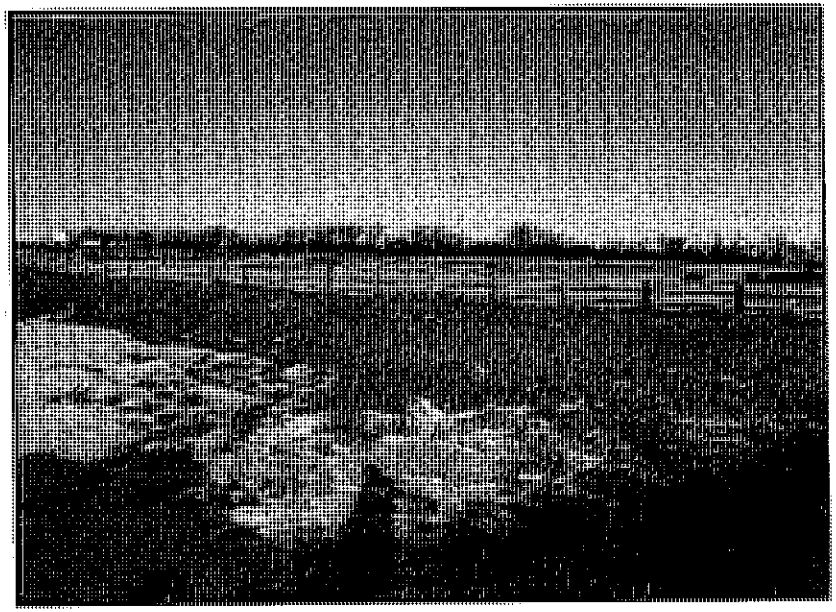


4. Looking southeast across the open lots

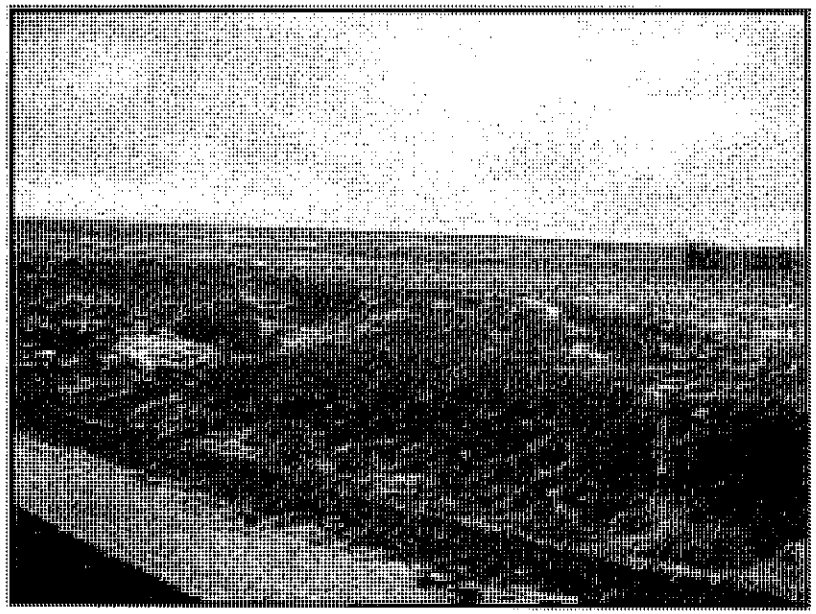
5. Looking south at the feed storage bunker.



7. Looking northwest across sediment basin and open lots.



8. Looking northwest from road toward Mayer Ranches feedlot. There was not evidence of surface water pollution.



9. Looking northeast down natural drainage.

10. Looking north up ditch.

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

ANIMAL FEEDING OPERATION (AFO) INSPECTION REPORT

Preliminary Information:

Facility/Producer:	**Mayer Ranches**
Owner/Operator:	**Mr. Lynn Mayer**
Owner/Operator Address:	Route 1, Box 56, Pukwana, SD 57370-9625
Phone Number:	Office: (605) 894-4440
	Cellular: (605) 680-0086
Inspection Date:	**July 21, 2008**
Department Inspector(s):	Jason A. Roggow, Natural Resources Engineer
Facility Location:	NE ¼ of Section 20, T 106 N, R 69 W; Buffalo County
Animal Type:	Beef cattle
Animal Population - Permitted:	999-head

Description of Inspection:

In response to a written complaint, the department inspected the Mayer Ranches feedlot. The complaint expressed concerns about elevated nutrient levels in a drainage downstream of the feedlot. The inspection was conducted to determine if the feedlot was contributing manure runoff into the drainage.

During the inspection Mr. Mayer indicated he has never needed to pump down the holding pond. Mr. Mayer does not have his own irrigation and pumping equipment but does have a custom pumper from North Dakota who is available for pumping the pond if necessary (General Irrigation from Oaks, ND – www.generalirrigation.com). Solid manure from the feedlot was land applied last fall to a field west of the feedlot.

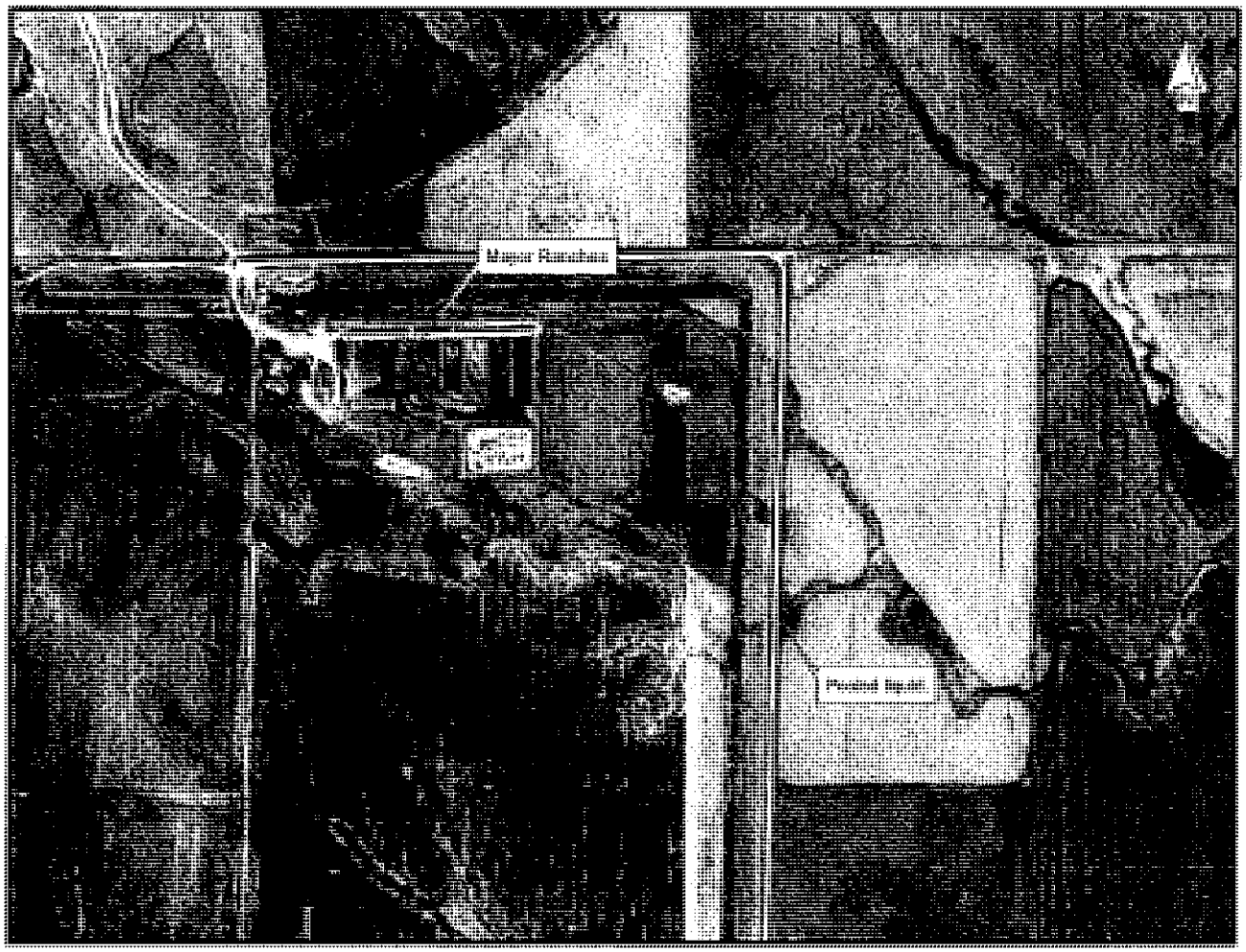
Manure runoff from the feedlot or manure containment system was not occurring at the time of the inspection and there was no evidence of past manure runoff from the feedlot or the manure containment system occurring.

There is a seasonal, intermittent drainage located along the south side of the feedlot and holding pond that runs in a southeasterly direction toward 353rd Avenue where the drainage passes through a culvert beneath 353rd Avenue (see Figure 1 on the following page). There was no liquid present in the drainage between 353rd Avenue and the feedlot. A small pool of liquid was present in the drainage along the east side of 353rd Avenue. This pooled liquid is approximately 0.25 miles downstream from the Mayer Ranches feedlot. The origin of the pooled liquid in the drainage along the east side of the 353rd Avenue was not known and there are runoff areas other

than the feedlot between the feedlot and the pooled liquid that could have contributed to this pooled liquid, so water quality samples of the liquid were not obtained.

Photographs taken during the inspection are found in Attachment A.

Figure 1: Mayer Ranches Feedlot Inspection Aerial Photograph

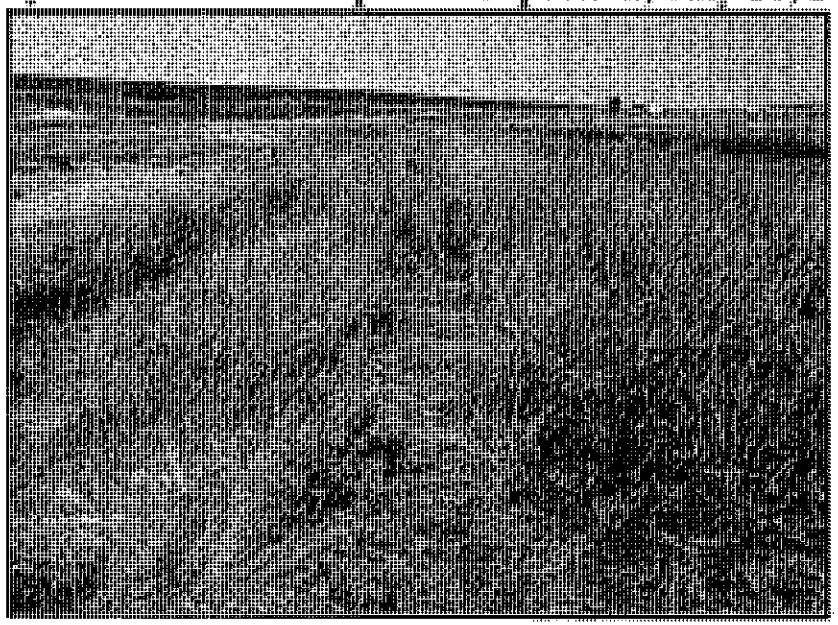


Inspection Findings and Conclusions:

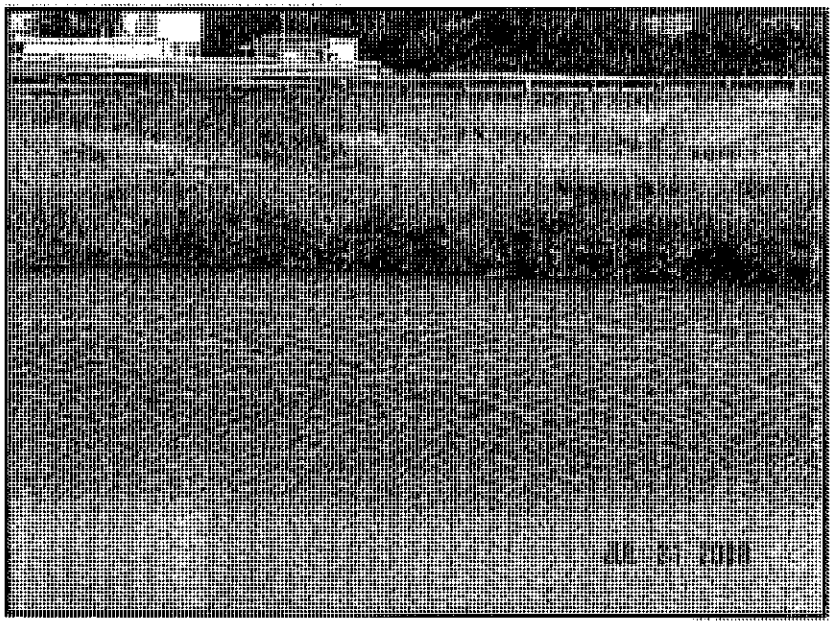
The Mayer Ranches feedlot is a permitted 999-head feedlot with a manure containment system designed to contain the runoff from the feedlot. Evidence of the feedlot causing manure runoff into the drainage along the south side of the feedlot was not found.

Following the feedlot inspection, the department inspector met with the complainant to discuss the submitted complaint and explained the inspection findings.

Attachment A

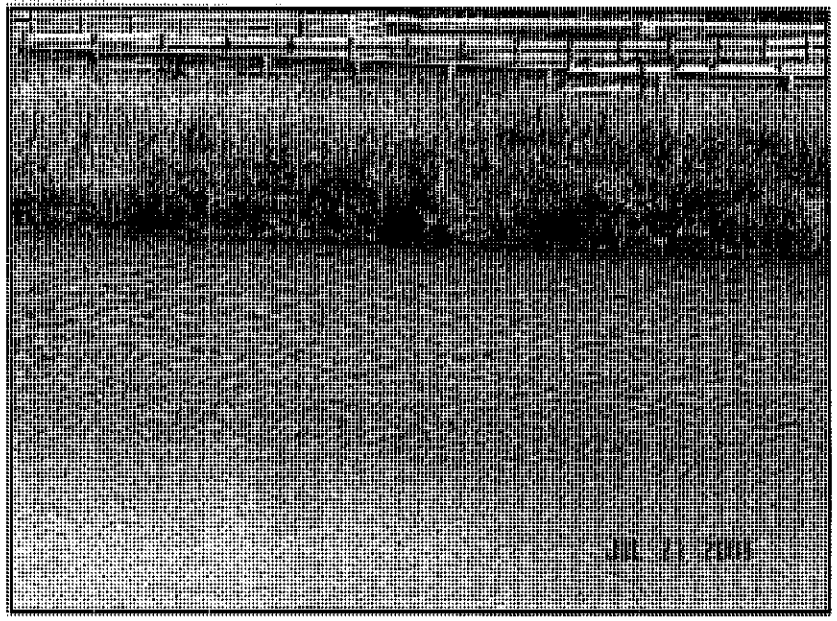


1. Looking west along the south berm of the holding pond.

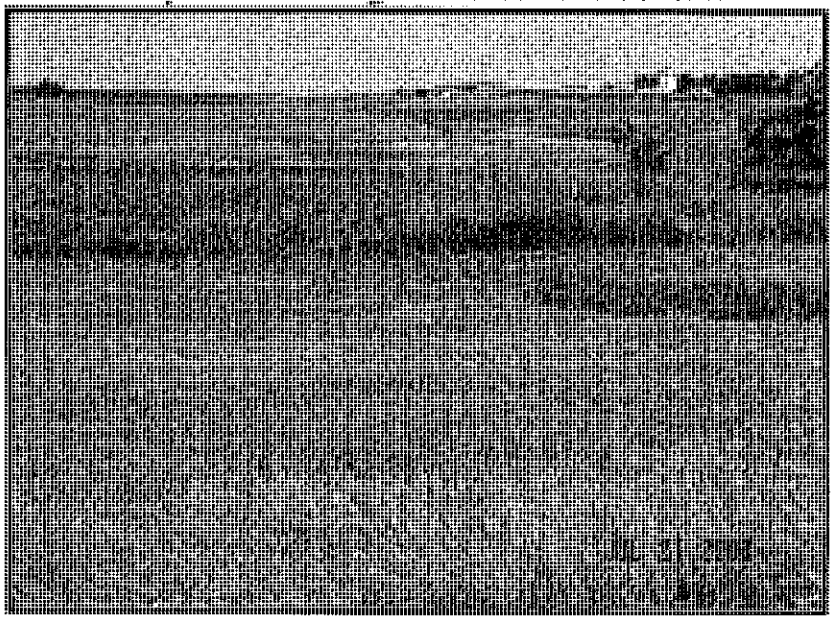


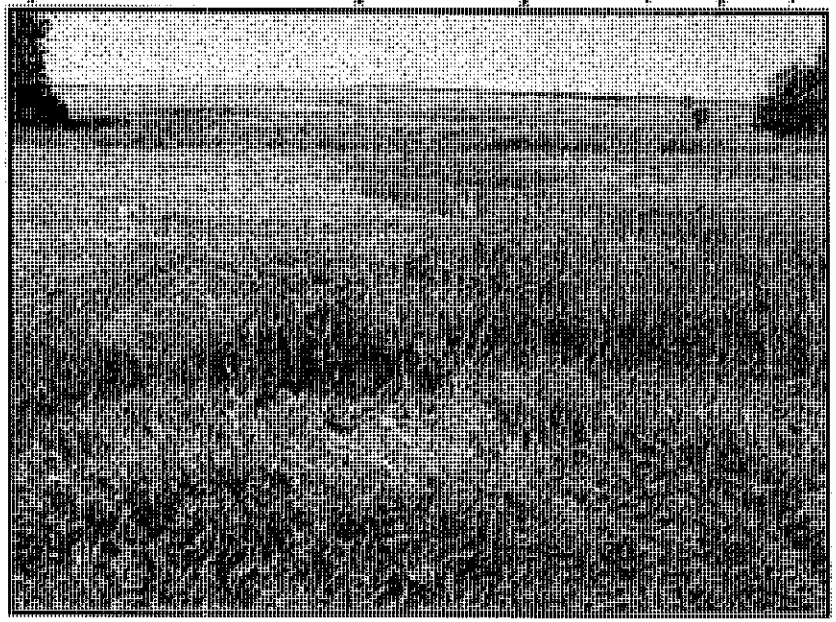
2. Looking northwest across the holding pond.

3. Looking north across the holding pond at the permanent marker.



4. Photograph taken from 353rd Avenue, looking northwest toward the feedlot at the seasonal drainage that flows in a southeasterly direction along the south side of the feedlot.





5. Close-up view from 353rd Avenue, looking west at the seasonal drainage that flows along the south side of the feedlot.

6. Looking east at pooled liquid on the east side (downstream) of 353rd Avenue in the seasonal drainage that flows along the south side of the feedlot.

Stacey R. Hennen
Associate
shennen@samplaw.com

Samp Law Offices

Rollyn H. Samp

Counselor at Law

2101 West 41st Street
Suite 2000
P.O. Box 495
Sioux Falls, South Dakota 57101

(605) 339-1020
TELEFAX: (605) 334-6630
rsamp@samplaw.com
MOBILE: (605) 366-1535 *24 Hrs.*

8ENF-W Page 10 Action

9 October 2013

Shaun McGrath
Regional Director
US Environmental Protection Agency
Region 8
1595 Wynkoop Street
Denver, CO 80202-1129

RECEIVED
U.S. EPA Region 8
RA's Office
OCT 21 2013

Re: Glenn Mayer

Dear Director:

We represent Glenn Mayer who is being continually damaged by an adjacent cattle feed lot allowing drainage into Crow Creek, South Dakota.

As you'll note, the State of South Dakota has some confusion as to their jurisdiction. My work on the Crow Creek Indian Reservation indicates that Crow Creek is under jurisdiction of the EPA.

As you'll see in the enclosed correspondence, the State of South Dakota has willfully neglected enforcing its rules on this pollution. My client has done a good deal of water sampling to prove the damage to the creek and his stock dam.

We would ask the EPA to take jurisdiction over this case asserting its rights over Crow Creek.

Among other problems, you will find the high concentration of E. coli in this creek which is a danger to not only my client and his family but also members of the Crow Creek Indian Reservation for which EPA has jurisdiction and a legal obligation to protect.

Thank you for reviewing this.

Sincerely yours,

Rollyn H. Samp

RHS/jj

Enclosures

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

NOV 0 4 2013

Ref: ENF-W-NP

Glenn Mayer
606 South Merrill Street
Chamberlain, SD 57325

RE: Mayer Ranch Complaint dated October 9, 2013

Dear Mr. Mayer,

Thank you for contacting the Environmental Protection Agency (EPA) Region 8 about your concerns regarding Mayer Ranch in Pukwana, South Dakota. The EPA has reviewed the material mailed in your complaint (enclosed) regarding Mayer Ranch. The South Dakota Department of Environment and Natural Resources (SDDENR) regularly inspects the Mayer Ranch under their Concentrated Animal Feeding Operations (CAFO) program. Inspections were conducted on July 21, 2008; January 24, 2009; December 6, 2011; and September 25, 2012, and no significant deficiencies were found.

Mayer Ranch has coverage under the South Dakota's General Water Pollution Control Permit (General Permit) for Concentrated Animal Feeding Operations (CAFO). The facility is currently permitted for a maximum of 999 head of beef cattle. The SDDENR has approved the plans and specifications for an expansion of the feedlot to increase the number of cattle to a maximum of 1,974 head of beef cattle. The EPA sent Mayer Ranch the permit application documents to acquire permit coverage from the EPA. Once the EPA receives the completed permit application documents, nutrient management plan, and has reviewed the documents; the EPA can issue the permit for Mayer Ranch. If Mayer Ranch obtains permit coverage from the EPA, South Dakota will then terminate its General Permit coverage for the feedlot.

Please contact me or my staff directly if you would like to discuss your concerns further. The most knowledgeable person on my staff is Seth Draper. He can be reached at (303) 312-6763. If you have NPDES permitting questions, please contact Qian Zhang (303) 312-6267. Thank you again for your time and effort to ensure environmental compliance.

Sincerely,

Arturo Palomares, Director
Water Technical Enforcement Program
Office of Enforcement, Compliance and
Environmental Justice

Cc: Kelli Buscher, SDDENR
Kent Woodmansey, SDDENR

Printed on Recycled Paper

Stacey R. Hennen
Associate
shennen@samplaw.com

Samp Law Offices

Rollyn H. Samp

Counselor at Law

2101 West 41st Street
Suite 2000
P.O. Box 495
Sioux Falls, South Dakota 57101

(605) 339-1020
TELEFAX: (605) 334-6630
rsamp@samplaw.com
MOBILE: (605) 366-1535 *24 Hrs.*

13 June 2014

Glenn Mayer
606 S Merrill St
Chamberlain, SD 57325

Re: EPA Complaint

Dear Glenn:

Enclosed is a response I received from EPA.

I also received a call from Senator Johnson's office. They are planning to do a follow-up as to the lack of responsiveness.

I will let you know when I hear more.

Sincerely yours,

Rollyn H. Samp

RHS/jj

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

Ref: ENF-W-NP

JUN 04 2014

Rollyn H. Samp
2101 West 41st Street, Ste 2000
PO Box 495
Sioux Falls, SD 57101

RE: Mayer Ranch Complaint dated May 6, 2014

Dear Mr. Samp,

We have received and thoroughly evaluated all information provided by your client, Mr. Glenn Mayer regarding his concerns about the Mayer Ranch in Pukwana, South Dakota.

After careful review, we determined that the information provided did not show a clear indication of a violation, in particular, a discharge to Crow Creek. Absent definitive evidence of a discharge to Crow Creek, EPA's CAFO program can take no further action. In addition, as noted in our November 4, 2013 response, the South Dakota Department of Environment and Natural Resources (SDDENR) regularly inspects the Mayer Ranch under their Concentrated Animal Feeding Operations (CAFO) program. Inspections were conducted on July 21, 2008; January 24, 2009; December 6, 2011; and September 25, 2012, and no significant deficiencies were found.

Please contact me or my staff directly if you would like to discuss your concerns further. The most knowledgeable person on my staff is Gwen Campbell. She can be reached at (303) 312-6463. If you have NPDES permitting questions, please contact Qian Zhang (303) 312-6267. Thank you again for your time and effort to ensure environmental compliance.

Sincerely,

Arturo Palomares, Director
Water Technical Enforcement Program
Office of Enforcement, Compliance and
Environmental Justice

Cc: Kelli Buscher, SDDENR
Kent Woodmansey, SDDENR

Printed on Recycled Paper

The Mayer's

From: Troy.Roth@state.sd.us

Sent: Tuesday, August 14, 2012 10:50 AM

To: mayer@midstatesd.net

Subject: Information Request 1

Attachments: 1208 Information Request Response Letter Glen Mayer.pdf; Mayer Ranches LLC Expansion Plan Sheet 1 of 2.pdf; Mayer Ranches LLC Expansion Plan Sheet 2 of 2.pdf

Mr. Mayer:

I am attaching a letter regarding your information request and a copy of the expansion application for Mayer Ranches LLC. Two more parts of the engineering report will be attached in a follow up emails.

The General Permit, a copy of the complaint form, and other related information can be found here:

http://denr.sd.gov/des/sw/cafo.aspx

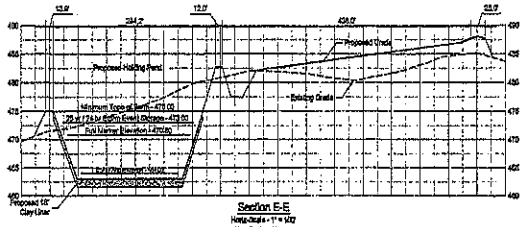
You may send written comments about the permit application to the following address:

PMB 2020
Joes Foss Building
523 East Capitol
Pierre, SD 57501

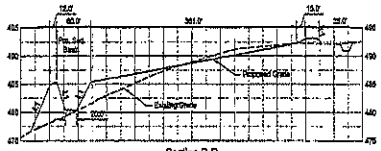
Please feel free to contact me if you have any questions.

Troy Roth
Natural Resources Engineer
South Dakota Dept. of Environment and Natural Resources
Surface Water Quality Program
(605) 773-3351

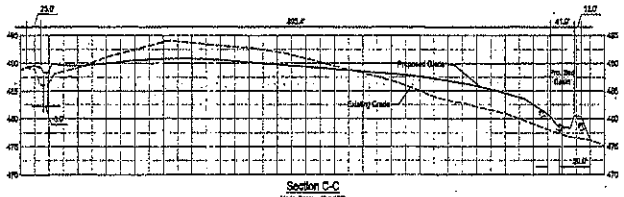
Lynn Mayer Feedlot
NE 1/4, Section 20, T105N, R69W
Buffalo County, SD
Location Map
Legend
GRAPHIC SCALE



Section E-E
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'

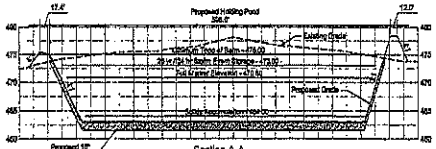


Section D-D
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'



Section C-C
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'

Section B-B
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'



Section A-A
Horiz Scale - 1" = 100'
Vert Scale - 1" = 10'

RECEIVED
JUL 11 202

Prepared by

Lynn Mayer Feedlot
Buffalo County, SD

Lynn Mayer
Gretna, NE

MARK	DATE	REMARKS

PROJECT NO. 1420407.00A
CAD DWG FILE C-GP10-SHEET
DRAWN BY CAD
REVISED BY SSW
COPYRIGHT: 2012 EIDENBENZ & ASSOCIATES, INC.

SHEET TITLE
CROSS SECTIONS

C-301

DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE SOUTH DAKOTA 57501-3181

January 14, 1998

Lynn Mayer
RR 01, Box 56
Pukwana, SD 57370-9625

RE: Lynn Mayer Manure Management System
Plans and Specifications - Comment Letter

Dear Mr. Mayer:

Thank you for submitting the plans and specifications for your cattle feeding operation in Buffalo County. Your system will consist of piping, diversion dikes or channels, a sediment basin, and an evaporation pond for 1,900-head of cattle. The sediment basin has been designed for 270 days of solids storage. The evaporation pond has been designed for a minimum of 365 days of liquid storage capacity.

We have reviewed the plans and specifications and require additional information before we can approve the plans and specifications and issue the certificate of compliance. Please submit information addressing the following items:

1. **Nutrient Management Plan**

   A nutrient management plan was not submitted with your plans and specifications. A nutrient management plan must be submitted for review and approval prior to plans and specifications approval. The nutrient management plan must account for both the solids in the sediment basins and lots and the liquids that may be applied from the pond. The nutrient management plan must include legal locations, maps, and a description of the predominant soils of the proposed application sites. The nutrient management plan must also include appropriate set back distances from drainages, wetlands, creeks, wells, etc.

   The plans and specifications indicate, if pumping of the evaporation pond is necessary, the manure water will be applied to cropland in accordance with the approved nutrient management plan and the operation and maintenance guideline 312. The nutrients in the manure water must be included in the nutrient management plan.

2. **Groundwater Monitoring**

   Based on the soil boring logs and other published reports and information concerning area hydrogeology, it appears the site is not located over a shallow aquifer. Therefore, ground water monitoring or a Ground Water Discharge Permit will not be required. However, should the design or operation of the facility change appreciably, new hydrogeological information become available, or any contamination problems be reported, DENR reserves the right to reassess the need for ground water monitoring, a Ground Water Discharge Permit, or possible remedial action.

3. Stock Piling of Manure

DENR is aware that feeding operations of this type usually have to stock pile manure on a temporary basis, especially to prevent application of manure on snow covered or frozen ground or during other inclement weather conditions. If you will be stock piling manure at this facility, then you must have a properly designed and DENR-approved stock piling site(s). Another alternative, is to stock pile the manure within the sediment basin lot area so that runoff will enter the proposed pond. Proposed stock piling sites must be shown on the plans.

4. Set Back Requirements

Land application sites must be located at least 150 feet from private wells owned by you, 250 feet from private wells not owned by you, and 1,000 feet from any public water supply well. These buffer zones cannot be included as part of the land application acreage. These set back distances also apply to the manure management system.

5. Notifications

All local, city, and county governmental agencies must be contacted for their approval or comments prior to construction of the manure management system. If a stream, lake, or wetland will be dredged or filled during the construction of the feeding operation, then you need to contact the United States Corps of Engineers at (605) 224-8531 prior to construction of the manure management system.

Thank you for your cooperation. We look forward to receiving this additional information so we may complete the review of your plans. If you have any questions, please feel free to contact us at the numbers below.

Sincerely,

Rodger A. Seefeldt

Rodger A. Seefeldt
Natural Resource Engineer
Air & Surface Water Program
Phone (605) 773-3351

Philip Greer

Philip Greer
Hydrologist
Ground Water Quality Program
Phone (605) 773-3296

cc: Ken Read, AE, NRCS, Brookings, SD
Buffalo County Commissioners

Read 1-20-98 EW

DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181
www.state.sd.us/denr

October 12, 1999

Lynn Mayer
Rt. 1, Box 56
Pukwana, SD 57370-9625

RE: Lynn Mayer Manure Management System
Revised General Permit Application Review

Dear Mr. Mayer:

The Department of Environment and Natural Resources has received three revised copies of your application for coverage under the General Water Pollution Control Permit for Concentrated Animal Feeding Operations. The manure management system is located in the Northeast ¼ of Section 20, Township 106 North, Rauge 69 West in Buffalo County, South Dakota.

Your manure management system is for an open lot for 999-head (999 animal units) of feeder cattle. Your system consists of piping, diversion dikes or channels, a sediment basin, a holding pond, and 8.63 acres of drainage area. The designed capacity of the sediment basin is 180 days of solids storage. The designed capacity of the holding pond is 365 days of liquid storage.

We have reviewed and hereby conditionally approve the revised plans and specifications for your project. This approval expires on October 12, 2001, unless construction of the manure management system has been started by that date. Requirements that you must implement are listed on the attached page(s). Failure to implement the requirements on the following page(s) prior to operation of the manure management system will invalidate this approval.

Two copies of the approved revised plans and specifications are being retained for our files. If any deviations are required from the approved revised plans, then those changes and all change orders must be submitted for approval prior to construction. A complete set of as-built plans will be required if several major deviations result.

Upon completion of construction, the enclosed Notice of Completion must be returned to the department. **The manure management system cannot be used to store manure until the department issues final permit coverage and a Certificate of Compliance.** Continued compliance is dependent upon you performing proper operation and maintenance activities. You will be liable for any noncompliance with applicable South Dakota environmental laws or regulations.

Our review is primarily to assure that the system meets the requirements of the general permit and does not cover items such as, quality of material, structural soundness, electrical, and mechanical design features. Approval of the plans and specifications does not in any way release you from the responsibility of ensuring that the project will be an operable facility when construction is completed.

For more information on this review and approval please see the attached page(s) of requirements. If you have any questions regarding the content of this letter, please feel free to contact Rodger Seefeldt, Surface Water Quality Program at 605-773-3351 or Tom Brandner, Ground Water Quality Program at 605-773-3296. Thank you for your cooperation.

Sincerely,

Raymond F. Birchem, P.E.

Raymond F. Birchem, PE
Staff Engineer
Department of Environment and Natural Resources
Phone: (605) 773-3754

cc: Ken Read, PE, NRCS, Brookings, SD
Buffalo County Commissioners

Read 10-15-99 File

DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

May 25, 2000

Lynn Mayer
Rt. 1, Box 56
Pukwana, SD 57370-9625

Re: Lynn Mayer Manure Management System
Plans and Specifications

Dear Mr. Mayer:

The Department of Environment and Natural Resources (DENR) reviewed and conditionally approved your plans and specifications on October 12, 1999. In the approval letter, additional information was required to be submitted so we could complete your conditional approval.

We received three copies of the revised Operation and Maintenance 312 guideline plus three copies of an operations and maintenance requirements sheet on May 12, 2000. We have reviewed the submitted information and concur with this information. In order for us to complete your conditional approval, the items listed on the attached page must still be addressed.

Two copies of the revised operation and maintenance guideline and operation and maintenance requirements sheet are being retained for our files.

Please replace the operation and maintenance guideline in your plans and specifications booklet with the enclosed revised operation and maintenance guideline. Also, please add the enclosed operation and maintenance requirements sheet into your plans and specifications booklet. If you have any questions regarding the content of this letter, please feel free to contact me. Thank you for your cooperation.

Sincerely,

Rodger A. Seefeldt

Rodger A. Seefeldt
Natural Resources Engineer
Surface Water Quality Program
Phone: (605) 773-3351

cc: Ken Read, PE, NRCS, Brookings, SD
Buffalo County Commissioners

Rcvd 5-26-2000

Requirements

1. **Feeding Operation Water Source(s)**

   Your submittal indicates there are no wells within 1,000 feet of the manure management system. You must supply the department with any and all sources of water to be used in your feeding operation. You must include the amount to be used and the maximum diversion rate from each source. If you plan to construct a well to supply water to your feeding operation, the location of the well(s) relative to the manure management system and the feeding operation must be submitted to the department for review and inclusion in our files.

2. **Water Rights Permit**

   Depending on your water usage, you may need to obtain a water rights permit. Once you have submitted the required information concerning the water sources(s), amounts, and diversion rates to be used in your feeding operation, the department can determine if a water rights permit is required. Information concerning this permit can be obtained by calling Eric Gronlund at 605-773-3352.

Filed 12-14-05

DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES
PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

GREAT FACES. GREAT PLACES.

December 12, 2005

Lynn Mayer
Mayer Ranchers, Inc.
RR 1, Box 56
Pukwana, SD 57370-9625

RE: Mayers Ranchers, Inc. Manure Management System
Phosphorus Based Nutrient Management Plan Review

Dear Mr. Mayer:

The Department of Environment and Natural Resources (DENR) has received four copies of the phosphorus based nutrient management plan for your operation. Your operation was permitted on May 9, 2001, **(Permit number SDG-0100014)** under the General Water Pollution Control Permit for Concentrated Animal Feeding Operations. The manure management system is located in the Northeast ¼ of Section 20, Township 106 North, Range 69 West in Buffalo County, South Dakota.

Your manure management system is for an open lot for 999-head of beef cattle. Your system consists of piping, diversion dikes or channels, a sediment basin, a holding pond, and 8.63 acres of drainage area. The designed capacity of the sediment basin is 180 days of solids storage. The designed capacity of the holding pond is 365 days of liquid storage.

We have reviewed and hereby conditionally approve the phosphorus based nutrient management plan for your operation. Requirements that you must implement are listed on the attached pages. Two copies of the approved phosphorus based nutrient management plan are being retained for our files. You are responsible for contacting your local planning and zoning office to determine if there are any local ordinances or requirements with which you need to comply.

If you have any questions regarding the content of this letter, please feel free to contact Kathy Heinemann, Surface Water Quality at (605) 773-3351. Thank you for your cooperation.

Sincerely,

Kent R. Woodmansey

Kent R. Woodmansey, PE
Natural Resources Engineering Director
Surface Water Quality Program

cc: Eric Barsness, Agronomist, NRCS Mitchell
Buffalo County Commissioners

REQUIREMENTS

The following requirements must be implemented. Failure to implement these requirements will invalidate this approval.

General Permit

You will be required to operate your feeding operation and manure management system in accordance with the requirements in the animal general permit.

1. Nutrient Management Plan

A. Manure Land Application Agreements

Upon verifying land ownership with the Buffalo County Director of Equalization, we have determined that *Field's T93 F1 and T94 F2* are located on tribal and/or allotted land, and not owned by William Stoll, as specified in the submitted lease agreement. Before these fields can be approved for the land application of manure, a lease agreement must be submitted to the department for review and approval. As required by the general permit, you must submit written lease agreements between you and the legal landowner(s) for any manure application fields not owned by you. The written agreement must include the field identification, the legal location, the number of acres available for manure application, the length of the agreement for manure application, and the printed name and signature of the landowner. The Bureau of Indian Affairs (BIA) may be able to assist you with submitting this information. If you feel there is an error in the ownership of the fields listed above, please contact the Buffalo County Director of Equalization office to correct the error and also submit proof of ownership to the department.

B. Annual Soil Testing

Annual soil samples are required on all manure land application areas submitted with the proposed nutrient management plan. The soil samples must be taken according to the table on the following page and are only required when manure application occurs. All fields require soil samples from 0 to 2 feet.

C. Nitrogen Based Manure Application

As indicated in your initial nutrient management plan, manure application on the following fields may be based on nitrogen need as determined from Table 2, on page 29 of the general permit. Please refer to Table 2, on page 29 of your permit prior to land application, to determine the proper procedure for calculating the appropriate application rate for each specific field.

REQUIREMENTS CONTINUED

Mayer Ranchers, Inc. –Approved Nitrogen based Manure Application Fields						
Line #	Field Number	County	Legal Description	Available Acres	Soil Sampling 0-2 feet	2-4 feet
1	T63 F1	Buffalo	S 1/2, Sec. 8, T106, R69	105	√	
2	T63 F2	Buffalo	S 1/2, Sec. 8, T106, R69	59	√	
3	T65 F1	Buffalo	SE 1/4, Sec. 17, T106, R69	133	√	
4	T74 F1	Buffalo	W 1/2, Sec. 20, T106, R69	196	√	
5	T68 F5	Buffalo	E 1/2, Sec. 20, T106, R69	205	√	
6	T69 F1	Buffalo	NW 1/4, Sec. 21, T106, R69	70	√	
7	T93 F1	Buffalo	NW 1/4, Sec. 28, T106, R69	77	√	
8	T94 F2	Buffalo	SW 1/4, Sec. 29, T106, R69	70	√	
9	T70 F2	Buffalo	E 1/2, Sec. 30, T106, R69	188	√	
10	T70 F8	Buffalo	NW 1/4, Sec. 30, T106, R69	54	√	
11	T91 F1	Buffalo	NW 1/4, Sec. 32, T106, R69	155	√	
12	T92 F2	Buffalo	NW 1/4, Sec. 33, T106, R69	104	√	
13	T92 F11	Buffalo	SW 1/4, Sec. 33, T106, R69	136	√	
			Total Nitrogen Acres	**1405**		

However, because your operation existed prior to February 12, 2003, and you are not expanding, you may use a nitrogen-based nutrient management plan until December 31, 2006, when the phosphorus-based portion your nutrient management plan will become effective.

D. Phosphorus Based Manure Application

As indicated in your initial nutrient management plan, there are no fields that currently require manure application to be based on crop removal of phosphorus. However, this determination may change in the future. Please refer to your nutrient management plan for the estimated time it will take to build your listed fields up to 50 ppm of phosphorus and Table 2, on page 29 of the general permit, for the proper manure application determination. You may need additional land in the future in order to apply to your fields based on phosphorus removal at that time.

2. Setback Distances

The manure management system and the application sites must be located at least 150 feet from a private well owned by you, 250 feet from a private well not owned by you, and 1,000 feet from any public supply well or other public drinking water source. These setback distances from identified wells cannot be included as part of the land application acreage.

DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES
PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
denr.sd.gov

October 10, 2012

Lynn Mayer
Mayer Ranches Inc.
23438 Pheasant Lane
Pukwana, SD 57370-9625

Re: Mayer Ranches Inc. Manure Management System Expansion
Plans and Specifications Review

Dear Mr. Mayer:

The Department of Environment and Natural Resources has received four copies of the plans and specifications for the proposed expansion to your existing Concentrated Animal Feeding Operation. You originally received permit coverage under the *General Water Pollution Control Permit for Concentrated Animal Feeding Operations* (General Permit) on May 9, 2001.

Your permitted manure management system is located in the Northeast ¼ of Section 20, Township 106 North, Range 69 West in Buffalo County, South Dakota. The permitted manure management system is for an open lot feeding a maximum of 999-head of beef cattle. The system consists of piping, diversion dikes or channels, a sediment basin, a holding pond, and 8.63 acres of drainage area. The designed capacity of the sediment basin is 180 days of solids storage. The design capacity of the holding pond meets the requirements of the general permit and has at least 365 days of liquid storage capacity.

The proposed expansion will be located east of the existing system in t he Northeast ¼ of Section 20, Township 106 North, Range 69 West in Buffalo County, South Dakota. The proposed expansion is for new open lots feeding an additional 975-head of beef cattle, for a maximum of 1,974-head of beef cattle at the operation. The proposed system consists of piping, diversion dikes or channels, two sediment basins, one holding pond, and 9.76 acres of drainage area. The designed capacity of the each sediment basin is 61 days of solids storage. The design capacity of the holding pond meets the requirements of the general permit and has at least 365 days of liquid storage capacity. A valved pipe will be installed from the southeast corner of the existing holding pond to the west end of the west sediment basin in the new system. The valved pipe will be used to transfer liquid from the west pond to the new holding pond.

We have reviewed and hereby conditionally approve the plans and specifications for your proposed expansion. This approval expires on October 10, 2014, unless construction of the revision to your manure management system has been started by that date. Requirements that you must implement

are listed on the attached pages. Failure to implement the requirements on the following pages prior to operation of the manure management system will invalidate this approval.

Two copies of the approved plans and specifications are being retained for our files. If any deviations are required from the approved plans, those changes and all change orders must be approved by the department prior to construction. A complete set of as-built plans will be required if any major deviations result.

Upon completion of construction of the proposed expansion, the enclosed Notice of Completion must be returned to the department. **The proposed lot areas and holding pond cannot be populated or used to store manure until the department issues final permit coverage and an amended Certificate of Compliance.** Continued compliance is dependent upon you performing proper operation and maintenance activities. You will be liable for any noncompliance with applicable South Dakota environmental laws or regulations.

Our review is primarily to assure that the system meets the requirements of the general permit and does not cover items such as, quality of material, structural soundness, electrical, and mechanical design features. Approval of the plans and specifications does not in any way release the producer from the responsibility of ensuring that the project will be an operable facility when construction is completed.

If you have any questions regarding the content of this letter, please feel free to contact Troy Roth, Surface Water Quality Program at (605) 773-3351. Thank you for your cooperation.

Sincerely,

Kent R. Woodmansey, PE
Natural Resources Engineering Director
Surface Water Quality Program

Enclosures: Notice of Intent Form
Construction Schedule Postcard
Notice of Completion Form

cc: Brad Woerner, PE, Eisenbraun & Associates, Yankton, SD
Buffalo County Commissioners
Amy Clark, EPA – Region 8 (8P-W-GW)

REQUIREMENTS

The following requirements must be implemented before we will issue an amended Certificate of Compliance and coverage under the general permit. Failure to implement these requirements will invalidate this approval.

Plans and Specifications

The plans and specifications review is to determine whether seepage, storage, and other design requirements will be met.

1. **Maximum Operating Marker**

   Plan Sheet 1 does not indicate the location of the maximum operating marker in the holding pond. Please have your engineer include the location of the maximum operating marker on the as-built plans.

2. **Transfer Pipe**

   The invert elevation of the transfer pipe from the west holding pond to the west sediment basin for the new holding pond system appears to above the maximum operating level elevation for the west holding pond. Also the project cover letter indicates that the purpose of the pipe is to allow the operator to drain a portion of the west pond into the new pond when the system is being dewatered. With the transfer pipe in the current configuration, no water will be able to be transferred during normal operation of the holding pond. The department recommends that the invert elevation of the transfer pipe in the west holding pond be at or below the maximum operating level for that holding pond. If the pipe is submerged during normal operation a pressure test of the transfer pipe will be required. A permeability test of the disturbed area of the liner will also be required if the pipe is placed below the maximum operating level. The pipe leakage test and permeability tests may be submitted with the as-built plans if they are necessary.

3. **Compaction Specification**

   The specifications indicate that soil compaction shall be ninety-five percent (95%) of the maximum dry density, optimum moisture plus or minus 3%. Part 1.4.3.4.4 of the general permit states that soil compaction for liners shall be constructed at 95 percent of standard proctor density at optimum moisture content plus or minus two percent or according to the recommendations of the soil testing laboratory. Please consult with your engineer and revise the specifications as necessary. The revised specifications may be submitted with the as-built plans.

REQUIREMENTS CONTINUED

General Permit

You will be required to operate your feeding operation and manure management system in accordance with the requirements in the general permit.

1. **Operation and Maintenance Guideline**

   A revised operation and maintenance guideline will need to be submitted that addresses the operation of the pipe and valves connecting the west holding pond to the west sediment basin for the new holding pond.

2. **Revised Notice of Intent Form**

   To complete your application for coverage under the *General Water Pollution Control Permit for Concentrated Animal Feeding Operations*, you will need to submit the revised Notice of Intent Form. To make it as quick and easy to complete as possible, we have filled out most of the form for you with information we have in our files. **Please correct any incorrect information on the form, sign and date it, and return it to DENR.**

3. **Ground Water Monitoring**

   Based on the system design, soil boring logs, and other published reports and information, the proposed system does not appear to overlie a shallow aquifer and should not impact ground water. Therefore, a Ground Water Discharge Permit or ground water monitoring will not be required. Should the design or operation of the facility change appreciably, new hydrogeological information become available, or any contamination problems be reported, the department reserves the right to reassess the need for possible remediation, monitoring of ground water, or a Ground Water Discharge Permit.

4. **Notification**

   Construction Schedule - You or your engineer must notify the department of the proposed construction schedule for your project to allow our personnel the opportunity for construction inspections. Please fill out the enclosed postcard and return it to us prior to beginning construction of the expansion. If any of the dates change from the ones submitted on the postcard, please notify us at (605) 773-3351 and ask for Troy Roth.

   Other Government - You are responsible for contacting your local planning and zoning office to determine if there are any local ordinances or requirements with which you need to comply. If a stream, lake, or wetland will be dredged or filled during the construction of the feeding operation, then you need to contact the United States Corps of Engineers at (605) 224-8531 prior to construction of the manure management system.

   Notice of Completion - The Notice of Completion form must be completed by your engineer and returned to the department when construction of the manure management system is complete. The department cannot issue you an amended Certificate of Compliance and coverage under the

REQUIREMENTS CONTINUED

general permit for the expansion until we receive a Notice of Completion. **The proposed lot areas and holding pond cannot be populated or used to store manure until the department issues final permit coverage and an amended Certificate of Compliance.**

5. **Field Addition Requirements**

To add fields to your approved phosphorus-based NMP, you must submit the required information for each additional field to the department for our review and approval. Required documentation includes the calculation of a RUSLE value for each field to be added. Information on adding fields to your approved phosphorus-based NMP may be obtained from your local NRCS office. You may also contact us for assistance at (605) 773-3351, or visit our website at http://denr.sd.gov/des/sw/fieldadditions.aspx for instructions on adding fields. **You may not apply manure to any fields not included in your approved phosphorus-based NMP.**

6. **Other Permits That May or Will Be Required**

Storm Water Permit - Since the construction of your project disturbs more than one acre in total land area, a general storm water construction permit is required. This permit must be obtained 15 days prior to starting construction. As part of the requirement for obtaining coverage under this permit you must develop and implement a pollution prevention plan. Information concerning this permit and the pollution prevention plan can be obtained by calling Andrew Renner at 1-800-737-8676. **A copy of this plan must be kept on site during construction for review by DENR inspectors.**

Water Right Permit - Depending on your water usage, you may need to obtain a water rights permit. You must submit information regarding the source(s) of all water to be used in the operation of your manure management system. You must include the average and maximum daily volumes of water to be used from each source. The water volumes must include all water usage such as water for consumption, washing, misters, milk cooling, overflow watering systems, cooling, dust control, etc. Information concerning this permit can be obtained by calling Eric Gronlund at (605) 773-3352. **Please contact Eric so he can assist you in determining if you need to obtain a water rights permit.**

Permit to Occupy Right of Way - If manure application will involve placing hoses or other equipment in a state highway right of way (for example, in a road ditch or through a culvert), you must first obtain a Permit to Occupy Right of Way. Application for this permit may be made through the local South Dakota Department of Transportation area office. Contact your local SD DOT area office for more information on this permit. In addition, please contact your county highway superintendent to determine if your county has similar requirements.

DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182

denr.sd.gov

AUG 27 2015

7157-3

Glenn Mayer
606 S Merrill St
Chamberlain SD 57325

Dear Mr. Mayer:

Enclosed is Water License No. 7157-3. This is the final water right document completing your process of obtaining a Water Right. Included with your license is a map prepared by the staff engineer who conducted the field investigation.

As long as you use the water beneficially, as stated in the Water License, State Water Laws provide that you have a continuing right to use the water.

Sincerely,

Jeanne Goodman

Jeanne Goodman, Chief Engineer
Water Rights Program
(605) 773-3352

enclosures

STATE OF SOUTH DAKOTA

WATER LICENSE NO. 7157-3

---

(1) Glenn Mayer, 606 S Merrill St., Chamberlain SD 57325 made Application No. 7157-3, August 18, 2009 for a water permit to impound 51.3 acre feet of water from runoff, Buffalo County, South Dakota for fish and wildlife propagation and livestock watering purposes. Permit No. 7157-3, with a priority date of August 18, 2009 was approved September 21, 2009 and issued to the applicant for impoundment of water with construction of the described storage dam to be completed on or before September 21, 2014 and for the application to beneficial use of said water on or before September 21, 2018.

(2) It is certified that the permit holder has complied with the provisions of South Dakota State Law relating to construction of the storage dam and is entitled to impound 51.3 acre feet of water for beneficial use.

The storage dam is located (spillway): 940 feet south and 2,190 feet west of the NE corner of Section 21, T106N, R69W (NW ¼ NE ¼).

(3) The permit holder has complied with the provisions of South Dakota State Law relating to the application of water to beneficial use.

(4) Pursuant to South Dakota Water Law 46-5-30.1 Glenn Mayer, 606 S Merrill St., Chamberlain SD 57325 the holder and/or owner of Water Right No. 7157-3 is issued a license to appropriate water, the right to impound 51.3 acre feet of water from runoff with a priority date of August 18, 2009 from the location specified in (2) of this license for fish and wildlife propagation and livestock watering purposes.

This license is subject to South Dakota Water Law, any limitations or conditions listed in Water Right No. 7157-3 and subject to the following qualifications:

- Water Permit No. 7157-3 authorizes a dam with a storage capacity of 51.3 acre feet of water and sufficient water annually to maintain the water level to the outlet elevation.
- Low flows as needed for downstream domestic use, including livestock water and prior water rights must be bypassed.

Jeanne Goodman

Jeanne Goodman, Chief Engineer
Water Rights Program
Department of Environment and Natural Resources

AUG 27 2015
date

7157-3

0 0.05 0.1 0.2 0.3 0.4 Miles

Mark D Rath
Natural Resource Engineer
May 20, 2015

THE IZAAK WALTON LEAGUE OF AMERICA

Izaak Walton League
Sunshine Chapter
1200 Izaak Walton Rd. • PO Box 896
Pierre, SD 57501

Subject: 2011 Wildlife Habitat Award
To: All South Dakota Conservation Districts

The South Dakota Division of the IWLA is pleased to be sponsoring our 58th annual WILDLIFE HABITAT AWARD contest. Last years winners were from the Conservation Districts of Minnehaha, Brule/Buffalo and Ziebach. We are again encouraging each District to recognize someone in their area for the outstanding work done to promote wildlife habitat

The S.D. Conservation Commission sponsors a Soil Conservation Award Program. If you participate in this program it could become a start for the Ikes award program

The application should include a write-up and photos of the activities and conservation practices of the operation. The narrative should include (1) responsible natural resource management to benefit wildlife habitat(2)strong personal interest in exercising good land stewardship(3)involvement in the community and other outreach activities(4)varieties of wildlife(5)utilization of cost sharing programs

The State Division will award a beautiful plaque to the top three applicants. An appropriate time will be selected to present the plaque to the winners. The District will receive an appreciation certificate.
Send your nominations to Larry G. Nelson, 303 N. Jackson, Pierre, S.D. by August 31, 2011. If you have any questions you can call Larry at 224-8028.

Jerry Schlekeway, State President

Jerry Schlekeway

STATE OF SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
COMPLAINT FORM

South Dakota law provides that:

"No inspection or other action pursuant to sections 34A-2-40, 34A-2-44, or 34A-2-45 that is based on, or is the result of a complaint or the provision of information by a member of the general public may be carried out unless the person making the complaint or providing the information signs the complaint. The complaint shall remain confidential with the board and the secretary." (South Dakota Codified Laws 34A-2-111).

In conformity with the provisions of SDCL 34A-2-111, I, Glenn J. Mayer, hereby register the following complaint regarding the violation of our state Water Pollution Control Act:

LOCATION OF VIOLATION (please print):
Feedyard Located NE 1/4 Sec 20 106-69 Buffalo County owned By Mayer Ranches Inc.

FACTS ALLEGED TO CONSTITUTE THE VIOLATION (use back of page or second sheet if you need more room – please print):
I took the water sample from standing water in the draw on my property below the feedyard. The water looked green & stagnet so we thought we would get it checked. Dave Gorman from SDSU contacted me with the results. This would indicate contamination but want other testing done to be sure. Draw is located E1/2 SW1/4 NE1/4 Sec. 21 106-69 Buffalo County.

By signing this form, I certify that the information included on this form is, to the best of my knowledge and belief, true, accurate, and complete.

I declare and affirm under the penalties of perjury that this claim (petition, application, information) has been examined by me, and to the best of my knowledge and belief, is in all things true and correct.

Dated at Chamberlain, South Dakota this 1st day of June, 2008.

Glenn J Mayer.
Complainant Name (Please Print)

605 734 6526 605 730 1281
Complainant telephone Number (required)

Complainant Signature

PURSUANT TO SDCL 1-27-3 AND 34A-2-111 THIS DOCUMENT IS NOT A PUBLIC RECORD SUBJECT TO OPEN INSPECTION AND SHALL BE SEPARATELY MAINTAINED AND HELD CONFIDENTIAL.

South Dakota State University

Oscar E. Olson Biochemistry Laboratories
Analytical Services Laboratory

Box 2170, Rm. 133 ASC
Brookings, SD 57007-1217
Telephone: (605) 688-6171
FAX: (605) 688-6295
WEB: http://anserv.sdstate.edu

Report of Analysis

GLENN MAYER
606 S MERRILL
CHAMBERLAIN, SD 57325

Reported: 05/16/2008
Received: 05/05/2008

08S-06319	WATER WITH MANURE CONTAMINATION
Ammonia Nitrogen, mg/L (ppm)	2.76
Total Kjeldahl Nitrogen (TKN), mg/L (ppm)	4.84
Total Phosphorus, mg/L (ppm)	2.01

Reviewed By: Nancy Thiex

CC: WATER RESOURCES INSTITUTE
SDSU AE 211 BOX 2120
BROOKINGS, SD 57007

Dave German SDSU called and explained the following:

PHOSPHORUS 10 Times normal

Ammonia nitrogen 100 Times normal

Glenn

10-24-08

Jason

This is the Results of the water samples we talked about on the phone. I still need a Follow up Report on your Last inspection

thank you

Gary Mayer

STATE OF SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
COMPLAINT FORM

South Dakota law provides that:

"No inspection or other action pursuant to sections 34A-2-40, 34A-2-44, or 34A-2-45 that is based on, or is the result of a complaint or the provision of information by a member of the general public may be carried out unless the person making the complaint or providing the information signs the complaint. The complaint shall remain confidential with the board and the secretary." (South Dakota Codified Laws 34A-2-111).

In conformity with the provisions of SDCL 34A-2-111, I, Glenn Mayer, hereby register the following complaint regarding the violation of our state Water Pollution Control Act:

LOCATION OF VIOLATION (please print):
E1/2 NW1/4 W1/2 NE1/4 Section 21 106-69 Buffalo County

FACTS ALLEGED TO CONSTITUTE THE VIOLATION (use back of page or second sheet if you need more room – please print):
water Run off coming across and through my property is highly contaminated with Ammonia nitrogen TKN and PHOSPHORUS. These Results came FROM SDSU Lab with Results Attached. Two seperate samples were taken #1 at property line #2 downstream. We have no Livestock and never have been present on my property FOR several years. Feedyard Lagoon Approx 1/2 mile west upstream FROM this site

By signing this form, I certify that the information included on this form is, to the best of my knowledge and belief, true, accurate, and complete.

I declare and affirm under the penalties of perjury that this claim (petition, application, information) has been examined by me, and to the best of my knowledge and belief, is in all things true and correct.

Dated at ~~10-23~~ Chamberlain, South Dakota this 23 day of OCT, 2008.

Glenn J. Mayer
Complainant Name (Please Print)

605 734 6526
Complainant telephone Number (required)

[signature]
Complainant Signature

PURSUANT TO SDCL 1-27-3 AND 34A-2-111 THIS DOCUMENT IS NOT A PUBLIC RECORD SUBJECT TO OPEN INSPECTION AND SHALL BE SEPARATELY MAINTAINED AND HELD CONFIDENTIAL.

South Dakota State University

Oscar E. Olson Biochemistry Laboratories
Analytical Services Laboratory

Box 2170, Rm. 133 ASC
Brookings, SD 57007-1217
Telephone: (605) 688-6171
FAX: (605) 688-6295
WEB: http://anserv.sdstate.edu

Report of Analysis

GLENN MAYER
606 S MERRILL
CHAMBERLAIN, SD 57325

Reported: 10/08/2008
Received: 09/30/2008

Sewage lagoon ponds

08S-16270	WATER #1 HOLDING POND		
Ammonia Nitrogen, mg/L (ppm)	1.21	.02-.05	
Total Kjeldahl Nitrogen (TKN), mg/L (ppm)	3.82	1.0	
Total Phosphorus, mg/L (ppm)	1.28	.03	ten times
08S-16271	WATER #2 HOLDING POND		
Ammonia Nitrogen, mg/L (ppm)	0.896		
Total Kjeldahl Nitrogen (TKN), mg/L (ppm)	3.42	1.0	
Total Phosphorus, mg/L (ppm)	1.63		

For additional information, please contact David German at the Water Resources Institute, 605-688-5611 or David.German@sdstate.edu.

Reviewed By: Nancy Thiex

CC: WATER RESOURCES INSTITUTE
SDSU AE 211 BOX 2120
BROOKINGS, SD 57007

F

11-06-08

We are filing a water quality complaint with Buffalo County.

The samples were taken on two different dates from water draining across our property located E½ NW¼ and NE¼ Sec. 21 106. 69.

The samples were sent to SDSU for testing with the results attached. David German made follow up phone calls explaining the results. He stated that this water is highly contaminated comparing it to water in a sewage holding pond.

Complaints were filed with DENR on 1 June 08 and 23 Oct. 08. Jason Roggow from DENR responded to first complaint and verbally said he done a drive around inspection and seen no visable reason water quality would be bad. We requested a follow up letter but so far have received non. He acknowledged the second complaint but noth. has been done to this date.

DENR has stated they would like to see the counties have the responsibility of controlling their own complaints as they are swamped.

Delilah Mayer
Delilah Mayer

South Dakota State University

SDSU

Oscar R. Olson Biochemistry Laboratories
Analytical Services Laboratory

Box 2170, Rm. 133 ASC
Brookings, SD 57007-1217
Telephone: (605) 688-6171
FAX: (605) 688-6295
WEB: http://ansery.sdstate.edu

Report of Analysis

GLENN MAYER
606 S MERRILL
CHAMBERLAIN, SD 57325

Reported: 10/08/2008
Received: 09/30/2008

sewage Holding ponds

08S-16270 WATER #1 HOLDING POND		
Ammonia Nitrogen, mg/L (ponp)	1.21	.02-.05
Total Kjeldahl Nitrogen (TKN), mg/L (ppm)	3.82	1
Total Phosphorus, mg/L (ppm)	1.28	.03 - .1

08S-16271 WATER #2 HOLDING POND		
Ammonia Nitrogen, mg/L (ppm)	0.896	
Total Kjeldahl Nitrogen (TKN), mg/L (ppm)	3.42	1.0
Total Phosphorus, mg/L (ppm)	1.63	

For additional information, please contact David German at the Water Resources Institute, 605-688-5811 or David.German@sdstate.edu.

Reviewed By: Nancy Thiex

CC: WATER RESOURCES INSTITUTE
SDSU AE 211 BOX 2120
BROOKINGS, SD 57007

South Dakota
State University

Oscar E. Olson Biochemistry Laboratories
Analytical Services Laboratory

Box 2170, Rm. 133 ASC
Brookings, SD 57007-1217
Telephone: (605) 688-6171
FAX: (605) 688-6295
WEB: http://anserv.sdstate.edu

Report of Analysis

GLENN MAYER
606 S MERRILL
CHAMBERLAIN, SD 57325

Reported: 05/16/2008
Received: 05/05/2008

08S-06319 WATER WITH MANURE CONTAMINATION

Ammonia Nitrogen, mg/L (ppm)	2.76
Total Kjeldahl Nitrogen (TKN), mg/L (ppm)	4.84
Total Phosphorus, mg/L (ppm)	2.01

Reviewed By: Nancy Thiex

CC: WATER RESOURCES INSTITUTE
SDSU AE 211 BOX 2120
BROOKINGS, SD 57007

South Dakota State University
SDSU

Water Resources Institute

Box 2120, Ag. Engineering 211
SDSU
Brookings, SD 57007
Phone: 605-688-4910
FAX: 605-688-4917
E mail: sdsu.wri@sdstate.edu

May 22, 2008

Glenn Mayer
606 S Merrill
Chamberlain, SD 57325

Dear Glenn,

This letter is in regards to sample number 08S-06319 that you submitted to the Water Quality Laboratory for analysis.

This sample appears to be consistent with water containing manure runoff and is highly enriched. Below is a table showing the comparison of your sample with runoff from land with winter manure application, Lake Minnewasta (high nutrient enrichment) and Pickerel Lake (medium nutrient enrichment).

	Sample Date	Ammonia Nitrogen, mg/L (ppm)	Total Kjeldahl Nitrogen (TKN), mg/L (ppm)	Total Phosphorus, mg/L (ppm)
Mayer Sample		2.76	4.84	2.01
Field Runoff from Winter Manure Application	3/12/2008	5.9	17.5	7.65
	3/13/2008	3.95	11.4	2.4
	4/3/2008	2.66	10.3	2.87
Lake Minnewasta (considered high nutrient enrichment)	5/16/2006	0.173	1.77	0.097
	6/15/2006	0.14	2.07	0.209
	7/17/2006	0.243	2.95	0.266
	8/17/2006	0.161	2.46	0.29
	9/19/2006	0.186	2.44	0.295
Pickerel Lake (considered medium nutrient enrichment)	5/16/2006	0.063	0.556	0.033
	6/15/2006	0.05	0.787	0.042
	7/17/2006	0.076	1.56	0.042
	8/17/2006	0.142	1.19	0.05
	9/19/2006	0.106	1.04	0.061

If you have any questions or would like to discuss further options, please call our office at (605) 688-4910 or (605) 688-5611.

Sincerely,

David German
Water Resources Institute

jlp

Landowner Permission - allowing access to private property

I grant permission to Tanner Veo, the EPA 106 Coordinator from the Crow Creek Sioux Tribe, accompanied by Ashli Maddox / D. Johnston *U.S. Geological Survey field crew from the South Dakota Water Science Center, to access my property as part of a study to determine surface water quality.*

_____ *Grant permission.*

___X___ *Grant permission, but with the following restrictions:*

Call First

Landowner Name (Please print): Glenn J Mayer

Landowner Signature Glenn Mayer

Date: 5-27-10

Phone Number: 605 734 6526 Cell 605 730 1281

Address: 606 S. Merrill

Chamberlain SD, 57325

A. Maddox, T. Veo
D. Johns[illegible]

May 27, 2010
arrival @ 6:30a
↳ had to finish notes [illegible]
locate ice - NOTE: gas s[illegible]
store hours are 7am-10pm

Todays goals: 2 sites:
Crow Creek mouth @ Dam
and Glenn Mayer's Ranch
(605-730-1281)
Called Glenn - he's able to
meet this morning (~7:30-8a)
8:26A
Glenn Mayer Ranch Site (in Posend)
GPS: 43° 58' 16.4" N
099° 07' 20.1" W
photos

01/02/2007

01/02/2007

01/03/2007

The Mayer's

From: Harris.Jennifer@epamail.epa.gov
Sent: Tuesday, June 14, 2011 5:40 PM
To: mayer@midstatesd.net
Subject: Re: Conference Call with EPA & USGS

The call is at 3 your time on June 23rd. The call in number is 1-866-299-3188, access code 3033126372. Thanks

Jennifer Harris, 8P-TA
1595 Wynkoop Street
Denver, CO 80202
Ph: 303-312-6372
Fax: 303-504-3120
harris.jennifer@epa.gov
http://www.epa.gov/region8/tribes/

The Mayer's

From: Harris.Jennifer@epamail.epa.gov

Sent: Tuesday, November 06, 2012 4:41 PM

To: mayer@midstatesd.net

Subject: Fw: Phone Message

Jennifer Harris, 8P-TA
1595 Wynkoop Street
Denver, CO 80202
Ph: 303-312-6372
Fax: 303-504-3120
harris.jennifer@epa.gov
http://www.epa.gov/region8/tribes/

----- Forwarded by Jennifer Harris/R8/USEPA/US on 11/06/2012 03:40 PM -----

From: Jennifer Harris/R8/USEPA/US
To: mayer@midstates.net
Date: 11/06/2012 03:38 PM
Subject: Phone Message

Good afternoon, Glen, hope you and your family are well. I got your voicemail message. Sam Vance is no longer the Project Officer for Crow Creek. The new Project Officer is Dale Roy and his phone number is 303-312-6292. Also, Wanda Marks is back as the Environmental Director, 605-245-2729. Joyce Williamson from the USGS is one we worked with also, her number is 605-394-3219. Please let me know if there is anything I can do further. thanks

Jennifer Harris, 8P-TA
1595 Wynkoop Street
Denver, CO 80202
Ph: 303-312-6372
Fax: 303-504-3120
harris.jennifer@epa.gov
http://www.epa.gov/region8/tribes/

South Dakota Department of Health

DIVISION OF ADMINISTRATION
Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 6/11/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC003180
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source
CROW CREEK SIOUX TRIBE

Date Rcvd: 6/5/2008
Time Rcvd: 1537
Date Coll: 6/5/2008
Time Coll: 1100
Spec Type: WATER
Coll By: LINDY COSGROVE
Project ID 21060508

Remarks: [redacted]
Site Location: CROW CREEK MOUTH SITE #21
Source: STREAM
Type of Sample: RAW
medium WATER

Final Results

E COLI	E.Coli	>4840 / 100 mL	
SM 9223B			
Nitrate		0.6 mg/L	Limit: 10.0
Phosphorous, total		0.950 mg/L	
TKN		3.42 mg/L	
Ammonia		0.20 mg/L	
EPA Method 350.2/350.3			

Crow Mouth
Site 21
6-5-08

South Dakota Department of Health

DIVISION OF ADMINISTRATION
Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 7/16/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC004424
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK SIOUX TRIBE

Date Rcvd: 7/9/2008
Time Rcvd: 1625
Date Coll: 7/9/2008
Time Coll: 1212
Spec Type: WATER
Coll By: LINDY COSGROVE/JERRICA

Other Comments: SITE 21 CROW MOUTH
Remarks: 21070908
Site Location: SITE 21 CROW MOUTH
Source: STREAM
Type of Sample: RAW
medium WATER

Final Results

Ammonia EPA Method 350.2/350.3	<0.02 mg/L	
E COLI SM 9223B	E.Coli 8.3 / 100 mL	
Nitrate	0.4 mg/L	Limit: 10.0
TKN	1.11 mg/L	
Phosphorus,total	0.219 mg/L	

Site 21
Crow Mouth
7-9-08
Event C8-3-B

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 8/14/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC005264
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK SIOUX TRIBE

Date Rcvd: 8/5/2008
Time Rcvd: 1537
Date Coll: 8/5/2008
Time Coll: 1341
Spec Type: WATER
Coll By: LINDY COSGROVE/JERRICA W

Remarks: SAMPLE # 21080508
Site Location: SITE #21 CROW CREEK MOUTH
Source: STREAM
Type of Sample: RAW
medium WATER

Final Results

E COLI	E.Coli	16.4 / 100 mL	
SM 9223B			
Nitrate		0.2 mg/L	Limit: 10.0
Phosphorus, total		0.248 mg/L	
TKN		1.90 mg/L	
Ammonia		<0.02 mg/L	
EPA Method 350.2/350.3			

Site 21
Crow Mouth
8-5-08
E. coli 08-4-A

South Dakota Department of Health

DIVISION OF ADMINISTRATION
Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6126
www.state.sd.us/doh/lab/index.htm

Date: 8/14/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC005264
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source
CROW CREEK SIOUX TRIBE

Date Rcvd: 8/5/2008
Time Rcvd: 1537
Date Coll: 8/5/2008
Time Coll: 1341
Spec Type: WATER
Coll By: LINDY COSGROVE/JERRICA W

Remarks: SAMPLE # 21080508
Site Location: SITE #21 CROW CREEK MOUTH
Source: STREAM
Type of Sample: RAW
medium WATER

Final Results

E COLI	E.Coli	16.4 / 100 mL	
SM 9223B			
Nitrate		0.2 mg/L	Limit: 10.0
Phosphorus,total		0.248 mg/L	
TKN		1.90 mg/L	
Ammonia		<0.02 mg/L	
EPA Method 350.2/350.3			

Site 21
Crow Mouth
8-5-08
E. coli 08-4-A

Site 21 Crow Creek Mouth

Date	Event	Statistics	E. coli #/100ml	Total P mg/L	Total N mg/L	Ammonia mg/L	TSS	Temperature celsius
Date-2006								
26-Jun	event1		2420	0.518	3.67	0		23.45
18-Jul	2		32.8	0.167	0.83	0		25.24
3-Aug	3		2420	0.268	1.32	0		23.89
16-Aug	4		162	0.279	0.82	0		23.52
30-Aug	5		70.8	0.135	0.53	0		20.48
25-Sep	6		64.4	0.12	0	0		16
12-Oct	7		31.4	0.104	0	0	55	3.87
Date-2007								
10-May	1		3970	1.74	3.45	0.24		na
23-May	2		579	0.365	1.38	0		23
14-Jun	3A		4840	1.88	5.86	0.19		22
20-Jun	3C		1160	1.07	2.19	0.05		na
18-Jul	4		5.1	0.144	1.26	0		24.5
2-Aug	5		21.3	0.132	1.49	na		22.37
29-Aug	6		7.2	0.166	1.54	0		23.74
20-Sep	7		64.6	0.077	1.2	0		21.58
30-Oct	8		148	0.254	1.69	0.04		8.62
		# samples	16	16	16	15	1	14
		Max value	4840	1.88	5.86	0.24	55	25.24
		Min value	5.1	0.077	0	0	55	3.87
		Median	109.4	0.2105	1.35	0.12	55	22.685
		Average	999.7875	0.463688	1.701875	0.034667	55	20.161429
		Criteria	406	0.67	0.88		<158	32

South Dakota Department of Health

D

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 12/1/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC008618
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK SIOUX TRIBE

Date Rcvd: 11/25/2008
Time Rcvd: 1500
Date Coll: 11/25/2008
Time Coll: 1153

Coll By: JERRICA WITHORN
Site Location: CROW CREEK DRAW
Site Number: SITE #31
Source: STREAM

Final Results

E COLI SM 9223B	E.Coli	770 / 100 mL

Specimen Comments:
RECEIVED 2 BOTTLES FOR ECOLI. NOTICABLE DIFFERNCE IN WATER IN BOTTLES PER JERRICA WITHORN BOTH BOTTLES WERE NUMBERED AND REPORTED FOR ECOLI.

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

12/9/08

Date: 12/3/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC008583
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK SIOUX TRIBE

Date Rcvd: 11/25/2008
Time Rcvd: 1500
Date Coll: 11/25/2008
Time Coll: 1153
Spec Type: WATER
Coll By: JERRICA WITHORN
Remarks: ENVIRONMENTAL PROGRAM CWA 106

Site Location: CROW CREEK DRAW
Site Number: 31
Source: STREAM
Type of Sample: RAW
medium WATER

Final Results

E COLI	E.Coli	488 / 100 mL	
SM 9223B			
Nitrate		0.9 mg/L	Limit: 10.0
Phosphorus,total		1.63 mg/L	

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 12/1/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC008618
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK SIOUX TRIBE

Date Rcvd: 11/25/2008
Time Rcvd: 1500
Date Coll: 11/25/2008
Time Coll: 1153

Coll By: JERRICA WITHORN
Site Location: CROW CREEK DRAW
Site Number: SITE #31
Source: STREAM

Final Results

E COLI SM 9223B	E.Coli	770 / 100 mL

Specimen Comments:
RECEIVED 2 BOTTLES FOR ECOLI. NOTICABLE DIFFERNCE IN WATER IN BOTTLES PER JERRICA WITHORN BOTH BOTTLES WERE NUMBERED AND REPORTED FOR ECOLI.

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

received 12/9/08

Date: 12/3/2008

Submitter copy to:

CROW CREEK SIOUX TRIBE EO-106909
ENVIRONMENTAL OFFICE
PO BOX 380
FORT THOMPSON, SD 57339

Spec #: E08EC008583
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK SIOUX TRIBE

Date Rcvd: 11/25/2008
Time Rcvd: 1500
Date Coll: 11/25/2008
Time Coll: 1153
Spec Type: WATER
Coll By: JERRICA WITHORN
Remarks: ENVIRONMENTAL PROGRAM CWA 106

Site Location: CROW CREEK DRAW
Site Number: 31
Source: STREAM
Type of Sample: RAW
medium WATER

Final Results

E COLI	E.Coli	488 / 100 mL	
SM 9223B			
Nitrate		0.9 mg/L	Limit: 10.0
Phosphorus,total		1.63 mg/L	

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

RECEIVED
JUL 6 2010
USGS
HURON, SD 57350

Date: 7/2/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB008266
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

DAM NEAR HWY 50

Date Rcvd: 6/29/2010
Time Rcvd: 1642
Date Coll: 6/29/2010
Time Coll: 0852

Coll By: A W MADDOX
Point of Colle* ~~DAM NEAR HWY~~ 50
Site Location: DAM NEAR HWY 50
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF Fecal Coliform [redacted]

June 10 (1.34)

June 12 (0.28) / June 13 (0.26) / June 14 (0.49)

Rain (Pierre, SD)

June 20 (0.39) / June 21 (0.45) / June 23 (0.37 in)

June 26 (0.10 in)

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 7/5/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

RECEIVED
JUL 9 2010
USGS
HURON, SD 57350

Spec #: E10WB008449
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK

Date Rcvd: 7/1/2010
Time Rcvd: 0831
Date Coll: 6/30/2010
Time Coll: 1030
Coll By: T VEO

Point of Colle* 52 FT LEW
Site Location: CROW CRK NR GANN VALLEY
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	[redacted]

Specimen Comments:
STABLE HIGH CONDITIONS WITH WEEK (OLD USGS STATION)

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

RECEIVED
July 6, 2010
USGS
HURON, SD 57350

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Date: 7/1/2010

Spec #: E10WB008232
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK

Community site

Date Rcvd: 6/29/2010
Time Rcvd: 0740
Date Coll: 6/28/2010

Time Coll: 1315
Point of Colle* 30 FT FROM REW
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	90 / 100 mL

Crow creek above
Smith creek confluen

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 7/2/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

RECEIVED
JUL 6 2010
USGS
HURON, SD 57350

Spec #: E10WB008265
Sub#:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

SMITH CREEK

Date Rcvd: 6/29/2010
Time Rcvd: 1642
Date Coll: 6/29/2010
Time Coll: 1445

Coll By: A MADDOX
Site Location: ~~SMITH CREEK~~
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	100 / 100 mL

Just Smith Creek

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 7/5/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

RECEIVED
JUL 8 2010
USGS
HURON, SD 57350

Spec #: E10WB008450
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

G MAYER RANCH

Date Rcvd: 7/1/2010
Time Rcvd: 0831
Date Coll: 6/30/2010
Time Coll: 1300

Coll By: T VEO
Point of Colle* POOLED WATER
Site Location: G MAYER RANCH
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	930 / 100 mL

Specimen Comments:
NO FLOW - POOLED WATER IN DRAINAGE

Station No. 435811609907200C

CROSS-SECTION SURVEY INFORMATION

Method used to determine measurement locations (62398): EWI (10) EDI (20) Single vertical (30) Point Sample (50) Other _____

No. of Verticals _____ Measurement Location: _____ ft upstream downstream of monitor

Stream Mixing: Excellent Good Fair Poor

Comments no flow - pooled water Rain/flow earlier this wk.

Station	Time	Ft from left bank (00009) or ft from right bank (72103)	Depth to bottom at meas. loc. ft (81903)	Measurement depth ft (00003)	Temp °C (00010)	pH units (00400)	SC µS/cm (00095)	DO mg/L (00300)	Turbidity ( )	Other ( )	NWIS Record No.
Gage ht =											
At monitor	downstream side of pool.										
1											
2	1249				27.90	8.12	1190		22.0		
3	1251				27.60	8.17	1192		15.8		
4	1253				27.53	8.17	1191		18.2		
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
At monitor											
Gage ht =											

CROSS-SECTION COMPARISON AT _____ CFS

Parameter	Cross-section median	Point value	Indicated coefficient
Water Temp	°C	°C	
pH	units	units	
SC	µS/cm	µS/cm	
DO	mg/L	mg/L	
Turbidity	_____	_____	
Other _____			

Monitor form ver. 4.0

DHY

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 4/12/2010

Submitter copy to:

ASHLI MADDOX
HURON/US GEOLOGICAL SURVEY-109622
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB003998
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

CROW CREEK MOUTH

Date Rcvd: 4/7/2010
Time Rcvd: 0505
Date Coll: 4/7/2010
Time Coll: 1250

Coll By: A MADDOX
Point of Colle* LEW 8 FT IN
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	60 / 100 mL

April 1 (0.11)/April 2 (0.08)

Rain (Pierre, SD)
April 13 (0.86)

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 4/15/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB004284
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

US GEOLOGICAL SURVEY

Date Rcvd: 4/14/2010
Time Rcvd: 0849
Date Coll: 4/13/2010
Time Coll: 1400
Coll By: D JOHNSTON

Point of Colle* MIDDLE (HN)
Sample Site: CROW/SMITH CREEK CONFLUENCE
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	20 / 100 mL

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 4/15/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB004026
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

US GEOLOGICAL SURVEY

Date Rcvd: 4/13/2010
Time Rcvd: 0724
Date Coll: 4/12/2010
Time Coll: 1300
Coll By: A MADDOX

Point of Colle* REW 6 FT IN
Site Location: CROW CREEK NEAR CROW CREEK COMMUNITY
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	10 / 100 mL

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 4/15/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB004285
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

US GEOLOGICAL SURVEY

Date Rcvd: 4/14/2010
Time Rcvd: 0849
Date Coll: 4/13/2010
Time Coll: 1445

Coll By: A MADDOX
Sample Site: CROW CREEK @ OLD GAGE
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	<10 / 100 mL

July 13 (0.86 in)

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 5/31/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB006148
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source
US GEOLOGICAL SURVEY

Date Rcvd: 5/28/2010
Time Rcvd: 1609
Date Coll: 5/27/2010
Time Coll: 1300
Coll By: T VEO

Point of Colle* Crow Creek Mouth
Sample Site: Crow Creek @ Historic Dam Site
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	120 / 100 mL

Rain (Pierre, SD)
may 22 (0.51in)
may 24 (0.54in)

may 10 (0.92)
may 12 (0.42)

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 5/31/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB006142
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source
US GEOLOGICAL SURVEY

Date Rcvd: 5/27/2010
Time Rcvd: 0903
Date Coll: 5/26/2010
Time Coll: 1430
Coll By: A MADDOX

Point of Colle* 24 FT REW
Site Location: CROW CREEK NEAR CROW CREEK SD
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	[redacted]

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 5/31/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB006141
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

US GEOLOGICAL SURVEY

Date Rcvd: 5/27/2010
Time Rcvd: 0903
Date Coll: 5/26/2010
Time Coll: 1100

Coll By: A MADDOX
Point of Colle* 30 FT LEW
Site Location: CONFLUENCE
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	[redacted]

South Dakota Department of Health

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 5/31/2010

Submitter copy to:

US GEOLOGICAL SURVEY-101421
111 KANSAS AVE SE
HURON, SD 57350

Spec #: E10WB006149
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

US GEOLOGICAL SURVEY

Date Rcvd: 5/28/2010
Time Rcvd: 1609
Date Coll: 5/27/2010
Time Coll: 0900

Coll By: T VEO
Point of Colle* ponded water
Sample Site: G Mayer Drainage
Test Reas: ROUTINE

Final Results

Fecal Coliform - MF	Fecal Coliform	60 / 100 mL

pecimen Comments:
cap dropped in grass - rinsed in Environmental water

COOPERATIVE EXTENSION SERVICE
SDSU

Extension Extra

ExEx 1010
Updated April 2002
Agriculture and
Biosystems
Engineering

COLLEGE OF AGRICULTURE & BIOLOGICAL SCIENCES / SOUTH DAKOTA STATE UNIVERSITY / USDA

RICHMOND LAKE WATER QUALITY PROJECT

Surface Water Pollution from Livestock Production

by Joseph Schumacher
Agricultural Engineering Department

The improper management of livestock wastes (manure) can cause surface and groundwater pollution. Water pollution from animal production systems can be by direct discharge, runoff, and/or seepage of pollutants to surface or ground water.

Pollutants are sediment, nutrients, pesticides, organic matter, salts, and micro-organisms.

Polluted surface water can kill fish, cause odors, spread infectious bacteria, and inhibit water-related activities.

The main livestock pollutants in surface water:

- Organic matter and excess nutrients
- Pathogen contamination

Organic matter and excess nutrients

Livestock manure used properly can improve soil fertility and tilth, increase the soil's water holding capacity, and reduce wind and water erosion. However, surface and groundwater pollution can occur if manure applications are mismanaged.

Livestock waste contains nutrient and organic material. Aquatic life relies on the breakdown of organic material for primary and secondary sources of food.

There is a limit, however, to the amount of organic material acceptable in the aquatic environment. Too much organic material produces highly colored, murky water with heavy bottom sludge accumulation. Excess nutrients (especially phosphorous and nitrogen) carried by organic matter may produce overabundant algae and weed growth in surface water. Toxic blue-green algae blooms may even appear when the conditions are right.

The oxidation of the organic material may cause such a reduction in dissolved oxygen that fish and other aquatic life are unable to survive.

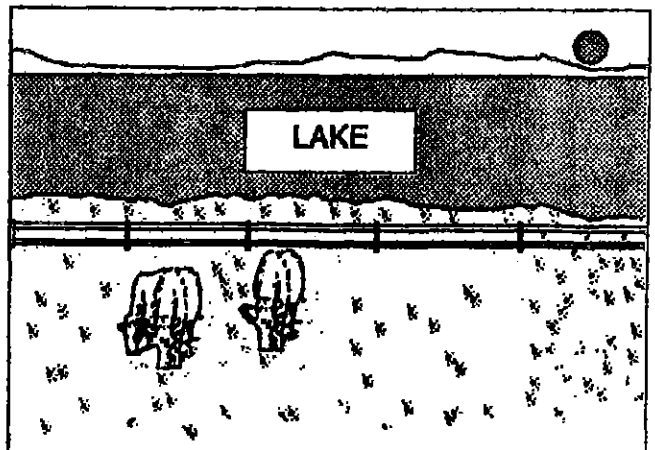
Possible sources of animal waste in surface water include feedlot runoff, manured land runoff, direct animal deposit, and septic systems.

Pathogen contamination

A pathogen is a disease causing microorganism. Possible pathogen contamination in water is determined by using biological indicators. The fecal coliform test is the most commonly used biological indicator.

Fecal coliform are intestinal bacteria found only in mammals and fowl. Fecal coliform are not found in soils, vegetation, insects or fish unless contaminated by mammal or fowl feces. They are not necessarily harmful but indicate the potential presence of other more serious disease-causing organisms.

Fecal bacteria enter surface water by direct deposit of feces and by movement with sediment in overland runoff. The organisms may be dispersed, lack proper environment, and die, or they may find conditions sufficient for long-term survival in bottom



Proper livestock waste management benefits all lake users by sustaining and improving water quality.

sludge or lake bank soils. Their survival depends on water, soil, and air temperature; lake size and flow rate; sediment volume; availability of nutrients and organic material; amount of light; soil type; pH, and other factors.

Seasonal variations in bacteria numbers can be extreme, depending on runoff volumes, temperature, animal activity, ground cover, and sunlight.

The original source of fecal bacteria in surface water is from livestock, wild animals, fowl, and rural septic tank overflows. Consequently, if fecal coliform is to be reduced, livestock contact with surface water and runoff from manured areas into surface water must be controlled and inadequate shoreline septic systems must be corrected.

Controlling surface water pollution from livestock

- **Fence animals out of surface water areas.** Lake water can be used for animal watering piping into approved water holding facilities.
- **Maintain grass buffer areas near surface water.** Buffer pasture and cropland from surface water and swamp areas.
- **Consider using retention ponds or lagoons** for runoff/waste collection.
- **Distribute pond or lagoon effluent back on the land. Do not** allow lagoon and retention pond outflow to enter the surface water.
- **Maintain proper areas for runoff disposal.** Dispose of runoff on grassed areas with good infiltration and percolation rates. These areas can be cropped but should not be allowed to stand without a cover crop during wet months.
- **Manage manure and/or lagoon effluent applied to cropland. Do not** apply effluent to frozen, sloping land susceptible to runoff.
- **Prevent overgrazing of pasture land.**
- **Maintain runoff control facilities.**

For additional information:

- Contact the Richmond Lake Water Quality Project, Soil Conservation Service, or your local Cooperative Extension Service office. Management and technical assistance is available, plus possible financial help.
- "Livestock Waste Facilities Handbook," MWPS-18, available through Midwest Plan Service Office, Agricultural Engineering Dept., SDSU (cost $6.30).
- "The Lake and Reservoir Restoration Guidance Manual," EPA, North American Lake Management Society, 1988.

This material is based upon work supported by the U.S. Department of Agriculture, Extension Service, under special project number 90-EWQI-1-9236.

This publication and others can be accessed electronically from the SDSU College of Agriculture & Biological Sciences publications page, which is at http://agbiopubs.sdstate.edu/articles/ExEx1010.pdf

COOPERATIVE EXTENSION SERVICE SDSU

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the USDA. Larry Tidemann, Director of Extension, Associate Dean, College of Agriculture & Biological Sciences, South Dakota State University, Brookings. SDSU is an Affirmative Action/Equal Opportunity Employer (Male/Female) and offers all benefits, services, and educational and employment opportunities without regard for ancestry, age, race, citizenship, color, creed, religion, gender, disability, national origin, sexual preference, or Vietnam Era veteran status.

ExEx 1010 - pdf by CES. December 1990; updated April 2002.

Stacey R. Hennen
Associate
shennen@samplaw.com

Samp Law Offices

Rollyn H. Samp

Counselor at Law

2101 West 41st Street
Suite 2000
P.O. Box 495
Sioux Falls, South Dakota 57101

(605) 339-1020
TELEFAX: (605) 334-6630
rsamp@samplaw.com
MOBILE: (605) 366-1535 *24 Hrs.*

24 August 2016

Arturo Palomares, Director
Water Technical Enforcement Program
Environmental Protection Agency Region 8
1565 Wynkoop Street
Denver, CO 80202

Kent R. Woodmansey
Feedlot Permit Program
DENR
PMB 2020 Joe Foss Building
523 E. Capitol
Pierre, SD 57501

Re: Mayer Ranch Complaint

Dear Gentlemen:

For your convenience I have enclosed prior correspondence on the aforesaid feedlot.

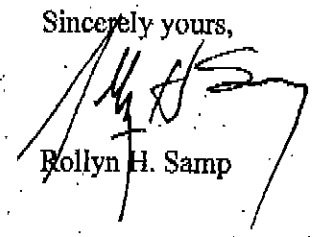
My client has been sampling feedlot runoff and has confirmation of the contaminants in Crow Creek and his stock dam from Mayer Ranch.

We are unclear as to which agency currently has jurisdiction on this Complaint.

My client would like direction as to where he can file a formal Complaint on this continuing pollution.

Thank you.

Sincerely yours,

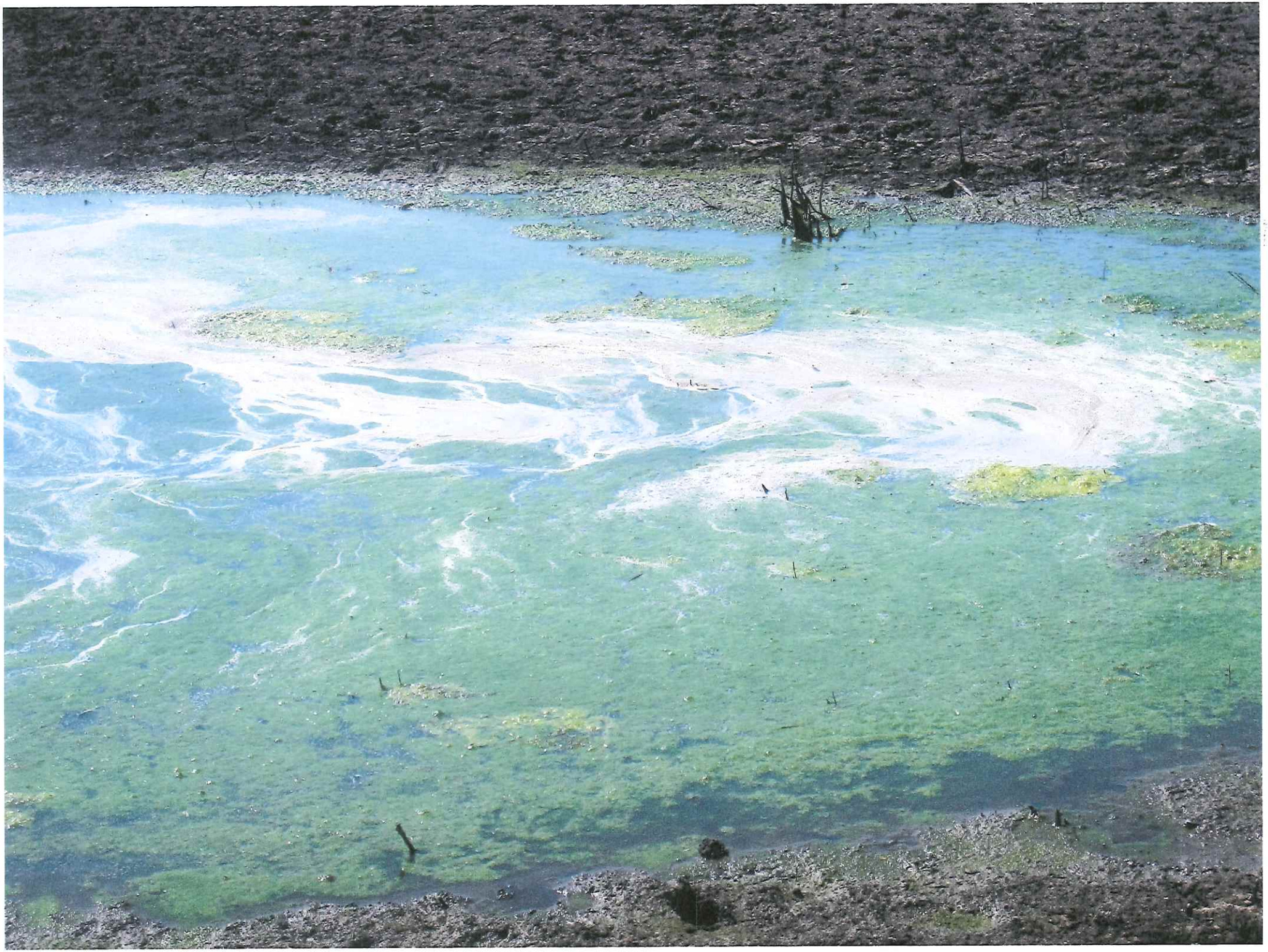


Rollyn H. Samp

RHS/jj

Enclosures:

cc: Rich Williams Assistant Attorney General
Client



ARCTIC CAT

#4
#1
#3
#2

Kathy Martin Exhibits 48 through 50

KATHY J. MARTIN, PE

3122 Tall Oaks Circle · Norman, Oklahoma 73072 · Cell: (405) 819-7626 Email: kjm2@aol.com

CURRENT OCCUPATION

ENVIRONMENTAL CONSULTANT, PRESIDENT, MARTIN ENVIRONMENTAL SERVICES, LLC NORMAN, OK
Professional Engineer in Civil Engineering - providing expertise in environmental permits for air quality, non-hazardous industrial wastewater, and closure of surface impoundments. Perform engineering review and critique of permit applications submitted by livestock facilities to state and federal regulatory agency with respect to wastewater treatment technology and compliance with environmental regulations.

EDUCATION

UNIVERSITY OF OKLAHOMA
M.S. Civil Engineering, 1989
Thesis: The Removal of Polychlorinated Biphenyls from Topsoil Using Nonionic Surfactants

UNIVERSITY OF OKLAHOMA
B.S. Petroleum Engineering, 1987
National Dean's List, 1986-87

EXPERIENCE

HYDRAULIC FRACTURING AND INJECTION WELL ISSUES
As Martin Environmental Services, 2009 to present
Provide guest lecturer and other speaking arrangements regarding potential environmental impacts of hydraulic fracturing of shale gas and shale oil formations. Perform technical and regulatory review of salt water injection well permit applications to determine if regulatory and environmental concerns are adequately addressed.

MOBILE MEAT HARVESTING UNIT
Team member, 2010 to present
Provide technical assistance in developing water and wastewater treatment strategies including potable water treatment, slaughter waste treatment and disposal, HAACP, and other USDA requirements for small slaughterhouses.

ADJACENT LANDOWNERS TO LIVESTOCK FACILITIES
Subcontracted as Martin Environmental Services, June 1997 to present
Perform technical and regulatory review of approximately 150 CAFO permit applications in 21 states nationally to determine if the application is sufficient for a permit writer to draft a permit. The purpose was to determine if there were technical and/or regulatory deficiencies in the application and prepare a written report for use in administrative proceedings by concerned citizens and adjacent landowners.

SEWARD COUNTY COMMISSIONERS, SEWARD COUNTY, KANSAS
Subcontracted as Martin Environmental Services, June - October 1998
Drafted environmental regulations for confined animal feeding operations (CAFOs) with respect to the design, construction, operation, maintenance, and closure of surface impoundments and the disposal of CAFO waste by land application. The resulting work product was a set of regulations that is a complete permitting program including public notice, hearings, permit application processes and fees, as well as provisions for compliance and enforcement.

DEPARTMENT OF ENVIRONMENTAL QUALITY
Environmental Engineer II, July 1, 1993 to November 1, 1996
Special training in areas of Air Quality and Hazardous Waste permits and regulatory requirements. Provided technical and regulatory assistance to business and industry with respect to environmental permits issued by the ODEQ in water quality, air quality, and solid waste programs.

OKLAHOMA WATER RESOURCES BOARD
Environmental Engineer I, April 1990 to June 30, 1993
Special training in areas of industrial wastewater disposal permits and inspections. Drafted state regulations for surface impoundments and land application of non-hazardous industrial wastewater. Issued state permits for non-discharge facilities. Project officer of Tar Creek Superfund Site.

TECHNICAL EXPERTISE

- 17 years continuing education regarding CAFO waste management systems
- Extensive research and knowledge of lagoon liner systems and waste/liner compatibility
- 13 years continuing education regarding pathogen transport and fate from CAFOs
- 15 years continuing education regarding air pollution and odors from CAFOs
- Other topics of continuing education: GPS, perimeter tile design, concrete, flow meters, backflow prevention, fate and transport, and soil science
- Drafted Oklahoma state regulations for permitting of surface impoundments and disposal by land application used by facilities with non-hazardous industrial wastewater
- Drafted county regulations for CAFO impoundments and land application of manure
- Familiarity with CAFO regulations in AR, CA, CO, GA, IA, ID, IL, IN, KS, KY, MO, MS, ND, NE, NM, OK, PA, SD, TX, UT, and WY
- Professional Engineer in Oklahoma (No. 18254) February 1997 to present; Professional Engineer in New Mexico 2012 (No. 21522)
- Coordinated Superfund activities between USGS, Oklahoma State and EPA
- Interacted with State Legislators (OK and KS) on technical issues related to CAFOs
- Provide expert testimony regarding CAFO waste management systems in Arkansas, Indiana, Kansas, Kentucky, Missouri, Nebraska, New Mexico, Oklahoma, and Utah
- Provide technical and regulatory reviews of CAFO permit applications in AR, CA, CO, GA, IA, ID, IL, IN, KS, KY, MO, MS, ND, NE, NM, OK, PA, SD, TX, UT, WI, and WY
- Graduate Degree coursework included: Groundwater Protection, Groundwater Seepage, Groundwater Modeling, Groundwater Pollution Control, Air Pollution Controls, Air Pollution Engineering, Environmental Impact Assessment, Risk Assessment, Industrial Hygiene, Reservoir Dam Engineering, Open Channel Flow, Chemical and Biological Aspects of Environmental Engineering, Advanced Wastewater Treatment, Soil Classification, Soil Science, Hazardous Waste Control, Solid Waste Engineering/Landfill Design, Land Use Management, Surfactants and Colloidal Science, Corrosion Engineering, Field Applications, and Nonparametric Statistics.
- Three years Chinese language
- Ten years leadership positions in local, state, and national organizations
- Developed state-wide foundry and metal casting facility environmental program in Oklahoma -- and trained state agencies in Louisiana and Arkansas to do the same.
- Active contributor to proposed regulatory language with respect to CAFOs at local, state, and federal levels, especially OK, KS, NE, CO, NM, IN, and IL.
- Provided lectures on CAFO environmental issues to groups in Oklahoma, Kansas, Nebraska, Indiana, Pennsylvania and Utah to groups as large as 600 people at a time.

ORGANIZATIONS AND BOARD POSITIONS

- STRONGER NATIONAL BOARD MEMBER – ENVIRONMENTAL STAKEHOLDER (2006-2010)
- DEQ Hazardous Waste Management Council - governor appointed member (past)
- STRONGER Audit Team - Oil and Gas Environmental Regulations in Oklahoma (2005), Kentucky (2006) and Tennessee (2007)
- Oklahoma Corporation Commission - Citizen Advisory Board member (past)
- Oklahoma Society of Environmental Professionals – Past President, Past Newsletter Editor, Past Secretary, Past Engineering Board Member
- American Society of Agricultural and Biological Engineers (ASABE) – member
- Society of Petroleum Engineers - Past Executive Committee two years, member 10 years
- National Association of Professional/Graduate Students - Past Board member and National Conference Chairperson
- Graduate Student Senate, University of Oklahoma - Past Chair two years, Past Vice Chair, Past Senator for Civil Engineering Department
- Oklahoma Chapter of Sierra Club - past member, 1 year
- Engineering Club of Oklahoma City - past member, 6 years
- OU Petroleum Engineers Club - past Vice President, member 4 years
- OU Society of Women Engineers - past President, member 7 years
- OU Engineer's Club - Loyal Knight of St. Pat, member 7 years

Expert Witness Testimony and Deposition History

Kathy J. Martin, PE (OK#18254)

List updated October 2015

Location	File Name	Date	Other
Okla Water Resources Board	Seaboard - Nichols Radcliffe Nursery Beaver County, OK	Oct 1997	OWRB Water permit administrative hearing
Okla Dept of Ag	BAR-D swine finisher Caddo County, OK	Dec 1997	CAFO permit administrative hearing
Okla Dept of Ag	Seaboard Fisher facility Texas County, OK	Dec 1997	CAFO permit administrative hearing
Okla Water Resources Board	PIC Gilt Facility Woodward County, OK	Aug 1997	OWRB Water permit administrative hearing
Utah DEQ	Circle Four Farms Administrative Hearing	mid 1998?	CAFO permit Board hearing
Okla Dept of Ag	Hanor/Kronseder Huffman Fac. Woodward County, OK	Jan 1998	CAFO permit administrative hearing
Okla Water Resources Board	Murphy Family Farms Luthi Facility Ellis County, OK	Jan 1998	OWRB water permit administrative hearing
Okla Dept of Ag	Tyson Chapman Facility Seminole, OK	Dec 1999	OWRB water permit administrative hearing
Okla Water Resources Board	Land of Lakes Taylor Facility Beaver County, OK	Mar 2000	OWRB water permit administrative hearing
Platte County Nebraska	TeVelde Dairy District Court	Nov-Dec 2000	County Permit Appeal to District Court
Okla Dept of Ag	Seaboard - Kendra East Beaver County, OK	May 2001	CAFO permit administrative hearing
Iowa French Creek	Wayne Weber hog farm Sierra Club, et al v Weber	2001	Deposition
Okla Dept of Ag	Land of Lakes Reddick Beaver County, OK	Mar 2002	CAFO permit administrative hearing
Okla Dept of Ag	Seaboard Schnackenberg Texas County, OK	Jan-Feb 2003	CAFO permit administrative hearing
Okla Dept of Ag	Land of Lakes, T Venable Beaver County, OK	Jan-June 2005	CAFO permit administrative hearing
Okla Dept of Ag	Land of Lakes, J. Venable Beaver County, OK	Jan-June 2005	CAFO permit administrative hearing

Okla Dept of Ag	Land of Lakes - Ferguson Nursery #1 & #2 Beaver County TX	Jan-Jun 2005	CAFO permit administrative hearing
Okla Dept of Ag	C&M Cattle Feedlot Cimarron County, OK	April 2006	CAFO permit Administrative hearing
Kendall County Illinois	Toftoy v Rosenwinkel	Oct 2006	Deposition
Kentucky Cabinet of Public Health and Environment	9 contract hog operations (Tosh) Fulton, Hickman and Carlisle counties combined into one hearing (wean-to-finish)	Jan 2007	CAFO permit (KDNOP) Administrative hearing Deposition
Kentucky Circuit Court	9 contract hog operations (Tosh) Fulton, Hickman and Carlisle counties combined into one hearing (wean-to-finish)	Oct 2007	Stay Hearing on agency permit action – air toxics
Indiana Office of Environmental Adjudication	Union Go Dairy (Vreba-Hoff) Appeal of Permit Issuance Appeal Hearing	Jan-Feb 2008	CAFO Permit (NPDES) Administrative Hearing
Missouri Administration Hearing Commission	Ozbun Poultry Facility Appeal of Permit Issuance Appeal Hearing	Jan 2009	CAFO Permit (state) Administrative Hearing
New Mexico Environmental Department	ParaSol Dairy Appeal of Ground Water Discharge Permit	Feb 2009	Discharge permit (state) Administrative Hearing
Indiana Office of Environmental Adjudication	Steuber Hog Farm Appeal of Permit Issuance Appeal Hearing	Feb 2009	CAFO Permit (NPDES) Administrative Hearing
Indiana Office of Environmental Adjudication	Duckwall Hog Farm Appeal of Permit Issuance Appeal Hearing	June 2009	CAFO Permit (NPDES) Administrative Hearing
Indiana Office of Environmental Adjudication	Optima Dairy (Vreba-Hoff) Appeal of Permit Issuance Appeal Hearing	July 2009	CAFO Permit (NPDES) Administrative Hearing Deposition
New Mexico Water Quality Control Commission	Dairy Rule-Making Hearing Technical testimony	June 2010	Rule-making
New Mexico Oil Conservation Commission	Pit Rule-Making Hearing Technical rebuttal testimony	Aug 2012	Rule-making
Indiana Office of Environmental Adjudication	Union Go Dairy (Vreba-Hoff) Appeal of Permit Modification Appeal Hearing	Jan 2013	Deposition
State of Wisconsin Div of Hearings and Appeals	Richfield Dairy Appeal of Permit Issuance Adams County, WI	June 2013	Plans and Specifications Administrative Hearing
Scott County, Illinois	Marsh, et al v Sandstone North, LLC, et al	Aug 2013	Deposition
Lea County, New	Pearson, et al v Rock View Dairy,	Oct 2013	Deposition

Mexico	High Lonesome Dairy, Rick Schaap, and Eddie Schaap		
Superior Court of California, County of Santa Clara	Acoba, et al v Olivera Egg	Nov 2013	Deposition
State of Wisconsin Div of Hearings and Appeals	Kinnard Dairy Appeal of Modified Permit Kewaunee County, WI	Feb 2014	Plans and Specifications Administrative Hearing
State of Indiana	Mark Holder v Trotter Farms, Inc, Ronald E. Trotter, Rosemary Trotter, and Barry Trotter	Feb 2014	Deposition (Indianapolis, IN)
State of Delaware	Brownfield Remediation Plan - Pinnacle Foods/Vlassic and proposed site of Allen-Harim poultry processing facility Technical Testimony	May 2014	Brownfield Remediation Plan Appeal Hearing Dover, Delaware
State of Indiana	Mark Holder v Trotter Farms, Inc, Ronald E. Trotter, Rosemary Trotter, and Barry Trotter	May 2014	Deposition (continuation in Kansas City, MO)
Superior Court of California, County of Santa Clara	Acoba, et al v Olivera Egg	June 2014	Testimony at Trial
New Mexico Water Quality Control Commission	Dairy Rule-Making Hearing Pre-filed Written Testimony and Rebuttal	Nov 2014	Rule-making hearing was postponed until April 2015
Missouri Clean Water Commission	Callaway Farrowing, LLC Appeal of Permit Issuance	Feb 2015	State No-Discharge permit appeal hearing before an administrative law judge.
Pennsylvania Department of Environmental Quality	Stedge v Chesapeake	March 2015	Appeal Hearing of Frack Flowback Tank Storage Permit
Nevada State Environmental Commission	Smith Valley Dairy Appeal of Permit Issuance	July 2015	Administrative Hearing
State of Iowa	Pauls v Warren Family Pork Dovico v Valley View Farms Winburn v Hoksbergen	Aug and Sept 2015	Deposition
State of New Mexico	Gonzalez, et al v Del Oro Dairy	Aug and Sept 2015	Deposition
Missouri Clean Water Commission	Trenton Farms RE, LLC Appeal of Permit Issuance	Oct 2015	State No-Discharge permit appeal hearing before an administrative law judge.

Written Comments on Proposed CAFO General Permit

Submitted to SD-DENR during Formal Comment Period

The following written comments were prepared by Kathy J. Martin, PE (OK#18254) at the request of citizen groups, including Dakota Rural Action, South Dakota Farmers Union and Socially Responsible Agriculture Project.

A. Rebuttal of DENR Response to Public Comments dated October 8, 2015

A1. Testing for leakage from concrete deep pits. During the informal public comment period, the DENR response to a concern about a lack of monitoring or testing of manure pits is "staff [will] visually inspect wastewater containment structures and review containment structure inspection records when conducting inspections."

- How does one inspect the concrete integrity of deep pits under swine barns after they are in use and contain liquid swine manure wastewater?
- If the operator only uses design factors to estimate the amount of manure and wastewater generated, how will the operator know if the amount of wastewater in the waste storage facility is undergoing "unusual changes"?

There is concern that the design engineer is the same person that certifies that the facility was constructed according to design plans and specifications. Perhaps the certification should also contain photographic evidence that shows the poured concrete does not have cracks and pits that could lead to excess seepage, infiltration into the concrete matrix and corrosion of the rebar.

A2. Restrictions for tiled land application fields. The concern expressed about fall application of manure wastewater was addressed by DENR's response that setbacks would apply in Section 1.4.4.3.k, however in the proposed General Permit there setback paragraph is found on page 33 of 45, item 1.4.4.2.k, which states:

> "A detailed map showing the outline of each field listed in item i. above and all buffer zones and separation distances required by this permit (including those in Sections 1.4.3.3.v, 1.4.4.1.g and any local government required buffers. If application to saturated, snow covered, or frozen soil may occur routinely or in an emergency, separate maps for each land application field showing the outline of each field and all winter buffer zones and separation distances shall be submitted."

Neither section of the proposed General Permit refers to identifying field tiles on lands used to dispose of manure wastewater by land application. Of the two sections listed, only 1.4.4.1.g refers to anything related to field tiles as follows (emphasis added):

> "The producer shall maintain at least a 100-foot buffer zone or 35-foot vegetated buffer between: (1) any manure land application areas and any down-gradient surface waters, *open tile line intake structures*, sinkholes, or other conduits to

> surface waters of the state; and (2) any irrigation of process wastewater and any down-gradient surface waters, *open tile line intake structures*, sinkholes, or other conduits to surface waters of the state."

The proposed General Permit does not include a definition for "open tile line intake structures". The DENR response to the request to restrict land application on tiled fields is:

> "EPA does not have the authority to require a NPDES permit for discharges of return flows from irrigated agriculture and the legislature has given the authority to regulate drainage to local government not to DENR."

The assumption that preventing land application over tiled fields is somehow a requirement for NPDES discharge permit is not logical. Typically, a field is tiled in order to drain excess water to provide a healthier root zone. The concern is when land application occurs during rainy season or when fields are close to saturation – that the manure wastewater will be drained from the subsurface and discharged to surface water via the field tile outlet. This contaminated drainage can be avoided by restricting land application on tiled fields during spring rains and during snow melt. The DENR could address these valid concerns as simply as requiring sampling at the field outlet tile or capping the field outlet tile during the land application event if contaminated discharge occurs.

A3. Because NPDES doesn't require it. Numerous DENR responses to public comment claim nothing can be done to assuage public concerns because the US EPA does not have requirements or authority to address those concerns. What is not stated is that the General Permit serves two purposes – a federal permit and a state permit – using the same exact language. The DENR certainly has the authority to protect public health and the environment and thus can include necessary permit language to insure that CAFOs in South Dakota do not pollute waters of the state or adversely impact public health.

A4. Public notice in printed media. According to their comments, the South Dakota Farm Bureau supports the removal of public notice in printed media for modifications to the manure management system or nutrient management plan. The purpose of public notice is to notify the public of a potential permit action not make the information difficult to obtain. How can the DENR fulfill its obligation of public notice when rural citizens may not have internet access to read the DENR website, much less know they would need to access the DENR website all of the time "just in case" a CAFO will be proposed in their neighborhood? There is no benefit to the public's interest by reducing the public's access to notice of permit actions.

B. Additional Issues with final proposed General Permit language.

B1. Annual report requirements. On page 39 of 43 in the proposed General Permit, items 2 (c) and (d) allow for estimation of amount of total manure generated at the facility and the total manure transferred to other persons.

- Why wouldn't the state require actual volumes of manure generated based on the depth to volume charts that indicate actual storage capacity of the waste storage facility and depth marker records?
- Estimates of manure generated imply book values could be used, thus never providing public access to the actual manure volumes generated. To continue to use book values after the facility is up and operational serves no purpose as the public and the state would never know if the design factors are accurate predictors of the actual volumes of manure generated.

B2. Recordkeeping requirements. On page 39 of 43 of the proposed General Permit, Section 1.4.6 lists the items required for the production area including "weekly records of the level of the manure and process wastewater in the process wastewater containment structures".

- This type of information would be more valuable if it was paired with the actual number of animals (rather than maximum permitted number) on the site that generated the manure and process wastewater. Otherwise, how would the operator and/or the state determine if there are any "unexpected changes" to the level of waste in the containment structure?
- Without groundwater monitoring or leak detection systems, the only indicator the operator and/or the state has to determine if leakage is occurring from the waste storage structure is changes in waste levels based on visual reading of liquid level on the depth marker. It is not clear how a change in liquid levels will directly correlate to leakage or could otherwise be explained by less manure generated (eg. less than maximum animals or change in cleaning methods).

B3. Allowed seepage rate. On page 24 of 45, the ground water protection section (4) provides for a specific discharge of 9×10^{-7} cm/sec from earthen liners constructed of 18 inches of clay materials. Equivalent value of the allowable seepage rate can be calculated as follows:

9×10^{-7} cm/sec x 3600 sec/hr x 24 hr/day x in/2.54 cm x gal/231 in^3 x 144 in^2/ft^2 x 43560 ft^2/acre = 831 gal/acre/day

or 303,427 gallons of manure wastewater per acre per year allowable seepage

After 20 years of operation, a 5 acre lagoon could have allowable seepage of 30 million gallons. If the concentration of nitrogen in the manure wastewater is 3000 ppm, the amount of nitrogen compounds discharged to the subsurface over a 20 year design life can be calculated as follows:

30 mgal x 3000 ppm x 8.34 lbs/gal = 750,600 lbs nitrogen over the design life

- At what maximum concentration of pollutants in the stored manure wastewater will the allowable seepage *not* cause degradation of ground water?
- Once the waste storage facility is built, how will DENR measure the nitrogen compounds and other pollutants that are allowed to discharge to the subsurface in the "allowable seepage"?

B4. Animal type and waste characteristics. A question was posed during the informal comment period about whether the DENR would consider additional permit requirements for very large CAFOs (Comment 53) to which the DENR claims "we do not believe additional requirements are needed for larger operations." No actual explanation was provided to help the public understand why DENR staff does not recognize a direct correlation between size of operation, amount of manure and wastewater generated, and the risk to public health and the environment.

- Does DENR have access to published studies that show no matter how large a CAFO is, the risk to the environment and public health is equivalent to a CAFO of only 1000 animal units?
- Does DENR believe that the risks from a dry manure system are the same as from a wet manure system?

1000 animal units or 2500 swine finishers produce the following amount of manure (as excreted) not including washwater using waste characteristics from Midwest Plan Services MWPS-18 and assuming an average weight of 150 pounds:

2500 hd finishers x 0.89 gal/hd/day x 365 days/yr = 812,125 gallons/yr

1000 animal units or 2500 swine sows produce the following amount of manure (as excreted) not including washwater using waste characteristics from Midwest Plan Services MWPS-18 and assuming an average weight of 400 pounds with 80 percent gestating and 20 percent lactating:

2000 hd gest sow x 1.10 gal/hd/day x 365 day/yr = 803,000 gal/yr
500 hd lact sow x 2.42 gal/hd/day x 365 day/yr = 441,650 gal/yr
Total manure as excreted (no washwater) = 1,244,650 gal/yr

1000 animal units or 700 dairy cattle produce the following amount of manure (as excreted) not including washwater using waste characteristics from Midwest Plan Services MWPS-18 and assuming an average weight of 1400 pounds and assuming all are lactating (not including the milking parlor wastewater, silage leachate, or any contaminated stormwater runoff directed to the waste storage facility):

700 dairy x 18.70 gal/hd/day x 365 days/yr = 4,777,850 gal/yr

In other words, a 1000 animal unit sow facility generates 150% of the manure generated (as excreted, no washwater included) by a 1000 animal unit swine finisher. Similarly, the

700 head dairy would produce nearly 6 times more manure than a 2500 head swine finisher and nearly 4 times more manure than a 2500 head sow facility.

B5. Additional requirements for treatment systems. The General Permit should incorporate by reference the National Engineering Handbook and specific NRCS-SD Conservation Practice Standards that include more detailed information about how a particular treatment system should be designed, constructed, operated, and maintained. On page 23 of 45 of the General Permit, section 1.4.3(3)(z) includes minimal design standards for anaerobic, naturally aerobic, and mechanically aerated lagoons. Only the subparagraph for anaerobic digesters includes a reference to a specific NRCS-SD Standard (Standard 366).

For example, an anaerobic lagoon should definitely be designed based on volatile solids loading, but it should also have a minimum treatment volume outside of the volumes required for waste storage, sludge accumulation, freeboard, and the 25-year, 24-hour storm event. The Animal Waste Management Field Handbook (Part 651 of the National Engineering Handbook (NEH)) provides minimum engineering design standards for anaerobic lagoons and other waste treatment systems. If the DENR included Part 651 of the NEH in section 1.4.3.3(3)(z), all applicants would know what is expected in the design to insure that the intended treatment purpose does actually occur during operation.

B6. Constructing in a 100 year floodplain. On page 22 of 45, subparagraph 1.4.3(3)(t) allows construction of a manure containment structure if the “top of the freeboard” is at least one foot above the elevation of the 100-year flood. This allowance does not make sense.

- Is DENR claiming that an earthen structure can withstand a 100-year flood that reaches within 1 foot of the top of the berm?
- How does the earthen berm survive the saturation and scouring of a flood event and still maintain structural integrity?
- Would the DENR allow a 20 million gallon manure wastewater impoundment to be constructed in the 100 year flood zone if the one or all sides were built above grade?

B7. Changes to the General Permit that are less protective. There are numerous occasions where a change in the proposed general permit seems to reduce or eliminate restrictive language. The DENR has not satisfactorily defended a less protective permit in its Statement of Basis for the following:

- Allowing land application on saturated or snow covered ground.
- Reduced operator liability for transferred manure.

- Removed requirement for out-of-state manure to be land applied under the South Dakota permitting program.
- Not providing contested case options for neighbors in the state permit approval process, but providing such for the applicant if DENR denies the application.
- Change notification to DENR if land application on snow from “shall” to “should”.
- Changes in public notice that relies too heavily on internet access.

B8. Storm water management of production area. On page 20 of 45, subparagraph 1.4.3(3)(h)(4) states:

> “If uncontaminated storm water runoff cannot be diverted away from the production area and manure management systems, the manure management system shall include adequate storage capacity for the additional clean water.”

The permit language does not specify how the DENR will determine if uncontaminated storm water *can* be diverted within the confines of the particular proposed site, the surrounding watershed, and available culverts and ditch systems. The use of HydroCad to predict stormwater runoff volumes and peak flow rates is an important part of proving that a proposed CAFO can control storm water and prevent its contamination. DENR should require modeling by HydroCad to show that the proposed facility layout will be functional with respect to stormwater run-on and run-off controls during operation.

B9. Ground water protection. The DENR relies heavily upon the shallow aquifer map and the map of permeable sediments to determine if a facility should be required to have a separate ground water permit or allowed to use the surface water general permit with ground water monitoring. The DENR has permitted numerous CAFOs in and amongst the upgradient watersheds to major river systems and their corresponding shallow aquifer systems in the east half of the state as can be seen when comparing Figure 1 and Figure 2 below. According to the Permitted CAFO map, the east half of the state contains 41 dairies (103,232 head), 124 swine (621,557 head) and 7 poultry (4,663,060 hd). The amount of manure that is land applied in the east half of the state can be estimated using Midwest Plan Services MWPS-18 waste characteristics as follows:

> 103,232 dairy x 18.70 gal manure/hd/day x 365 days/yr = 704,610,016 gal/yr
> 621,557 swine x 0.89 gal manure/hd/day x 365 days/yr = 201,912,792 gal/yr
> 4,663,060 poultry x 0.017 gal manure/hd/day x 365 days/yr = 28,934,287 gal/yr
> Total gallons manure per year: 935,457,095 gallons manure per year

This nearly one billion gallons of manure contains 61,902,656 lbs of nitrogen and 28,782,306 lbs P2O5. The DENR has chosen to control one billion gallons of manure using one general permit regardless of CAFO type or size or risk to human health and the environment. Where is the monitoring data to justify this CAFO general permit?

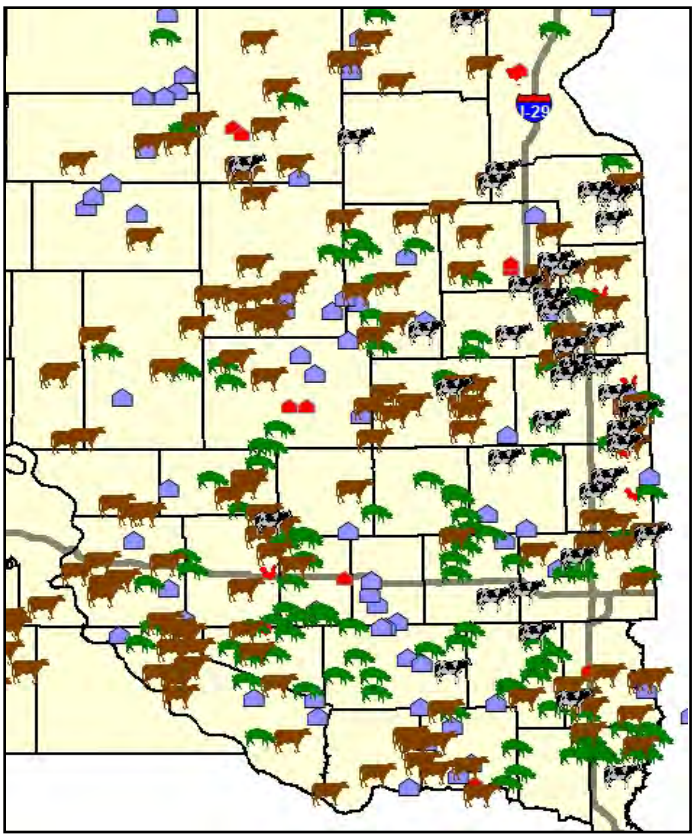


Figure 1 – CAFOs located along I-29 corridor and westward amongst numerous shallow aquifer and alluvial areas.

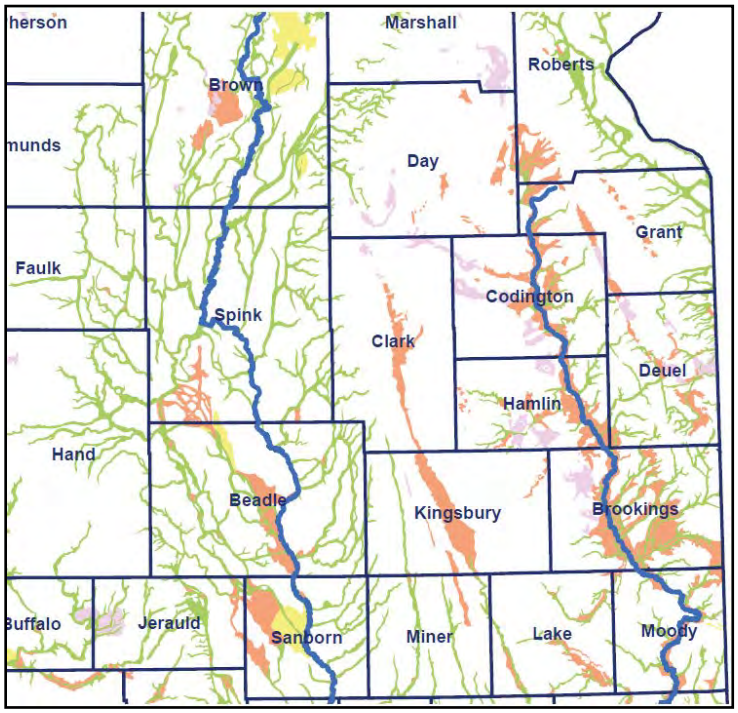


Figure 2 – Permeable sediments map of eastern South Dakota.

Don Kelley Exhibits 51 through 64

ANTIBIOTIC RESISTANCE THREATS
in the United States, 2013

U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention

TABLE OF CONTENTS

Foreword 5
Executive Summary 6
Section 1: The Threat of Antibiotic Resistance 11
Introduction 11
National Summary Data 13
Cycle of Resistance Infographics 14
Minimum Estimates of Morbidity and Mortality from Antibiotic-Resistant Infections 15
Limitations of Estimating the Burden of Disease Associated with Antibiotic-Resistant Bacteria 18
Assessment of Domestic Antibiotic-Resistant Threats 20
Running Out of Drugs to Treat Serious Gram-Negative Infections 22
People at Especially High Risk 24
Antibiotic Safety 25
Gaps in Knowledge of Antibiotic Resistance 27
Developing Resistance: Timeline of Key Antibiotic Resistance Events 28
Section 2: Fighting Back Against Antibiotic Resistance 31
Four Core Actions to Prevent Antibiotic Resistance 31
1. Preventing Infections, Preventing the Spread of Resistance 32
CDC's Work to Prevent Infections and Antibiotic Resistance in Healthcare Settings 32
CDC's Work to Prevent Antibiotic Resistance in the Community 34
CDC's Work to Prevent Antibiotic Resistance in Food 36
2. Tracking Resistance Patterns 39
3. Antibiotic Stewardship: Improving Prescribing, Improving Use 41
4. Developing New Antibiotics and Diagnostic Tests 44
Section 3: Current Antibiotic Resistance Threats in the United States, by Microorganism 49
Microorganisms with a Threat Level of Urgent 50
Clostridium difficile 51
Carbapenem-resistant Enterobacteriaceae 53
Drug-resistant *Neisseria gonorrhoeae* 55
Microorganisms with a Threat Level of Serious 58
Multidrug-resistant *Acinetobacter* 59
Drug-resistant *Campylobacter* 61
Fluconazole-resistant *Candida* (a fungus) 63
Extended spectrum β-lactamase producing Enterobacteriaceae (ESBLs) 65
Vancomycin-resistant *Enterococcus* (VRE) 67
Multidrug-resistant *Pseudomonas aeruginosa* 69
Drug-resistant non-typhoidal *Salmonella* 71
Drug-resistant *Salmonella* Typhi 73
Drug-resistant *Shigella* 75
Methicillin-resistant *Staphylococcus aureus* (MRSA) 77
Drug-resistant *Streptococcus pneumoniae* 79
Drug-resistant tuberculosis 81
Microorganisms with a Threat Level of Concerning 84
Vancomycin-resistant *Staphylococcus aureus* (VRSA) 85
Erythromycin-resistant Group A *Streptococcus* 87
Clindamycin-resistant Group B *Streptococcus* 89
Technical Appendix 93
Glossary 107
Acknowledgements 112

ACINETOBACTER

FOREWORD

Antimicrobial resistance is one of our most serious health threats. Infections from resistant bacteria are now too common, and some pathogens have even become resistant to multiple types or classes of antibiotics (antimicrobials used to treat bacterial infections). The loss of effective antibiotics will undermine our ability to fight infectious diseases and manage the infectious complications common in vulnerable patients undergoing chemotherapy for cancer, dialysis for renal failure, and surgery, especially organ transplantation, for which the ability to treat secondary infections is crucial.

When first-line and then second-line antibiotic treatment options are limited by resistance or are unavailable, healthcare providers are forced to use antibiotics that may be more toxic to the patient and frequently more expensive and less effective. Even when alternative treatments exist, research has shown that patients with resistant infections are often much more likely to die, and survivors have significantly longer hospital stays, delayed recuperation, and long-term disability. Efforts to prevent such threats build on the foundation of proven public health strategies: immunization, infection control, protecting the food supply, antibiotic stewardship, and reducing person-to-person spread through screening, treatment and education.

Dr. Tom Frieden, MD, MPH
Director, U.S. Centers for Disease Control and Prevention
Meeting the Challenges of Drug-Resistant Diseases in Developing Countries
Committee on Foreign Affairs Subcommittee on Africa, Global Health, Human Rights, and International Organizations
United States House of Representatives
April 23, 2013

ANTIBIOTIC RESISTANCE THREATS IN THE UNITED STATES, 2013

Executive Summary

Antibiotic Resistance Threats in the United States, 2013 is a snapshot of the complex problem of antibiotic resistance today and the potentially catastrophic consequences of inaction. The overriding purpose of this report is to increase awareness of the threat that antibiotic resistance poses and to encourage immediate action to address the threat. This document can serve as a reference for anyone looking for information about antibiotic resistance. It is specifically designed to be accessible to many audiences. For more technical information, references and links are provided.

This report covers bacteria causing severe human infections and the antibiotics used to treat those infections. In addition, *Candida,* a fungus that commonly causes serious illness, especially among hospital patients, is included because it, too, is showing increasing resistance to the drugs used for treatment. When discussing the pathogens included in this report, *Candida* will be included when referencing "bacteria" for simplicity. Also, infections caused by the bacteria *Clostridium difficile (C. difficile)* are also included in this report. Although *C. difficile* infections are not yet significantly resistant to the drugs used to treat them, most are directly related to antibiotic use and thousands of Americans are affected each year.

Drug resistance related to viruses such as HIV and influenza is not included, nor is drug resistance among parasites such as those that cause malaria. These are important problems but are beyond the scope of this report. The report consists of multiple one or two page summaries of cross-cutting and bacteria- specific antibiotic resistance topics. The first section provides context and an overview of antibiotic resistance in the United States. In addition to giving a national assessment of the most dangerous antibiotic resistance threats, it summarizes what is known about the burden of illness, level of concern, and antibiotics left to defend against these infections. This first section also includes some basic background information, such as fact sheets about antibiotic safety and the harmful impact that resistance can have on high-risk groups, including those with chronic illnesses such as cancer.

CDC estimates that in the United States, more than two million people are sickened every year with antibiotic-resistant infections, with at least 23,000 dying as a result. The estimates are based on conservative assumptions and are likely minimum estimates. They are the best approximations that can be derived from currently available data.

Regarding level of concern, CDC has — for the first time — prioritized bacteria in this report into one of three categories: urgent, serious, and concerning.

Urgent Threats

- *Clostridium difficile*
- Carbapenem-resistant Enterobacteriaceae (CRE)
- Drug-resistant *Neisseria gonorrhoeae*

Serious Threats

- Multidrug-resistant *Acinetobacter*
- Drug-resistant *Campylobacter*
- Fluconazole-resistant *Candida* (a fungus)
- Extended spectrum β-lactamase producing Enterobacteriaceae (ESBLs)
- Vancomycin-resistant *Enterococcus* (VRE)
- Multidrug-resistant *Pseudomonas aeruginosa*
- Drug-resistant Non-typhoidal *Salmonella*
- Drug-resistant *Salmonella* Typhi
- Drug-resistant *Shigella*
- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Drug-resistant *Streptococcus pneumoniae*
- Drug-resistant tuberculosis

Concerning Threats

- Vancomycin-resistant *Staphylococcus aureus* (VRSA)
- Erythromycin-resistant Group A *Streptococcus*
- Clindamycin-resistant Group B *Streptococcus*

The second section describes what can be done to combat this growing threat, including information on current CDC initiatives. Four core actions that fight the spread of antibiotic resistance are presented and explained, including 1) preventing infections from occurring and preventing resistant bacteria from spreading, 2) tracking resistant bacteria, 3) improving the use of antibiotics, and 4) promoting the development of new antibiotics and new diagnostic tests for resistant bacteria.

The third section provides summaries of each of the bacteria in this report. These summaries can aid in discussions about each bacteria, how to manage infections, and implications for public health. They also highlight the similarities and differences among the many different types of infections.

This section also includes information about what groups such as states, communities, doctors, nurses, patients, and CDC can do to combat antibiotic resistance. Preventing the spread of antibiotic resistance can only be achieved with widespread engagement, especially among leaders in clinical medicine, healthcare leadership, agriculture, and public health. Although some people are at greater risk than others, no one can completely avoid

the risk of antibiotic-resistant infections. Only through concerted commitment and action will the nation ever be able to succeed in reducing this threat.

A reference section provides technical information, a glossary, and additional resources.

Any comments and suggestions that would improve the usefulness of future publications are appreciated and should be sent to Director, Division of Healthcare Quality Promotion, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, 1600 Clifton Road, Mailstop A-07, Atlanta, Georgia, 30333. E-mail can also be used: hip@cdc.gov.

CAMPYLOBACTER

THE THREAT OF ANTIBIOTIC RESISTANCE

Introduction

Antibiotic resistance is a worldwide problem. New forms of antibiotic resistance can cross international boundaries and spread between continents with ease. Many forms of resistance spread with remarkable speed. World health leaders have described antibiotic-resistant microorganisms as "nightmare bacteria" that "pose a catastrophic threat" to people in every country in the world.

Each year in the United States, at least 2 million people acquire serious infections with bacteria that are resistant to one or more of the antibiotics designed to treat those infections. At least 23,000 people die each year as a direct result of these antibiotic-resistant infections. Many more die from other conditions that were complicated by an antibiotic-resistant infection.

In addition, almost 250,000 people each year require hospital care for *Clostridium difficile (C. difficile)* infections. In most of these infections, the use of antibiotics was a major contributing factor leading to the illness. At least 14,000 people die each year in the United States from *C. difficile* infections. Many of these infections could have been prevented.

Antibiotic-resistant infections add considerable and avoidable costs to the already overburdened U.S. healthcare system. In most cases, antibiotic-resistant infections require prolonged and/or costlier treatments, extend hospital stays, necessitate additional doctor visits and healthcare use, and result in greater disability and death compared with infections that are easily treatable with antibiotics. The total economic cost of antibiotic resistance to the U.S. economy has been difficult to calculate. Estimates vary but have ranged as high as $20 billion in excess direct healthcare costs, with additional costs to society for lost productivity as high as $35 billion a year (2008 dollars).[1]

The use of antibiotics is the single most important factor leading to antibiotic resistance around the world. Antibiotics are among the most commonly prescribed drugs used in human medicine. However, up to 50% of all the antibiotics prescribed for people are not needed or are not optimally effective as prescribed. Antibiotics are also commonly used in food animals to prevent, control, and treat disease, and to promote the growth of food-producing animals. The use of antibiotics for promoting growth is not necessary, and the practice should be phased out. Recent guidance from the U.S. Food and Drug Administration (FDA) describes a pathway toward this goal.[2] It is difficult to directly compare the amount of drugs used in food animals with the amount used in humans, but there is evidence that more antibiotics are used in food production.

---

1 http://www.tufts.edu/med/apua/consumers/personal_home_5_1451036133.pdf (accessed 8-5-2013); extrapolated from Roberts RR, Hota B, Ahmad I, et al. Hospital and societal costs of antimicrobial-resistant infections in a Chicago teaching hospital: implications for antibiotic stewardship. Clin Infect Dis. 2009 Oct 15;49(8):1175-84

2 http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM299624.pdf

The other major factor in the growth of antibiotic resistance is spread of the resistant strains of bacteria from person to person, or from the non-human sources in the environment, including food.

There are four core actions that will help fight these deadly infections:

- preventing infections and preventing the spread of resistance
- tracking resistant bacteria
- improving the use of today's antibiotics
- promoting the development of new antibiotics and developing new diagnostic tests for resistant bacteria

Bacteria will inevitably find ways of resisting the antibiotics we develop, which is why aggressive action is needed now to keep new resistance from developing and to prevent the resistance that already exists from spreading.

NATIONAL SUMMARY DATA

Estimated minimum number of illnesses and deaths caused by antibiotic resistance*:

At least **2,049,442** illnesses,

23,000 deaths

**bacteria and fungus included in this report*

+

Estimated minimum number of illnesses and death due to *Clostridium difficile* (*C. difficile*), a unique bacterial infection that, although not significantly resistant to the drugs used to treat it, is directly related to antibiotic use and resistance:

At least **250,000** illnesses,

14,000 deaths

WHERE DO INFECTIONS HAPPEN?

Antibiotic-resistant infections can happen anywhere. Data show that most happen in the general community; however, most deaths related to antibiotic resistance happen in healthcare settings, such as hospitals and nursing homes.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

CS239559

How Antibiotic Resistance Happens

1. Lots of germs. A few are drug resistant.

2. Antibiotics kill bacteria causing the illness, as well as good bacteria protecting the body from infection.

3. The drug-resistant bacteria are now allowed to grow and take over.

4. Some bacteria give their drug-resistance to other bacteria, causing more problems.

Examples of How Antibiotic Resistance Spreads

Animals get antibiotics and develop resistant bacteria in their guts.

George gets antibiotics and develops resistant bacteria in his gut.

Drug-resistant bacteria can remain on meat from animals. When not handled or cooked properly, the bacteria can spread to humans.

George stays at home and in the general community. Spreads resistant bacteria.

George gets care at a hospital, nursing home or other inpatient care facility.

Fertilizer or water containing animal feces and drug-resistant bacteria is used on food crops.

Resistant germs spread directly to other patients or indirectly on unclean hands of healthcare providers.

Healthcare Facility

Vegetable Farm

Drug-resistant bacteria in the animal feces can remain on crops and be eaten. These bacteria can remain in the human gut.

Patients go home.

Resistant bacteria spread to other patients from surfaces within the healthcare facility.

Simply using antibiotics creates resistance. These drugs should only be used to treat infections.

CS239559

Minimum Estimates of Morbidity and Mortality from Antibiotic-Resistant Infections*

Antibiotic-Resistant Microorganism	Infections Included in Case/Death Estimates	Infections Not Included	Estimated Annual Number of Cases	Estimated Annual Number of Deaths
Carbapenem-resistant Enterobacteriaceae (CRE)	Healthcare-associated Infections (HAIs) caused by *Klebsiella* and *E. coli* with onset in hospitalized patients	Infections occurring outside of acute care hospitals (e.g., nursing homes) Infections acquired in acute care hospitals but not diagnosed until after discharge Infections caused by Enterobacteriaceae other than *Klebsiella* and *E. coli* (e.g., *Enterobacter spp.*)	9,300	610
Drug-resistant *Neisseria gonorrhoeae* (any drug)	All infections	Not applicable	246,000	<5
Multidrug-resistant *Acinetobacter* (three or more drug classes)	HAIs with onset in hospitalized patients	Infections occurring outside of acute care hospitals (e.g., nursing homes) Infections acquired in acute care hospitals but not diagnosed until after discharge	7,300	500
Drug-resistant *Campylobacter* (azithromycin or ciprofloxacin)	All infections	Not applicable	310,000	28
Drug-resistant *Candida* (fluconazole)	HAIs with onset in hospitalized patients	Infections occurring outside of acute care hospitals (e.g., nursing homes) Infections acquired in acute care hospitals but not diagnosed until after discharge	3,400	220
Extended-spectrum β-lactamase producing Enterobacteriaceae (ESBLs)	HAIs caused by *Klebsiella* and *E. coli* with onset in hospitalized patients	Infections occurring outside of acute care hospitals (e.g., nursing homes) Infections acquired in acute care hospitals but not diagnosed until after discharge Infections caused by Enterobacteriaceae other than *Klebsiella* and *E. coli* (e.g., Enterobacter *spp.*)	26,000	1,700

Antibiotic-Resistant Microorganism	Infections Included in Case/Death Estimates	Infections Not Included	Estimated Annual Number of Cases	Estimated Annual Number of Deaths
Vancomycin-resistant *Enterococcus* (VRE)	HAIs with onset in hospitalized patients	Infections occurring outside of acute care hospitals (e.g., nursing homes) Infections acquired in acute care hospitals but not diagnosed until after discharge	20,000	1,300
Multidrug-resistant *Pseudomonas aeruginosa* (three or more drug classes)	HAIs with onset in hospitalized patients	Infections occurring outside of acute care hospitals (e.g., nursing homes) Infections acquired in acute care hospitals but not diagnosed until after discharge	6,700	440
Drug-resistant non-typhoidal *Salmonella* (ceftriaxone, ciprofloxacin†, or 5 or more drug classes)	All infections	Not applicable	100,000	40
Drug-resistant *Salmonella* Typhi (ciprofloxacin†)	All infections	Not applicable	3,800	<5
Drug-resistant *Shigella* (azithromycin or ciprofloxacin)	All infections	Not applicable	27,000	<5
Methicillin-resistant *Staphylococcus aureus* (MRSA)	Invasive infections	Both healthcare and community-associated non-invasive infections such as wound and skin and soft tissue infections	80,000	11,000
***Streptococcus pneumoniae* (full resistance to clinically relevant drugs)**	All infections	Not applicable	1,200,000	7,000

Antibiotic-Resistant Microorganism	Infections Included in Case/Death Estimates	Infections Not Included	Estimated Annual Number of Cases	Estimated Annual Number of Deaths
Drug-resistant tuberculosis (any clinically relevant drug)	All infections	Not applicable	1,042	50
Vancomycin-resistant *Staphylococcus aureus* (VRSA)	All infections	Not applicable	<5	<5
Erythromycin-resistant Group A *Streptococcus*	Invasive infections	Non-invasive infections including common upper-respiratory infections like strep throat	1,300	160
Clindamycin-resistant Group B *Streptococcus*	Invasive infections	Non-invasive infections and asymptomatic intrapartum colonization requiring prophylaxis	7,600	440
Summary Totals for Antibiotic-Resistant Infections			2,049,442	23,488
***Clostridium difficile* Infections**	Healthcare-associated infections in acute care hospitals or in patients requiring hospitalization	Infections occurring outside of acute care hospitals (e.g., nursing homes, community) Infections acquired in acute care hospitals but not diagnosed until after discharge	250,000	14,000

*See technical appendix for discussion of estimation methods.

†Resistance or partial resistance

Limitations of Estimating the Burden of Disease Associated with Antibiotic-Resistant Bacteria

This report uses several methods, described in the technical appendix, to estimate the number of cases of disease caused by antibiotic-resistant bacteria and fungi and the number of deaths resulting from those cases of disease. The data presented in this report are approximations, and totals, as provided in the national summary tables, can provide only a rough estimate of the true burden of illness. Greater precision is not possible at this time for a number of reasons:

- Precise criteria exist for determining the resistance of a particular species of bacteria to a specific antibiotic. However, for many species of bacteria, there are no standard definitions that allow for neatly dividing most species into only two categories—resistant vs. susceptible without regard to a specific antibiotic. This report specifies how resistance is defined for each microorganism.
- There are very specific criteria and algorithms for the attribution of deaths to specific causes that are used for reporting vital statistics data. In general, there are no similar criteria for making clinical determinations of when someone's death is primarily attributable to infection with antibiotic-resistant bacteria, as opposed to other co-existing illnesses that may have contributed to or caused death. Many studies attempting to determine attributable mortality rely on the judgment of chart reviewers, as is the case for many surveillance systems. Thus, the distinction between an antibiotic-resistant infection leading directly to death, an antibiotic-resistant infection contributing to a death, and an antibiotic-resistant infection related to, but not directly contributing to a death are usually determined subjectively, especially in the preponderance of cases where patients are hospitalized and have complicated clinical presentations.

In addition, the estimates provided in this report represent an underestimate of the total burden of bacterial resistant disease.

- The methodology employed in this report likely underestimates, at least for some pathogens, the impact of antibiotic resistance on mortality. As described in the technical appendix, the percentage of resistant isolates for some bacteria was multiplied by the total number of cases or the number of deaths ascribed to that bacterium. A number of studies have shown that the risk of death following infection with a strain of resistant bacteria is greater than that following infection with a susceptible strain of the same bacteria. More accurate data for all bacteria would be necessary to estimate the extent of the differential risk for death associated with a resistant infection vs. the risk of death associated with a susceptible infection. But, lacking that data, the lower, more conservative estimate has been used. That estimate is the approximation of the number of deaths derived by applying the proportion of resistant isolates to the estimated total number of deaths caused by that pathogen.

- For several pathogens, complete data from all types of infections are not available since tracking is limited to the more severe types of infections. For some pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA), only cases due to invasive disease are counted. For other pathogens, where resistance is predominately limited to healthcare settings, only disease occurring in acute care hospitals, or requiring hospitalization, are counted.

The actual number of infections and the actual number of deaths, therefore, are certainly higher than the numbers provided in this report.

This report does not provide a specific estimate for the financial cost of antibiotic-resistant infections. Although a variety of studies have attempted to estimate costs in limited settings, such as a single hospital or group of hospitals, the methods used are quite variable. Similarly, careful work has been done to estimate costs for specific pathogens, such as *Streptococcus pneumoniae* and MRSA. However, no consensus methodology currently exists for making such monetary estimates for many of the other pathogens listed in this report. For this reason, this report references non-CDC estimates in the introduction, but does not attempt to estimate the overall financial burden of antibiotic resistance to the United States.

Assessment of Domestic Antibiotic Resistance Threats

CDC conducted an assessment of antibiotic resistance threats, categorizing the threat level of each bacteria as urgent, serious, or concerning. The assessment was done in consultation with non-governmental experts in antibiotic resistance who serve on the Antimicrobial Resistance Working Group of the CDC Office of Infectious Diseases Board of Scientific Counselors (http://www.cdc.gov/oid/BSC.html). CDC also received input and recommendations from the National Institutes of Health (NIH) and the U.S. Food and Drug Administration (FDA). Threats were assessed according to seven factors associated with resistant infections:

- clinical impact
- economic impact
- incidence
- 10-year projection of incidence
- transmissibility
- availability of effective antibiotics
- barriers to prevention

The assessment was focused on domestic impact, but the threat of importing international antibiotic-resistant pathogens was taken into account in the 10-year incidence projection. Because antibiotic resistance is a rapidly evolving problem, this assessment will be revised at least every five years. Examples of findings that could result in a change in threat status are:

- Multidrug-resistant and extensively drug-resistant tuberculosis (MDR and XDR TB) infections are an increasing threat outside of the United States. In the United States, infections are uncommon because a robust prevention and control program is in place. If infection rates of MDR and XDR TB increase within the U.S., this antibiotic-resistant threat will change from serious to urgent, because it is transmissible through respiratory secretions, and because treatment options are very limited.
- MRSA infections can be very serious and the number of infections is among the highest of all antibiotic-resistant threats. However, the number of serious infections is decreasing and there are multiple effective antibiotics for treating infections. If MRSA infection rates increase or MRSA strains become more resistant to other antibiotic agents, then MRSA may change from a serious to an urgent threat.
- *Streptococcus pneumoniae* (pneumococcus) can cause serious and sometimes life-threatening infections. Antibiotic resistance significantly affects the ability to manage these infections. A new version of the pneumococcal conjugate vaccine (PCV13), introduced in 2010, protects against infections with the most resistant pneumococcus strains and rates of resistant infections are declining. The extent to which this trend will continue is unknown, but a significant and sustainable drop in resistant infection rates could result in this threat being recategorized as concerning.

In general, threats assigned to the urgent and serious categories require more monitoring and prevention activities, whereas the threats in the concerning category require less. Regardless of category, threat-specific CDC activities are tailored to meet the epidemiology of the infectious agent and to address any gaps in the ability to detect resistance and to protect against infections.

HAZARD LEVEL
URGENT

These are high-consequence antibiotic-resistant threats because of significant risks identified across several criteria. These threats may not be currently widespread but have the potential to become so and require urgent public health attention to identify infections and to limit transmission.

Clostridium difficile (C. difficile), Carbapenem-resistant Enterobacteriaceae (CRE), Drug-resistant *Neisseria gonorrhoeae* (cephalosporin resistance)

HAZARD LEVEL
SERIOUS

These are significant antibiotic-resistant threats. For varying reasons (e.g., low or declining domestic incidence or reasonable availability of therapeutic agents), they are not considered urgent, but these threats will worsen and may become urgent without ongoing public health monitoring and prevention activities.

Multidrug-resistant *Acinetobacter,* Drug-resistant *Campylobacter,* Fluconazole-resistant *Candida* (a fungus), Extended spectrum β-lactamase producing Enterobacteriaceae (ESBLs), Vancomycin-resistant *Enterococcus* (VRE), Multidrug-resistant *Pseudomonas aeruginosa,* Drug-resistant Non-typhoidal *Salmonella,* Drug-resistant *Salmonella* Typhi, Drug-resistant *Shigella,* Methicillin-resistant *Staphylococcus aureus* (MRSA), Drug-resistant *Streptococcus pneumonia,* Drug-resistant tuberculosis (MDR and XDR)

HAZARD LEVEL
CONCERNING

These are bacteria for which the threat of antibiotic resistance is low, and/or there are multiple therapeutic options for resistant infections. These bacterial pathogens cause severe illness. Threats in this category require monitoring and in some cases rapid incident or outbreak response.

Vancomycin-resistant *Staphylococcus aureus* (VRSA), Erythromycin-resistant *Streptococcus* Group A, Clindamycin-resistant *Streptococcus* Group B

Although *C. difficile* is not currently significantly resistant to antibiotics used to treat it, it was included in the threat assessment because of its unique relationship with resistance issues, antibiotic use, and its high morbidity and mortality.

Running Out of Drugs to Treat Serious Gram-Negative Infections

Among all of the bacterial resistance problems, gram-negative pathogens are particularly worrisome, because they are becoming resistant to nearly all drugs that would be considered for treatment. This is true as well, but not to the same extent, for some of the gram-positive infections (e.g., *Staphylococcus* and *Enterococcus)*. The most serious gram-negative infections are healthcare-associated, and the most common pathogens are Enterobacteriaceae, *Pseudomonas aeruginosa,* and *Acinetobacter*. Treating infections of either pan-resistant or nearly pan-resistant gram-negative microorganisms is an increasingly common challenge in many hospitals. The table below describes the drug classes used to treat these infections and a description of important drug resistance and other limitations. The classes are in order of most likely to be used to less likely to be used.

Drug Class	Important Characteristics	Resistance and Other Limitations
β-lactams	A large class of broad-spectrum drugs that are the main treatment for gram-negative infections. The subclasses are listed below and are presented in an order from narrow-spectrum (penicillins) to broad-spectrum (carbapenem) β-lactam drugs.	Gram-negative bacteria have developed several pathways to β-lactam resistance. Perhaps the most concerning are β-lactamases, enzymes that destroy the β-lactam antibiotics. Some β-lactamases destroy narrow spectrum drugs (e.g., only active against penicillins) while newer β-lactamases (e.g. carbapenemases found in carbapenem-resistant Enterobacteriaceae or CRE) are active against all β-lactam antibiotics.
β-lactam subclass:		
Penicillin, aminopenicillins, and early generation cephalosporins	Among the first antibiotics developed for treatment of bacterial infections. In the absence of resistance, these drugs are active against a broad range of bacterial pathogens.	Resistance among gram-negative bacteria is widespread. These drugs are rarely recommended as treatment for serious gram-negative infections.
β-lactamase inhibitor combinations	These drugs are still active against gram-negative bacteria that have β-lactamases with limited activity for destroying β-lactam antibiotics.	These drugs are important for treatment of serious gram- negative infections but resistance is increasing. Bacteria that are resistant to extended-spectrum cephalosporins and carbapenems are usually resistant to these drugs as well. New β-lactamase inhibitor combination drugs in development have the potential to overcome some, but not all, of resistance from the most potent β-lactamases such as those found in CRE.
Extended-spectrum Cephalosporins	These drugs have been a cornerstone for treatment of serious gram-negative infections for the past 20 years.	Resistant gram-negative infections first emerged in healthcare settings but now are also spreading in the community. When resistance occurs, a carbapenem is the only remaining β-lactam agent.

Drug Class	Important Characteristics	Resistance and Other Limitations
Carbapenems	A broad-spectrum β-lactam antibiotic that is considered the last resort for treatment of serious gram-negative infections.	CRE infections are spreading in healthcare facilities throughout the United States and the world. It is reasonable to expect that this resistance will expand to bacteria that circulate in the community, as witnessed by extended-spectrum β-lactamase producing bacteria. Carbapenem resistance can also be found among other gram-negative bacteria including *Pseudomonas* and *Acinetobacter spp*. Once bacteria become resistant to carbapenems, they are usually resistant to all β-lactams.
Fluoroquinolones	These are broad-spectrum antibiotics that are often given orally, making them convenient to use in both inpatients and outpatients.	Resistant bacteria develop quickly with increased use in a patient population. Increased use is also associated with an increase in infections caused by fluoroquinolone-resistant, hyper-virulent strains of *Clostridium difficile*.
Aminoglycosides	These drugs are often used in combination with β-lactam drugs for the treatment of serious gram-negative infections.	Despite growing resistance problems, these drugs continue to be an important therapeutic option. However, clinicians rarely use these drugs alone because of concerns with resistance and side effects.
Tetracyclines & Glycyclines	Tetracyclines are not a first-line treatment option for serious gram negative infections; however, with increasing resistance to other drug classes, tetracyclines are considered as a treatment option. Glycyclines (i.e., tigecycline) are often considered for treatment of multidrug-resistant gram-negative infections.	Tigecycline is a drug that does not distribute evenly in the body, so it is often used in combination with other drugs depending upon the site of infection. Resistance to tigecycline has emerged but it is still relatively uncommon.
Polymyxins	These drugs are an older class that fell out of favor because of toxicity concerns. Now they are often used as a "last resort" agent for treatment of multidrug-resistant gram-negative infections.	Because these are generic drugs, there are limited contemporary data on proper dosing. In addition, resistance is emerging, but there are limited data guiding the accurate detection of resistance in hospital labs. As a result, use of these drugs present significant challenges for clinicians. In the absence of a drug sponsor, FDA and NIH are funding studies to fill these critical information gaps.

People at Especially High Risk

As antibiotic resistance grows, the antibiotics used to treat infections do not work as well or at all. The loss of effective antibiotic treatments will not only cripple the ability to fight routine infectious diseases but will also undermine treatment of infectious complications in patients with other diseases. Many of the advances in medical treatment—joint replacements, organ transplants, cancer therapy, and treatment of chronic diseases such as diabetes, asthma, rheumatoid arthritis—are dependent on the ability to fight infections with antibiotics. If that ability is lost, the ability to safely offer people many life-saving and life-improving modern medical advantages will be lost with it. For example:

CANCER CHEMOTHERAPY

People receiving chemotherapy are often at risk for developing an infection when their white blood cell count is low. For these patients, any infection can quickly become serious and effective antibiotics are critical for protecting the patient from severe complications or death.

COMPLEX SURGERY

Patients who receive cardiac bypass, joint replacements, and other complex surgeries are at risk of a surgical site infection (SSI). These infections can make recovery from surgery more difficult because they can cause additional illness, stress, cost, and even death. For some, but not all surgeries, antibiotics are given before surgery to help prevent infections.

RHEUMATOID ARTHRITIS

Inflammatory arthritis affects the immune system, which controls how well the body fights off infections. People with certain types of arthritis have a higher risk of getting infections. Also, many medications given to treat inflammatory arthritis can weaken the immune system. Effective antibiotics help ensure that arthritis patients can continue to receive treatment.

DIALYSIS FOR END-STAGE RENAL DISEASE

Patients who undergo dialysis treatment have an increased risk for getting a bloodstream infection. In fact, bloodstream infections are the second leading cause of death in dialysis patients. Infections also complicate heart disease, the leading cause of death in diaysis patients. Infection risk is higher in these patients because they have weakened immune systems and often require catheters or needles to enter their bloodstream. Effective antibiotics help ensure that dialysis patients can continue to receive life-saving treatment.

ORGAN AND BONE MARROW TRANSPLANTS

Transplant recipients are more vulnerable to infections. Because a patient undergoes complex surgery and receives medicine to weaken the immune system for a year or more, the risk of infection is high. It is estimated that 1% of organs transplanted in the United States each year carry a disease that comes from the donor—either an infection or cancer. Effective antibiotics help ensure that organ transplants remain possible.

Antibiotic Safety

ANTIBIOTICS ARE RESPONSIBLE FOR ALMOST

1 OUT OF 5

EMERGENCY DEPARTMENT VISITS FOR ADVERSE DRUG EVENTS

ANTIBIOTICS ARE THE **MOST COMMON CAUSE OF EMERGENCY DEPARTMENT VISITS** FOR ADVERSE DRUG EVENTS **IN CHILDREN UNDER 18 YEARS OF AGE.**

- Antibiotics are powerful drugs that are generally safe and very helpful in fighting disease, but there are times when antibiotics can actually be harmful.
- Antibiotics can have side effects, including allergic reactions and a potentially deadly diarrhea caused by the bacteria *Clostridium difficile (C. difficile)*. Antibiotics can also interfere with the action of other drugs a patient may be taking for another condition. These unintended reactions to antibiotics are called adverse drug events.
- When someone takes an antibiotic that they do not need, they are needlessly exposed to the side effects of the drug and do not get any benefit from it.
- Moreover, taking an antibiotic when it is not needed can lead to the development of antibiotic resistance. When resistance develops, antibiotics may not be able to stop future infections. Every time someone takes an antibiotic they don't need, they increase their risk of developing a resistant infection in the future.

Types of Adverse Drug Events Related to Antibiotics

Allergic Reactions

Every year, there are more than 140,000 emergency department visits for reactions to antibiotics. Almost four out of five (79%) emergency department visits for antibiotic-related adverse drug events are due to an allergic reaction. These reactions can range from mild rashes and itching to serious blistering skin reactions swelling of the face and throat, and breathing problems. Minimizing unnecessary antibiotic use is the best way to reduce the risk of adverse drug events from antibiotics. Patients should tell their doctors about any past drug reactions or allergies.

C. difficile

C. difficile causes diarrhea linked to at least 14,000 American deaths each year. When a person takes antibiotics, good bacteria that protect against infection are destroyed for several months. During this time, patients can get sick from *C. difficile* picked up from contaminated surfaces or spread from a healthcare provider's hands. Those most at risk are people, especially older adults, who take antibiotics and also get medical care. Take antibiotics exactly and only as prescribed.

Drug Interactions and Side Effects

Antibiotics can interact with other drugs patients take, making those drugs or the antibiotics less effective. Some drug combinations can worsen the side effects of the antibiotic or other drug. Common side effects of antibiotics include nausea, diarrhea, and stomach pain. Sometimes these symptoms can lead to dehydration and other problems. Patients should ask their doctors about drug interactions and the potential side effects of antibiotics. The doctor should be told immediately if a patient has any side effects from antibiotics.

GAPS IN KNOWLEDGE OF ANTIBIOTIC RESISTANCE

LIMITED NATIONAL, STATE, AND FEDERAL CAPACITY TO DETECT AND RESPOND TO URGENT AND EMERGING ANTIBIOTIC RESISTANCE THREATS

Even for critical pathogens of concern like carbapenem-resistant Enterobacteriaceae (CRE) and *Neisseria gonorrhoeae,* we do not have a complete picture of the domestic incidence, prevalence, mortality, and cost of resistance.

CURRENTLY, THERE IS NO SYSTEMATIC INTERNATIONAL SURVEILLANCE OF ANTIBIOTIC RESISTANCE THREATS

Today, the international identification of antibiotic resistance threats occurs through domestic importation of novel antibiotic resistance threats or through identification of overseas outbreaks.

DATA ON ANTIBIOTIC USE IN HUMAN HEALTHCARE AND IN AGRICULTURE ARE NOT SYSTEMATICALLY COLLECTED

Routine systems of reporting and benchmarking antibiotic use wherever it occurs need to be piloted and scaled nationwide.

PROGRAMS TO IMPROVE ANTIBIOTIC PRESCRIBING ARE NOT WIDELY USED IN THE UNITED STATES

These inpatient and outpatient programs hold great promise for reducing antibiotic resistance threats, improving patient outcomes, and saving healthcare dollars.

ADVANCED TECHNOLOGIES CAN IDENTIFY THREATS MUCH FASTER THAN CURRENT PRACTICE

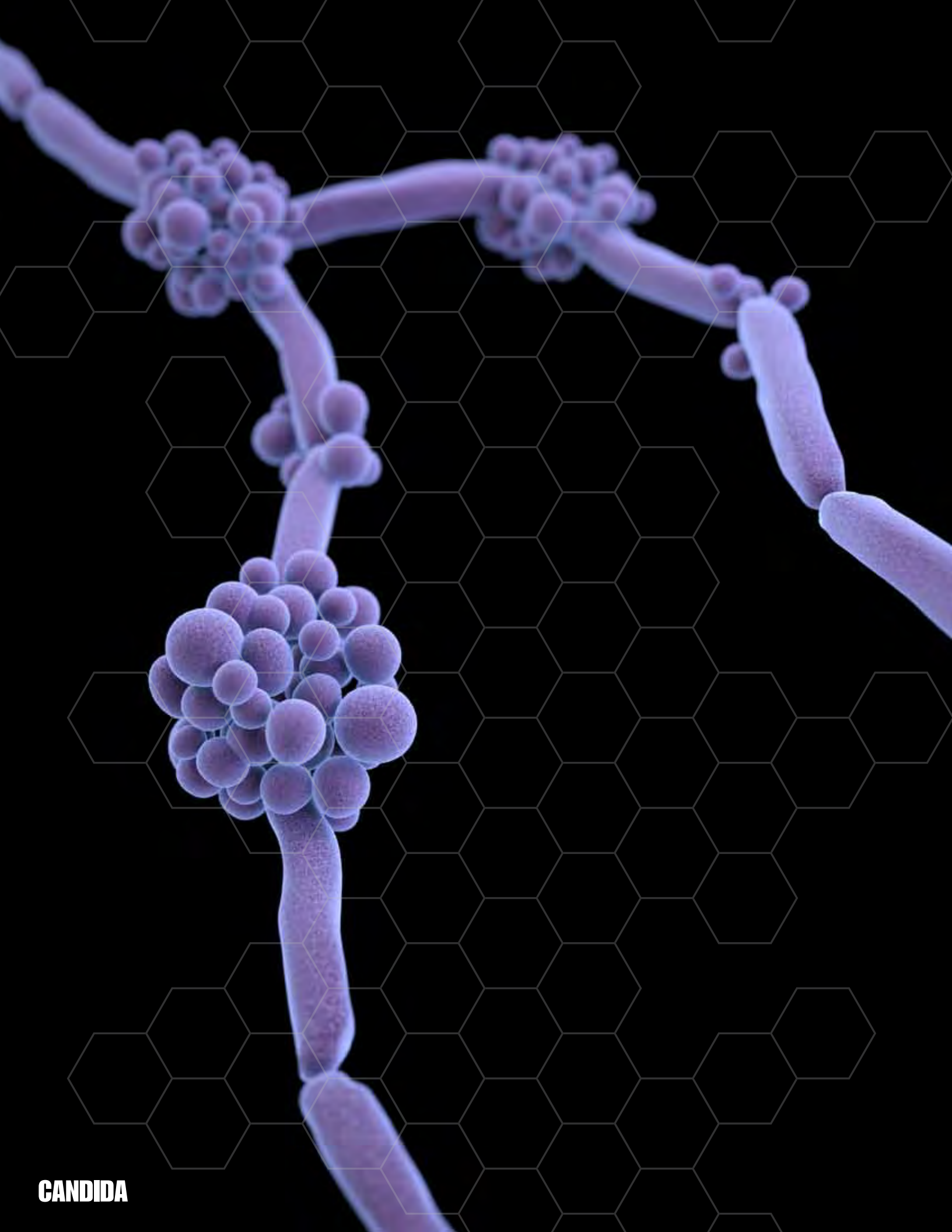
Advanced molecular detection (AMD) technologies, which can identify AR threats much faster than current practice, are not being used as widely as necessary in the United States.

Developing Resistance

Timeline of Key Antibiotic Resistance Events

Dates are based upon early reports of resistance in the literature. In the case of pan drug-resistant (PDR)-*Acinetobacter* and *Pseudomonas,* the date is based upon reports of healthcare transmission or outbreaks. Note: penicillin was in limited use prior to widespread population usage in 1943.

ANTIBIOTIC RESISTANCE INDENTIFIED		ANTIBIOTIC INTRODUCED	
penicillin-R *Staphylococcus*	1940		
		1943	penicillin
		1950	tetracycline
		1953	erythromycin
tetracycline-R *Shigella*	1959		
		1960	methicillin
methicillin-R *Staphylococcus*	1962		
penicillin-R pneumococcus	1965		
erythromycin-R *Streptococcus*	1968	1967	gentamicin
		1972	vancomycin
gentamicin-R *Enterococcus*	1979		
		1985	imipenem and ceftazidime
ceftazidime-R Enterobacteriaceae	1987		
vancomycin-R *Enterococcus*	1988		
levofloxacin-R pneumococcus	1996	1996	levofloxacin
imipenem-R Enterobacteriaceae	1998		
XDR tuberculosis	2000	2000	linezolid
linezolid-R *Staphylococcus*	2001		
vancomycin-R *Staphylococcus*	2002		
PDR-*Acinetobacter and Pseudomonas*	2004/5	2003	daptomycin
ceftriaxone-R *Neisseria gonorrhoeae* PDR-Enterobacteriaceae	2009	2010	ceftaroline
ceftaroline-R *Staphylococcus*	2011		

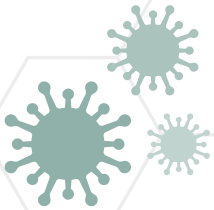


CANDIDA

FIGHTING BACK AGAINST ANTIBIOTIC RESISTANCE

Four Core Actions to Prevent Antibiotic Resistance

1 PREVENTING INFECTIONS, PREVENTING THE SPREAD OF RESISTANCE



Avoiding infections in the first place reduces the amount of antibiotics that have to be used and reduces the likelihood that resistance will develop during therapy. There are many ways that drug-resistant infections can be prevented: immunization, safe food preparation, handwashing, and using antibiotics as directed and only when necessary. In addition, preventing infections also prevents the spread of resistant bacteria.

2 TRACKING

CDC gathers data on antibiotic-resistant infections, causes of infections and whether there are particular reasons (risk factors) that caused some people to get a resistant infection. With that information, experts can develop specific strategies to prevent those infections and prevent the resistant bacteria from spreading.

3 IMPROVING ANTIBIOTIC PRESCRIBING/STEWARDSHIP

Perhaps the single most important action needed to greatly slow down the development and spread of antibiotic-resistant infections is to change the way antibiotics are used. Up to half of antibiotic use in humans and much of antibiotic use in animals is unnecessary and inappropriate and makes everyone less safe. Stopping even some of the inappropriate and unnecessary use of antibiotics in people and animals would help greatly in slowing down the spread of resistant bacteria. This commitment to always use antibiotics appropriately and safely—only when they are needed to treat disease, and to choose the right antibiotics and to administer them in the right way in every case—is known as antibiotic stewardship.

4 DEVELOPING NEW DRUGS AND DIAGNOSTIC TESTS

Because antibiotic resistance occurs as part of a natural process in which bacteria evolve, it can be slowed but not stopped. Therefore, we will always need new antibiotics to keep up with resistant bacteria as well as new diagnostic tests to track the development of resistance.

1. PREVENTING INFECTIONS, PREVENTING THE SPREAD OF RESISTANCE

FOUR CORE ACTIONS

PREVENTING INFECTIONS, PREVENTING SPREAD.

TRACKING RESISTANCE PATTERNS.

IMPROVING USE OF ANTIBIOTICS.

DEVELOPING NEW ANTIBIOTICS AND DIAGNOSTIC TESTS.

Preventing infections from developing reduces the amount of antibiotics used. This reduction in antibiotic use, in turn, slows the pace of antibiotic resistance. Preventing infections also prevents the spread of resistant bacteria. Antibiotic-resistant infections can be prevented in many ways. This section focuses on CDC's works to prevent antibiotic-resistant infections in healthcare settings, in the community, and in food.

CDC's Work to Prevent Infections and Antibiotic Resistance in Healthcare Settings

Antibiotic resistance in healthcare settings is a significant threat to public health. Because almost all Americans will receive care in a medical setting at some point, the problem can affect anyone. In addition, many times, patients in medical settings such as hospitals and long-term care facilities (e.g., skilled nursing facilities and nursing homes) are already vulnerable due to weak immune systems and underlying illness. For these patients, contracting an antibiotic-resistant infection is especially dangerous. By preventing antibiotic resistance in healthcare settings, patients' lives are better protected and their health can be better preserved. In addition, healthcare facilities, systems, insurers and patients can save dollars that otherwise would have been spent on more complex care and medications needed to manage antibiotic-resistant infections.

CDC works to prevent antibiotic resistance in healthcare settings by providing a system to track resistance and prescribing patterns at national, regional, and local levels; providing guidance to healthcare facilities interested in better antibiotic use; and working to prevent all patient infections through infection control guidelines, assistance implementing these guidelines, and laboratory expertise. Here are some examples of how CDC is working to prevent antibiotic resistance in healthcare settings:

Tracking

CDC's National Healthcare Safety Network (NHSN) is used by healthcare facilities to electronically report infections, antibiotic use, and resistance. Data currently submitted by hospitals to NHSN allow facilities, states, and regions the ability to track and benchmark antibiotic resistance in bacteria responsible for many healthcare-associated infections. As more hospitals submit data to the new NHSN Antibiotic Use and Resistance Module, they will be able to track and benchmark antibiotic resistance in all bacteria, as well as track antibiotic usage. This information will allow facilities to target areas of concern, to make needed improvements and to track the success of their efforts. In addition, NHSN allows CDC to perform and report national assessments of antibiotic resistance.

CDC's specialized, national reference laboratory tests bacteria samples from around the country to detect new and emerging resistance patterns that affect patient health. This

reference testing also provides an early warning of new resistance that has the potential to spread across the nation and that requires public health action.

Additionally, CDC recently conducted a survey in collaboration with its Emerging Infections Program to estimate the number of healthcare-associated infections and to better understand antibiotic use among inpatients in U.S. hospitals. The survey found that antibiotic use was frequent, that most antibiotic use was for treating active infections, and that vancomycin was the most commonly used antibiotic overall. Formal results are due to be published in late 2013 and 2014. CDC plans to conduct a repeat survey in 2014 that will include assessments of appropriate antibiotic prescribing.

Improving Antibiotic Prescribing

CDC manages the Get Smart program, a national campaign to improve antibiotic prescribing and use in both outpatient and inpatient settings. The program supports a variety of state-based programs modeled on the national effort. Each November, CDC publicizes its annual Get Smart About Antibiotics Week to raise awareness among patients, healthcare providers, hospital administrators, and policy makers about the threat of antibiotic resistance and the need to decrease inappropriate antibiotic use. CDC provides public health messages and resources for improving antibiotic use in healthcare settings and is now working with a variety of partners to improve the use of antibiotics in healthcare settings. One core activity is the development and implementation of the Antibiotic Stewardship Drivers and Change Package, a tool that provides healthcare facilities with a menu of interventions they can select from to improve antibiotic use. CDC developed and tested this tool with the Institute for Healthcare Improvement. Additional information about Get Smart About Antibiotics Week activities and messages can be found on CDC's website: http://www.cdc.gov/getsmart/. The Drivers and Change Package can be found at http://www.cdc.gov/getsmart/healthcare/improve-efforts/driver-diagram/index.html.

Protecting Patients from Infections

Preventing infections negates the need for antibiotic use in the first place, and scientific evidence shows that reducing antibiotic use in a single facility can reduce resistance in that facility. Taken on a national scale, infection prevention efforts can significantly decrease resistance. To help prevent infections, CDC conducts research to find new ways of preventing infections; provides the nation with infection prevention guidelines and tools to prevent infections; serves as the nation's reference laboratory to identify microorganisms; and offers the nation's largest healthcare-associated infection tracking system, NHSN, allowing facilities and states to identify and address problem areas.

CDC's Work to Prevent Antibiotic Resistance in the Community

Antibiotic-resistant infections outside of the hospital setting were rare until recently. Today, resistant infections that can be transmitted in the community include tuberculosis and respiratory infections caused by *Streptococcus pneumoniae*, skin infections caused by methicillin-resistant *Staphylococcus aureus,* and sexually transmitted infections such as gonorrhea.

CDC works to prevent antibiotic resistance in the community by providing systems to track infections and changes in resistance; improving prescribing at national, regional, and local levels; and limiting or interrupting the spread of infections. These activities are similar to the strategies used in medical settings, but the approach can differ because the population (potentially everyone) is large and the settings are different. Here are some examples of the strategies CDC uses to prevent antibiotic resistance in communities:

Tracking Community Infections and Resistance

These programs are examples of CDC's effort to identify critical infections in the community and monitor resistance trends.

- **Active Bacterial Core surveillance (ABCs):** Tracking infections caused by *Neisseria meningitidis, Streptococcus pneumoniae,* Groups A and B *Streptococcus,* and methicillin-resistant *Staphylococcus aureus*
- **Gonococcal Isolate Surveillance Project (GISP):** Collecting isolates from gonorrhea infections to monitor antibiotic resistance
- **National Tuberculosis Surveillance System (NTSS):** National Electronic Disease Surveillance System (NEDSS)-based reporting of tuberculosis cases including resistance data
- **Healthcare-Associated Infections-Community Interface (HAIC):** Tracking infections with *C. difficile* and with multidrug-resistant gram-negative microorganisms.

Improving Antibiotic Prescribing

Prescribing antibiotics when they are not needed or prescribing the wrong antibiotic in outpatient settings such as doctors' offices is common. In some cases, doctors might not order laboratory tests to confirm that bacteria are causing the infection, and therefore the antibiotic might be unnecessarily prescribed. In other cases, patients demand treatment for conditions such as a cold when antibiotics are not needed and will not help. Likewise, healthcare providers can be too willing to satisfy a patient's expectation for an antibiotic prescription. CDC manages the Get Smart program, a national campaign to improve antibiotic prescribing and use in both outpatient and inpatient settings, and supports a variety of state-based programs modeled on the national effort. CDC provides local public health authorities with messages and resources for improving antibiotic use in outpatient settings and is now working with a variety of partners to identify new approaches for improving antibiotic use.

Limiting and Interrupting the Spread of Antibiotic-Resistant Infections in the Community

Preventing the spread of infection in the community is a significant challenge, and many prevention interventions are used, depending on the type of infection and the route of transmission.

Here are some examples of CDC's activities to limit and interrupt the spread of antibiotic-resistant community infections:

- Contact Tracing: A prevention strategy that has proven successful is tracking cases (individuals who are infected) and tracing contacts (people who have had contact with a case that puts them at risk for infection as well). This process is used to ensure that all persons requiring an intervention such as treatment, prophylaxis, or temporary isolation from the general public are identified and managed appropriately. This approach is resource intensive, but it has successfully limited transmission of infections including tuberculosis, gonorrhea, and meningococcus.
- Vaccination: There are few vaccines for antibiotic-resistant bacteria, but the *S. pneumoniae* vaccine has proven that an effective vaccine can reduce antibiotic resistance rates. The vaccine targets certain types of the bacteria, even if it is a resistant type, and reduces the overall number of infections, including those that are caused by resistant strains. The first version of the vaccine was introduced in 2000 and reduced the frequency of antibiotic-resistant infections, but it did not protect against a particular strain of *S. pneumoniae* called serotype 19A. This strain became increasingly resistant to antibiotics and caused more infections because the vaccine did not offer protection. A new version of the vaccine, approved for use in 2010, protects against serotype 19A. As a result, the rate of resistant pneumococcal infections is decreasing.
- Treatment Guidelines: The spread of antibiotic resistance can be prevented if infections are effectively treated before the pathogen is spread to others. For some infections, laboratory tests for guiding treatment are not easily available or the turn-around time is slow or incomplete. This is the case for treating gonorrhea and tuberculosis. For these infections, healthcare providers rely on treatment guidelines for proper management of infections. CDC monitors resistance trends in *Neisseria gonorrhoeae* (the cause of gonorrhea) and *Mycobacterium tuberculosis* (the cause of tuberculosis) and publishes treatment guidelines to limit the progression of these diseases and the spread of bacteria.
- Promotion of Safe Sex: Increases in the spread of drug-resistant *Neisseria gonorrhoeae* poses unique challenges. To prevent transmission of this infection, CDC works to promote safer sexual behaviors such as abstinence, mutual monogamy, and correct and consistent condom use.

Preventing Infections: CDC's Work to Prevent Antibiotic Resistance in Food

Each year, millions of people in the United States become sick from foodborne and other enteric (gastrointestinal) infections. While many of these infections are mild and do not require treatment, antibiotics can be lifesaving in severe infections. Antibiotic resistance compromises our ability to treat these infections and is a serious threat to public health. Preventing resistant enteric infections requires a multifaceted approach and partnerships because bacteria that cause some infections, such as salmonellosis and campylobacteriosis, have animal reservoirs, while other bacteria, such as those that cause shigellosis and typhoid fever, have human reservoirs. To prevent antibiotic-resistant foodborne infections, CDC works closely with state and local health departments; with the U.S. Food and Drug Administration (FDA), which regulates antibiotics, many foods, animal feed, and other products; and with the U.S. Department of Agriculture (USDA), which regulates meat, poultry, and egg products.

Tracking Antibiotic Resistance

In 1996, the National Antimicrobial Resistance Monitoring System (NARMS) was established as a collaboration among CDC, FDA, USDA, and state and local public health departments. This national public health surveillance system tracks antibiotic resistance among *Salmonella, Campylobacter,* and other bacteria transmitted commonly through food. NARMS tests bacteria from humans (CDC), retail meats (FDA), and food-producing animals (USDA) in the United States. The primary objectives of the NARMS program are to:

- Monitor trends in antibiotic resistance among enteric bacteria from humans, retail meats, and food-producing animals.
- Disseminate information on antibiotic resistance to promote interventions that reduce antibiotic resistance among foodborne bacteria.
- Conduct research to better understand the emergence, persistence, and spread of antibiotic resistance.
- Provide data that assist the FDA in making decisions about approving safe and effective antibiotic drugs for animals.

The CDC reference laboratory conducts antibiotic susceptibility testing on isolates from sporadic cases and outbreaks of illness. The lab also confirms and studies bacteria that have new antibiotic resistance patterns. NARMS provides information about patterns of emerging resistance among enteric pathogens to stakeholders, including federal regulatory agencies, policymakers, consumer advocacy groups, industry, and the public, to guide public health prevention and policy efforts that protect people from resistant infections. For more information about NARMS: www.cdc.gov/narms.

Improving Antibiotic Use

Antibiotics are widely used in food-producing animals, and according to data published by FDA, there are more kilograms of antibiotics sold in the United States for food-producing animals than for people. (http://www.fda.gov/downloads/ForIndustry/UserFees/AnimalDrugUserFeeActADUFA/UCM338170.pdf). This use contributes to the emergence of antibiotic-resistant bacteria in food-producing animals. Resistant bacteria in food-producing animals are of particular concern because these animals serve as carriers.

Resistant bacteria can contaminate the foods that come from those animals, and people who consume these foods can develop antibiotic-resistant infections. Antibiotics must be used judiciously in humans and animals because both uses contribute to not only the emergence, but also the persistence and spread of antibiotic-resistant bacteria.

Scientists around the world have provided strong evidence that antibiotic use in food-producing animals can harm public health through the following sequence of events:

- Use of antibiotics in food-producing animals allows antibiotic-resistant bacteria to thrive while susceptible bacteria are suppressed or die.
- Resistant bacteria can be transmitted from food-producing animals to humans through the food supply.
- Resistant bacteria can cause infections in humans.
- Infections caused by resistant bacteria can result in adverse health consequences for humans.

Because of the link between antibiotic use in food-producing animals and the occurrence of antibiotic-resistant infections in humans, antibiotics should be used in food-producing animals only under veterinary oversight and only to manage and treat infectious diseases, not to promote growth. CDC encourages and supports efforts to minimize inappropriate use of antibiotics in humans and animals, including FDA's strategy to promote the judicious use of antibiotics that are important in treating humans (http://www.fda.gov/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/JudiciousUseofAntimicrobials/default.htm). CDC supports FDA's plan to implement draft guidance in 2013 that will operationalize this strategy (http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM299624.pdf). CDC has also contributed to a training curriculum for veterinarians on prudent antibiotic use in animals. CDC's efforts to improve antibiotic prescribing in humans are described in other sections of this report.

Preventing Infections

Efforts to prevent foodborne and other enteric infections help to reduce both antibiotic-resistant infections and antibiotic-susceptible infections (those that can be treated effectively with antibiotics). CDC activities that help prevent these infections include:

- Estimating how much foodborne illness occurs.
- Monitoring trends in foodborne infections.
- Investigating outbreaks and sporadic cases of foodborne illness to stop outbreaks and improve prevention.
- Attributing illnesses to specific foods and settings.
- Tracking and responding to changes in resistance.
- Determining the sources of antibiotic-resistant enteric infections.
- Educating consumers and food workers about safe food handling practices.
- Identifying and educating groups at high risk for infection.
- Promoting proper handwashing.

- Strengthening the capacity of state and local health departments to detect, respond to, and report foodborne infections.
- Developing better diagnostic tools to rapidly and accurately find sources of contamination.
- Providing recommendations for travelers on safe food and clean water.

2. TRACKING RESISTANCE PATTERNS

CDC gathers data on antibiotic-resistant infections, causes of infections, and whether there are particular reasons (risk factors) that caused some people to get a resistant infection. With that information, experts develop specific strategies to prevent those infections and prevent the resistant bacteria from spreading.

FOUR CORE ACTIONS

PREVENTING INFECTIONS, PREVENTING SPREAD.

TRACKING RESISTANCE PATTERNS.

IMPROVING USE OF ANTIBIOTICS.

DEVELOPING NEW ANTIBIOTICS AND DIAGNOSTIC TESTS.

CDC's Antibiotic Resistance and Antibiotic-Resistant Infections Tracking Platform

Tracking Networks	Data Collected	Resistant Bacteria/Fungus[3]
EIP Emerging Infections Program There are three main programs within the EIP: ■ **ABCs:** Active Bacterial Core surveillance ■ **HAIC:** Healthcare-Associated Infections-Community Interface ■ **FoodNet:** Foodborne Diseases Active Surveillance Network	A network of public health-academic-hospital collaborations in 10 states. It provides access to bacterial and fungal samples for testing and detailed clinical case data. The three main programs within EIP collect different types of resistance data: ■ ABCs provides clinical information and resistance data for bacteria that cause infections predominately in the community. ■ The HAIC provides clinical information and resistance data for bacteria and fungi that cause infections at the intersection of healthcare and the general community. ■ FoodNet supplies clinical and epidemiologic data on some human isolates in the National Antimicrobial Resistance Monitoring System (NARMS).	**ABCs:** *Streptococcus pneumoniae* Groups A and B *Streptococcus* Methicillin-resistant *Staphylococcus aureus* **HAIC:** *C. difficile* *Candida* (a fungus) Carbapenem-R Enterobacteriaceae MDR *Acinetobacter* FoodNet: (see NARMS list)
NARMS National Antimicrobial Resistance Monitoring System	A national public health surveillance system that tracks changes in the susceptibility of foodborne and other enteric bacteria to antibiotics of human and veterinary medical importance. NARMS is a collaboration among CDC, FDA, USDA, and state and local health departments. CDC tests bacterial isolates from humans, while FDA and USDA test isolates from retail meats and food animals.	*Salmonella* *Campylobacter* *Shigella*

Tracking Networks	Data Collected	Resistant Bacteria/Fungus[3]
NHSN National Healthcare Safety Network	A system that collects and provides data on infections and drug-resistance in healthcare settings. Since NHSN collects data directly from healthcare facilities, it can provide facility-level information on healthcare-associated infections and antibiotic resistance (and in the future, on antibiotic use).	*Staphylococcus aureus* *Enterococcus* Enterobacteriaceae *Acinetobacter* *Pseudomonas aeruginosa* *Candida* (a fungus)
GISP Gonococcal Isolate Surveillance Program	A program to track antibiotic resistance data for gonococcal isolates. Isolates are collected from sexually transmitted disease clinics in approximately 28 cities.	*Neisseria gonorrhoeae*
NTSS National Tuberculosis Surveillance System	National Electronic Disease Surveillance System (NEDSS)-based reporting of tuberculosis cases including resistance data. Public health departments from 50 states and the US territories contribute data.	*Mycobacterium tuberculosis*

[3]ABCs also includes surveillance for *Neisseria meningitidis* and *Haemophilus influenzae.* NARMS also includes surveillance for *E. coli O157* and *Vibrio* (non-*V. cholerae).*

3. ANTIBIOTIC STEWARDSHIP: IMPROVING PRESCRIBING AND USE

FOUR CORE ACTIONS

PREVENTING INFECTIONS, PREVENTING SPREAD.

TRACKING RESISTANCE PATTERNS.

IMPROVING USE OF ANTIBIOTICS.

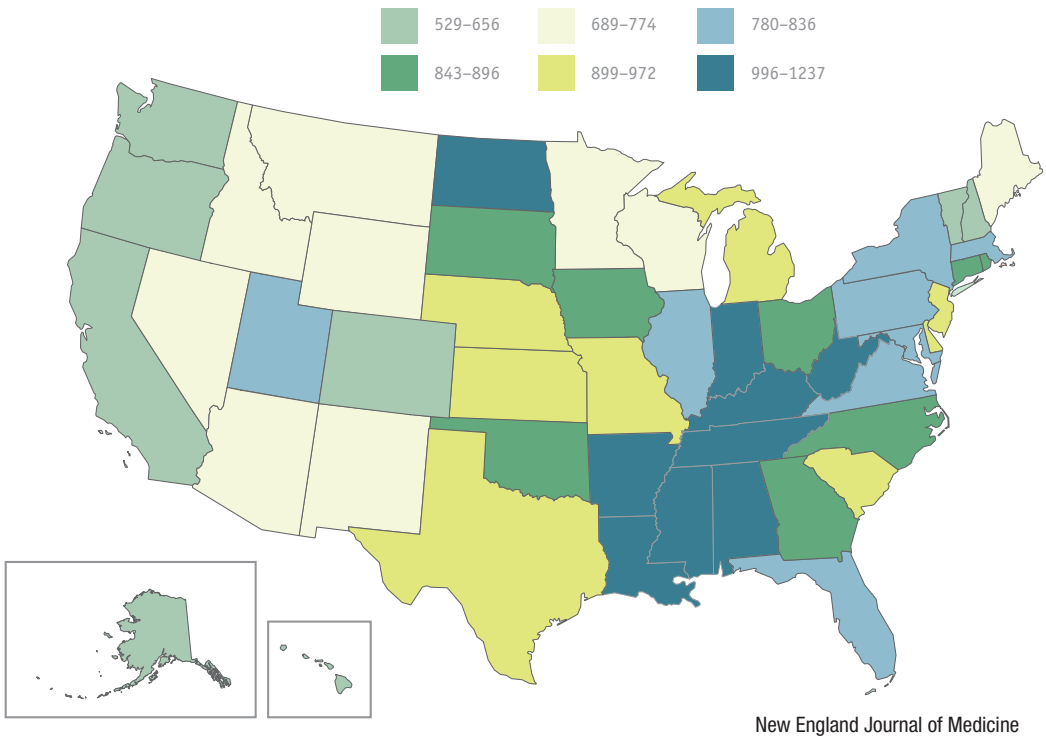
DEVELOPING NEW ANTIBIOTICS AND DIAGNOSTIC TESTS.

Antibiotics were first used to treat serious infections in the 1940s. Since then, antibiotics have saved millions of lives and transformed modern medicine. During the last 70 years, however, bacteria have shown the ability to become resistant to every antibiotic that has been developed. And the more antibiotics are used, the more quickly bacteria develop resistance *(see the Antibiotic Resistance Timeline in this report)*.

Anytime antibiotics are used, this puts biological pressure on bacteria that promotes the development of resistance. When antibiotics are needed to prevent or treat disease, they should always be used. But research has shown that as much as 50% of the time, antibiotics are prescribed when they are not needed or they are misused (for example, a patient is given the wrong dose). This not only fails to help patients; it might cause harm. Like every other drug, antibiotics have side effects and can also interact or interfere with the effects of other medicines. This inappropriate use of antibiotics unnecessarily promotes antibiotic resistance.

Antibiotics are a limited resource. The more that antibiotics are used today, the less likely they will still be effective in the future. Therefore, doctors and other health professionals around the world are increasingly adopting the principles of responsible antibiotic use, often called antibiotic stewardship. Stewardship is a commitment to always use antibiotics only when they are necessary to treat, and in some cases prevent, disease; to choose the right antibiotics; and to administer them in the right way in every case. Effective stewardship ensures that every patient gets the maximum benefit from the antibiotics, avoids unnecessary harm from allergic reactions and side effects, and helps preserve the life-saving potential of these drugs for the future. Efforts to improve the responsible use of antibiotics have not only demonstrated these benefits but have also been shown to improve outcomes and save healthcare facilities money in pharmacy costs.

Antibiotic Prescriptions per 1000 Persons of All Ages According to State, 2010



The frequency with which doctors prescribe antibiotics varies greatly from state to state. The reasons for this variation are being studied and might suggest areas where improvements in antibiotic prescribing (fewer unnecessary prescriptions) would be most helpful.

ANTIBIOTIC STEWARDSHIP
IN YOUR FACILITY WILL

DECREASE

- ANTIBIOTIC RESISTANCE
- C. DIFFICILE INFECTIONS
- COSTS

INCREASE

- GOOD PATIENT OUTCOMES

PROMOTE ANTIBIOTIC BEST PRACTICES— A FIRST STEP IN ANTIBIOTIC STEWARDSHIP

- ENSURE ALL ORDERS HAVE DOSE, DURATION, AND INDICATIONS
- GET CULTURES BEFORE STARTING ANTIBIOTICS
- TAKE AN "ANTIBIOTIC TIMEOUT" REASSESSING ANTIBIOTICS AFTER 48–72 HOURS

ANTIBIOTIC STEWARDSHIP PROGRAMS ARE A "WIN-WIN" FOR ALL INVOLVED

A UNIVERSITY OF MARYLAND STUDY SHOWED ONE ANTIBIOTIC STEWARDSHIP PROGRAM **SAVED A TOTAL OF $17 MILLION** OVER EIGHT YEARS

ANTIBIOTIC STEWARDSHIP HELPS **IMPROVE PATIENT CARE AND SHORTEN HOSPTIAL STAYS,** THUS **BENEFITING PATIENTS AS WELL AS HOSPITALS**

4. DEVELOPING NEW ANTIBIOTICS AND DIAGNOSTIC TESTS

Because antibiotic resistance occurs as part of a natural evolution process, it can be significantly slowed but not stopped. Therefore, new antibiotics will always be needed to keep up with resistant bacteria as well as new diagnostic tests to track the development of resistance.

FOUR CORE ACTIONS

PREVENTING INFECTIONS, PREVENTING SPREAD.

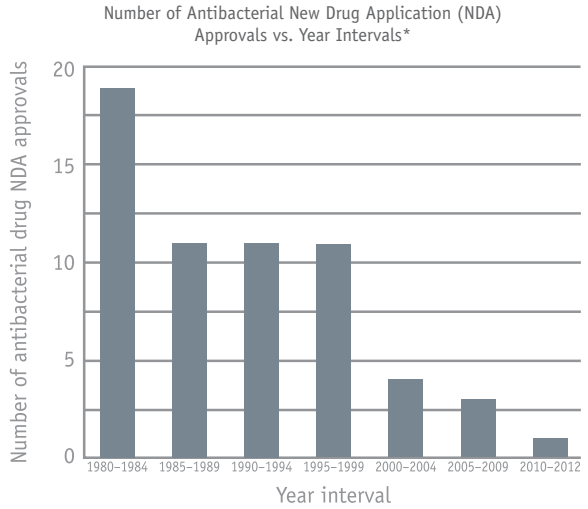
TRACKING RESISTANCE PATTERNS.

IMPROVING USE OF ANTIBIOTICS.

DEVELOPING NEW ANTIBIOTICS AND DIAGNOSTIC TESTS.

Tomorrow's Antibiotics: The Drug Pipeline

The number of new antibiotics developed and approved has steadily decreased in the past three decades, leaving fewer options to treat resistant bacteria.



*Intervals from 1980–2009 are 5-year intervals; 2010–2012 is a 3-year interval. Drugs are limited to systemic agents.
Data courtesy of FDA' s Center for Drug Evaluation and Research (CDER).

Examples of Recently Approved Drugs

Drug Name	Year Approved	Key Targeted Pathogens	Drug's Use and Resistance Trends
Quinupristin/ Dalfoprisitin	1999	*Staphylococcus* *Streptococcus*	This is a combination of two drugs that can be used to treat gram-positive infections. Because side effects are common, this drug is usually not a first choice for therapy. Resistance in target pathogens has been described, but the percentage in the United States is still low.
Moxifloxacin	1999	Enterobacteriaceae *Staphylococcus* *Streptococcus*	Moxifloxacin, like other fluoroquinolones, demonstrates broad spectrum activity, and it can be used to treat a range of infections. Unfortunately, there is cross-resistance among the fluoroquinolones, and resistance is increasing in all targeted pathogens, especially Enterobacteriaceae.
Linezolid	2000	*Staphylococcus* *Enterococcus*	Linezolid can be used to treat serious gram-positive infections. Resistance has occurred but it is still uncommon.
Ertapenem	2001	Enterobacteriaceae *Staphylococcus* *Streptococcus*	Ertapenem is a carbapenem that can be used to treat a wide range of infections. Dissemination of carbapenem-resistant Enterobacteriaceae (CRE) is impacting the drug's overall effectiveness.
Gemifloxacin	2003	Enterobacteriaceae *Streptococcus*	Gemifloxacin is a fluoroquinolone that can be used to treat mild to moderate community-associated respiratory disease. Like moxifloxacin, there is cross-resistance with other fluoroquinolone drugs so resistance is increasing.
Daptomycin	2003	*Staphylococcus* *Streptococcus* *Enterococcus*	Daptomycin is often used for treatment of serious gram-positive infections. Resistance is emerging in all of the targeted pathogens, but the resistance rates are currently low.
Tigecycline	2005	Enterobacteriaceae *Staphylococcus* *Streptococcus* *Enterococcus*	Tigecycline is often one of the only active agents for carbapenem-resistant gram-negative infections, and resistance is emerging. However, even in the absence of resistance, the effectiveness of this agent for treatment of the most serious infections is a concern.
Doripenem	2007	Enterobacteriaceae *Pseudomonas aeruginosa* *Acinetobacter spp.* *Streptococcus spp.*	Doripenem is a carbapenem drug most commonly used to treat serious gram-negative infections. Dissemination of carbapenem-resistant gram-negative pathogens like CRE is reducing the overall effectiveness of this drug.
Telavancin	2008	*Staphylococcus* *Streptococcus* *Enterococcus*	Telavancin is approved for treatment of gram-positive skin and soft tissue infections. Use is limited because it is administered intravenously and is therefore difficult to use in an outpatient setting. In addition, it should not be used in a woman of childbearing age without a pregnancy test.

Drug Name	Year Approved	Key Targeted Pathogens	Drug's Use and Resistance Trends
Ceftaroline	2010	Enterobacteriaceae *Staphylococcus* *Streptococcus*	Ceftaroline is a cephalosporin drug, but unlike other cephalosporins, this one can be used to treat MRSA infections. Resistance has been identified but is rare. Ceftaroline does not demonstrate any enhanced activity compared to other cephalosporins for Enterobacteriaceae. ESBL-producing isolates and CRE isolates are resistant to this drug as well. ESBL (extended-spectrum β-lactamase) is an enzyme that allows bacteria to become resistant to a wide variety of penicillins and cephalosporins .Bacteria that contain this enzyme are known as ESBLs or ESBL-producing bacteria.

CARBAPENEM-RESISTANT ENTEROBACTERIACEAE (CRE)

CURRENT ANTIBIOTIC RESISTANCE THREATS IN THE UNITED STATES, BY MICROORGANISM

This section includes summaries for each microorganism, grouped by threat level: URGENT, SERIOUS, and CONCERNING.

THREAT LEVEL
URGENT

These bacteria are immediate public health threats that require urgent and aggressive action.

MICROORGANISMS WITH A THREAT LEVEL OF URGENT

Clostridium difficile

Carbapenem-resistant **Enterobacteriaceae**

Drug-resistant ***Neisseria gonorrhoeae***

CLOSTRIDIUM DIFFICILE

THREAT LEVEL
URGENT

This bacteria is an immediate public health threat that requires urgent and aggressive action.

250,000
INFECTIONS PER YEAR

14,000
DEATHS

$1,000,000,000
IN EXCESS MEDICAL COSTS PER YEAR

Clostridium difficile (C. difficile) causes life-threatening diarrhea. These infections mostly occur in people who have had both recent medical care and antibiotics. Often, *C. difficile* infections occur in hospitalized or recently hospitalized patients.

RESISTANCE OF CONCERN

- Although resistance to the antibiotics used to treat *C. difficile* infections is not yet a problem, the bacteria spreads rapidly because it is naturally resistant to many drugs used to treat other infections.
- In 2000, a stronger strain of the bacteria emerged. This strain is resistant to fluoroquinolone antibiotics, which are commonly used to treat other infections.
- This strain has spread throughout North America and Europe, infecting and killing more people wherever it spreads.

PUBLIC HEALTH THREAT

- 250,000 infections per year requiring hospitalization or affecting already hospitalized patients.
- 14,000 deaths per year.
- At least $1 billion in excess medical costs per year.
- Deaths related to *C. difficile* increased 400% between 2000 and 2007, in part because of a stronger bacteria strain that emerged.
- Almost half of infections occur in people younger than 65, but more than 90% of deaths occur in people 65 and older.
- About half of *C. difficile* infections first show symptoms in hospitalized or recently hospitalized patients, and half first show symptoms in nursing home patients or in people recently cared for in doctors' offices and clinics.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

FIGHTING THE SPREAD OF RESISTANCE

WHAT CDC IS DOING

- Tracking and reporting national progress toward preventing *C. difficile* infections.
- Promoting *C. difficile* prevention programs and providing gold-standard patient safety recommendations.
- Providing prevention expertise, as well as outbreak and laboratory assistance, to health departments and healthcare facilities.

WHAT YOU CAN DO

CEOs, Medical Officers, and other Healthcare Facility Leaders Can:

- Support better testing (nucleic acid amplification tests), tracking, and reporting of infections and prevention efforts.
- Ensure policies for rapid detection and isolation of patients with *C. difficile* are in place and followed.
- Assess hospital cleaning to be sure it is performed thoroughly, and augment this using an Environmental Protection Agency-approved, spore-killing disinfectant in rooms where *C. difficile* patients are treated.
- Notify other healthcare facilities about infectious diseases when patients transfer, especially between hospitals and nursing homes.
- Participate in a regional *C. difficile* prevention effort.

Healthcare Providers Can:

- Prescribe antibiotics carefully (see http://www.cdc.gov/getsmart/specific-groups/hcp/index.html). Once culture results are available, check whether the prescribed antibiotics are correct and necessary.
- Order a *C. difficile* test (preferably a nucleic acid amplification test) if the patient has had 3 or more unformed stools within 24 hours.
- Be aware of infection rates in your facility or practice, and follow infection control recommendations with every patient. This includes using contact precautions (gloves and gowns) and isolation for patients who are suspected to have *C. difficile,* and continuing those practices for those with positive test results.

Patients can:

- Take antibiotics only as prescribed by your doctor and complete the prescribed course of treatment. Antibiotics can be lifesaving medicines.
- Tell your doctor if you have been on antibiotics and get diarrhea within a few months.
- Wash your hands before eating and after using the bathroom.
- Try to use a separate bathroom if you have diarrhea, or be sure the bathroom is cleaned well if someone with diarrhea has used it.

ONLINE RESOURCES

Vital Signs, March 2012: Making Health Care Safer
http://www.cdc.gov/vitalsigns/hai/

Clostridium difficile Infection resources
http://www.cdc.gov/HAI/organisms/cdiff/Cdiff_infect.html

CS239559-B

CARBAPENEM-RESISTANT ENTEROBACTERIACEAE

9,000 DRUG-RESISTANT INFECTIONS PER YEAR

600 DEATHS

CARBAPENEM-RESISTANT *KLEBSIELLA* SPP. **7,900**

1,400 CARBAPENEM-RESISTANT *E. COLI*

CRE HAVE BECOME RESISTANT TO ALL OR NEARLY ALL AVAILABLE ANTIBIOTICS

THREAT LEVEL
URGENT

This bacteria is an immediate public health threat that requires urgent and aggressive action.

Untreatable and hard-to-treat infections from carbapenem-resistant Enterobacteriaceae (CRE) bacteria are on the rise among patients in medical facilities. CRE have become resistant to all or nearly all the antibiotics we have today. Almost half of hospital patients who get bloodstream infections from CRE bacteria die from the infection.

RESISTANCE OF CONCERN

- Some Enterobacteriaceae are resistant to nearly all antibiotics, including carbapenems, which are often considered the antibiotics of last resort.
- More than 9,000 healthcare-associated infections are caused by CRE each year.
- CDC laboratories have confirmed at least one type of CRE in healthcare facilities in 44 states.
- About 4% of U.S. short-stay hospitals had at least one patient with a serious CRE infection during the first half of 2012. About 18% of long-term acute care hospitals had one.

PUBLIC HEALTH THREAT

An estimated 140,000 healthcare-associated Enterobacteriaceae infections occur in the United States each year; about 9,300 of these are caused by CRE. Up to half of all bloodstream infections caused by CRE result in death. Fortunately, bloodstream infections account for a minority of all healthcare-associated infections caused by Enterobacteriaceae. Each year, approximately 600 deaths result from infections caused by the two most common types of CRE, carbapenem-resistant *Klebsiella* spp. and carbapenem-resistant *E. coli*.

	Percentage of Enterobacteriaceae healthcare-associated infections resistant to carbapenems	Estimated number of infections	Estimated number of deaths attributed
Carbapenem-Resistant *Klebsiella* spp.	11%	7,900	520
Carbapenem-resistant *E. coli*	2%	1,400	90

For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

CARBAPENEM-RESISTANT ENTEROBACTERIACEAE

FIGHTING THE SPREAD OF RESISTANCE

WHAT CDC IS DOING

- Tracking illness and identifying risk factors for CRE infections using two systems, the National Healthcare Safety Network and the Emerging Infections Program.
- Providing CRE outbreak support, such as staff expertise, prevention guidelines, tools, and lab assistance, to states and facilities.
- Developing tests and prevention programs to identify and control CRE. CDC's "Detect and Protect" effort (http://www.cdc.gov/hai/pdfs/cre/CDC_DetectProtect.pdf) supports regional CRE programs.
- Helping medical facilities improve antibiotic prescribing practices.

WHAT YOU CAN DO

States and Communities Can:

- Know CRE trends in your region.
- Coordinate regional CRE tracking and control efforts in areas with CRE. Areas not yet or rarely affected by CRE infections can be proactive in CRE prevention efforts.
- Require facilities to alert each other when transferring patients with any infection.
- Consider including CRE infections on your state's Notifiable Diseases list.

Healthcare CEOs, Medical Officers, and Other Healthcare Facility Leaders Can:

- Require and strictly enforce CDC guidance for CRE detection, prevention, tracking, and reporting.
- Make sure your lab can accurately identify CRE and alert clinical and infection prevention staff when these bacteria are present.
- Know CRE trends in your facility and in the facilities around you.
- When transferring a patient, require staff to notify the other facility about infections, including CRE.
- Join or start regional CRE prevention efforts, and promote wise antibiotic use.

Health Care Providers Can:

- Know if patients with CRE are hospitalized at your facility, and stay aware of CRE infection risks. Ask if your patients have received medical care somewhere else, including another country.
- Follow infection control recommendations with every patient, using contact precautions for patients with CRE. Whenever possible, dedicate rooms, equipment, and staff to CRE patients.
- Prescribe antibiotics wisely (http://www.cdc.gov/getsmart/healthcare). Use culture results to modify prescriptions if needed.
- Remove temporary medical devices as soon as possible.

Patients Can:

- Tell your doctor if you have been hospitalized in another facility or country.
- Take antibiotics only as prescribed.
- Insist that everyone wash their hands before touching you.

ONLINE RESOURCES

Vital Signs, March 2013: Making Health Care Safer

2012 CRE Toolkit
http://www.cdc.gov/hai/organisms/cre/cre-toolkit/index.html

MMWR, March 2013
http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6209a3.htm?s_cid=mm6209a3_w

Get Smart for Healthcare
http://www.cdc.gov/getsmart/healthcare

Carbapenem-resistant Enterobacteriaceae (CRE) Resources
http://www.cdc.gov/HAI/organisms/cre/index.html

CS239559-B

DRUG-RESISTANT NEISSERIA GONORRHOEAE

246,000 DRUG-RESISTANT GONORRHEA INFECTIONS

188,600 RESISTANCE TO TETRACYCLINE

11,480 REDUCED SUSCEPTIBILITY TO CEFIXIME

3,280 REDUCED SUSCEPTIBILITY TO CEFTRIAXONE

2,460 REDUCED SUSCEPTIBILITY TO AZITHROMYCIN

820,000 GONOCOCCAL INFECTIONS PER YEAR

THREAT LEVEL
URGENT

This bacteria is an immediate public health threat that requires urgent and aggressive action.

Neisseria gonorrhoeae causes gonorrhea, a sexually transmitted disease that can result in discharge and inflammation at the urethra, cervix, pharynx, or rectum.

RESISTANCE OF CONCERN

N. gonorrhoeae is showing resistance to antibiotics usually used to treat it. These drugs include:

- cefixime (an oral cephalosporin)
- ceftriaxone (an injectable cephalosporin)
- azithromycin
- tetracycline

PUBLIC HEALTH THREAT

Gonorrhea is the second most commonly reported notifiable infection in the United States and is easily transmitted. It causes severe reproductive complications and disproportionately affects sexual, racial, and ethnic minorities. Gonorrhea control relies on prompt identification and treatment of infected persons and their sex partners. Because some drugs are less effective in treating gonorrhea, CDC recently updated its treatment guidelines to slow the emergence of drug resistance. CDC now recommends only ceftriaxone plus either azithromycin or doxycycline as first-line treatment for gonorrhea. The emergence of cephalosporin resistance, especially ceftriaxone resistance, would greatly limit treatment options and could cripple gonorrhea control efforts.

In 2011, 321,849 cases of gonorrhea were reported to CDC, but CDC estimates that more than 800,000 cases occur annually in the United States.

	Percentage	Estimated number of cases
Gonorrhea		820,000
Resistance to any antibiotic	30%	246,000
Reduced susceptibility to cefixime	<1%	11,480
Reduced susceptibility to ceftriaxone	<1%	3,280
Reduced susceptibility to azithromycin	<1%	2,460
Resistance to tetracycline	23%	188,600

Source: The Gonococcal Isolate Surveillance Project (GISP)–5,900 isolates tested for susceptibility in 2011.
For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

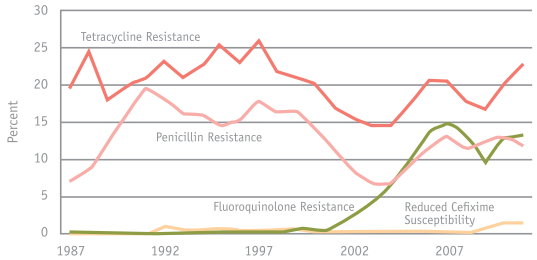
DRUG-RESISTANT NEISSERIA GONORRHOEAE

FIGHTING THE SPREAD OF RESISTANCE

Cephalosporin-resistant *N. gonorrhoeae* is often resistant to multiple classes of other antibiotics and as a result, infections caused by these bacteria will likely fail empiric treatment regimens. If cephalosporin-resistant *N. gonorrhoeae* becomes widespread, the public health impact during a 10-year period is estimated to be 75,000 additional cases of pelvic inflammatory disease (a major cause of infertility), 15,000 cases of epididymitis, and 222 additional HIV infections because HIV is transmitted more readily when someone is co-infected with gonorrhea. In addition, the estimated direct medical costs would total $235 million. Additional costs are anticipated to be incurred as a result of increased susceptibility monitoring, provider education, case management, and the need for additional courses of antibiotics and follow-up.

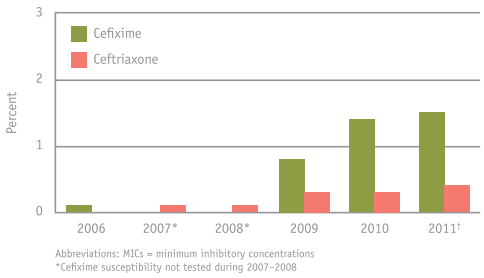
Gonorrhea is a global problem, requiring a global approach. Action in the United States alone is unlikely to prevent resistance from developing, but rapid detection and effective treatment of patients and their partners might slow the spread of resistance. Preventing gonorrhea is critical. Screening, rapid detection, prompt treatment, and partner services are the foundations of gonorrhea control in the United States. Effectively addressing the heavy burden of gonorrhea and anticipated arrival of cephalosporin resistance requires continued use of these strategies as well as the use of expedited partner therapy, promotion of safer sexual behaviors such as abstinence, mutual monogamy, and correct and consistent condom use, and activities designed to rapidly detect and respond to antibiotic-resistant infections

New resistance patterns have developed over time. Resistance to previously used antibiotics, such as penicillin, remains common.



Source: The Gonococcal Isolate Surveillance Project (GISP).

These trends are an early warning of cephalosporin resistance.



Source: The Gonococcal Isolate Surveillance Project (GISP).

WHAT CDC IS DOING

CDC is closely monitoring resistance in *N. gonorrhoeae* in the United States and actively collaborating with the World Health Organization to enhance global surveillance. In the United States, CDC recently released a national response plan and is working closely with local and state STD programs to enhance preparedness. CDC recently updated its gonorrhea treatment recommendations to stay a step ahead of this rapidly evolving bacterium, and is collaborating with the NIH National Institute of Allergy and Infectious Diseases to find new treatment options.

ONLINE RESOURCES

CDC's gonorrhea website
http://www.cdc.gov/std/gonorrhea/default.htm

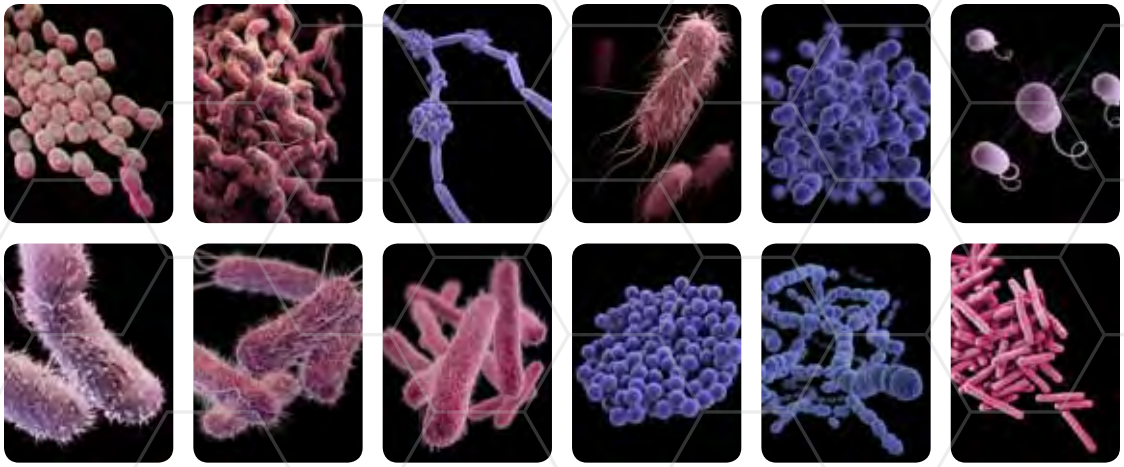
CDC's Antibiotic-Resistant Gonorrhea website:
http://www.cdc.gov/std/Gonorrhea/arg/default.htm

New Treatment Guidelines for Gonorrhea: Antibiotic Change. MedScape CDC Expert Commentary, 2012. http://www.medscape.com/viewarticle/768883

Kirkcaldy RD, Bolan GA, Wasserheit JN. Cephalosporin-Resistant Gonorrhea in North America. JAMA 2013;209(2):185-187.
http://jama.jamanetwork.com/article.aspx?articleid=1556135

CDC. Update to CDC's Sexually Transmitted Diseases Treatment Guidelines, 2010: Oral cephalosporins no longer a recommended treatment for gonococcal infections. MMWR 2012;61(31):590-594.
http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6131a3.htm?

CS239559-B



THREAT LEVEL
SERIOUS

These bacteria are a serious concern and require prompt and sustained action to ensure the problem does not grow.

MICROORGANISMS WITH A THREAT LEVEL OF SERIOUS

Multidrug-resistant ***Acinetobacter***

Drug-resistant ***Campylobacter***

Fluconazole-resistant ***Candida*** (a fungus)

Extended spectrum β-lactamase producing **Enterobacteriaceae (ESBLs)**

Vancomycin-resistant ***Enterococcus*** **(VRE)**

Multidrug-resistant ***Pseudomonas aeruginosa***

Drug-resistant **non-typhoidal *Salmonella***

Drug-resistant ***Salmonella*** **Typhi**

Drug-resistant ***Shigella***

Methicillin-resistant ***Staphylococcus aureus*** **(MRSA)**

Drug-resistant ***Streptococcus pneumoniae***

Drug-resistant **tuberculosis**

MULTIDRUG-RESISTANT ACINETOBACTER

7,300 MULTIDRUG-RESISTANT *ACINETOBACTER* INFECTIONS

500 DEATHS FROM MULTIDRUG-RESISTANT INFECTIONS

12,000 *ACINETOBACTER* INFECTIONS PER YEAR

AT LEAST THREE DIFFERENT CLASSES OF ANTIBIOTICS
NO LONGER CURE RESISTANT ACINETOBACTER INFECTIONS

THREAT LEVEL
SERIOUS

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Acinetobacter is a type of gram-negative bacteria that is a cause of pneumonia or bloodstream infections among critically ill patients. Many of these bacteria have become very resistant to antibiotics.

RESISTANCE OF CONCERN

Some *Acinetobacter* strains are resistant to nearly all or all antibiotics including carbapenems, often considered antibiotics of last resort.

- About 63% of *Acinetobacter* is considered multidrug-resistant, meaning at least three different classes of antibiotics no longer cure *Acinetobacter* infections.
- Approximately 2% of healthcare-associated infections reported to CDC's National Healthcare Safety Network are caused by *Acinetobacter,* but the proportion is higher among critically ill patients on mechanical ventilators (about 7%).

PUBLIC HEALTH THREAT

An estimated 12,000 healthcare-associated *Acinetobacter* infections occur in the United States each year. Nearly 7,000 (or 63%) of these are multidrug-resistant, and about 500 deaths are attributed to these infections.

	Percentage of all *Acinetobacter* healthcare-associated infections that are multidrug-resistant	Estimated number of infections	Estimated number of deaths attributed
Multidrug-resistant *Acinetobacter*	63%	7,300	500

For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

MULTIDRUG-RESISTANT ACINETOBACTER

FIGHTING THE SPREAD OF RESISTANCE

WHAT CDC IS DOING

- Tracking illness and identifying risk factors for drug-resistant infections using two systems, the National Healthcare Safety Network and the Emerging Infections Program.
- Providing outbreak support such as staff expertise, prevention guidelines, tools, and lab assistance, to states and facilities.
- Developing tests and prevention recommendations to control drug-resistant infections.
- Helping medical facilities improve antibiotic prescribing practices.

WHAT YOU CAN DO

States and Communities Can:

- Know resistance trends in your region.
- Coordinate local and regional infection tracking and control efforts.
- Require facilities to alert each other when transferring patients with any infection.

Healthcare CEOs, Medical Officers, and other Healthcare Facility Leaders Can:

- Require and strictly enforce CDC guidance for infection detection, prevention, tracking, and reporting.
- Make sure your lab can accurately identify infections and alert clinical and infection prevention staff when these bacteria are present.
- Know infection and resistance trends in your facility and in the facilities around you.
- When transferring a patient, require staff to notify the other facility about all infections.
- Join or start regional infection prevention efforts.
- Promote wise antibiotic use.

Healthcare Providers Can:

- Know the type of drug-resistant infections that are present in your facility and patients.
  - Request immediate alerts when the lab identifies drug-resistant infections in your patients.
  - Alert the other facility when you transfer a patient with a drug-resistant infection.
- Protect patients from drug-resistant infections.
  - Follow relevant guidelines and precautions at every patient encounter.
  - Prescribe antibiotics wisely.
  - Remove temporary medical devices such as catheters and ventilators as soon as no longer needed.

Patients and Their Loved Ones Can:

- Ask everyone including doctors, nurses, other medical staff, and visitors, to wash their hands before touching the patient.
- Take antibiotics exactly as prescribed.

ONLINE RESOURCES

***Acinetobacter* in Healthcare Settings**
http://www.cdc.gov/HAI/organisms/acinetobacter.html

Healthcare-associated Infections, Guidelines and Recommendations
http://www.cdc.gov/HAI/prevent/prevent_pubs.html

CS239559-B

DRUG-RESISTANT CAMPYLOBACTER

310,000 DRUG-RESISTANT *CAMPYLOBACTER* INFECTIONS PER YEAR

1,300,000 *CAMPYLOBACTER* INFECTIONS PER YEAR

13,000 HOSPITALIZATIONS

120 DEATHS

THREAT LEVEL **SERIOUS**

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Campylobacter usually causes diarrhea (often bloody), fever, and abdominal cramps, and sometimes causes serious complications such as temporary paralysis.

RESISTANCE OF CONCERN

Physicians rely on drugs like ciprofloxacin and azithromycin for treating patients with severe disease. Resistant infections sometimes last longer. *Campylobacter* is showing resistance to:

- ciprofloxacin
- azithromycin

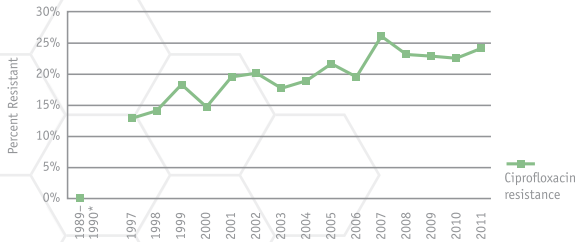
PUBLIC HEALTH THREAT

Campylobacter is estimated to cause approximately 1.3 million infections, 13,000 hospitalizations, and 120 deaths each year in the United States. CDC is seeing resistance to ciprofloxacin in almost 25% of *Campylobacter* tested and resistance to azithromycin in about 2%. Costs are expected to be higher for resistant infections because antibiotic-resistant *Campylobacter* infections sometimes last longer.

	Percentage of all *Campylobacter**	Estimated number of illnesses per year	Estimated illnesses per 100,000 U.S. population	Estimated number of deaths per year
Resistance to ciprofloxacin	23%	310,000	102.3	28
Resistance to azithromycin	2%	22,000	7.4	<5
Resistance to azithromycin or ciprofloxacin	24%	310,000	103.9	28

Campylobacter drug resistance increased from 13% in 1997 to almost 25% in 2011.

Increasing Resistance to Ciprofloxacin in *Campylobacter*, 1989–2011



*3-year average (2009–2011)

*Data for 1989–1990 were from a sentinel county survey. Annual testing began in 1997.

For more information about data methods and references, please see appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

DRUG-RESISTANT CAMPYLOBACTER

FIGHTING THE SPREAD OF RESISTANCE

Campylobacter spreads from animals to people through contaminated food, particularly raw or undercooked chicken and unpasteurized milk. Infections may also be acquired through contact with animals and by drinking contaminated water. Antibiotic use in food animals can result in resistant *Campylobacter* that can spread to humans. Resistant *Campylobacter* are common in many countries and cause illness in travelers. Key measures to prevent resistant infections include:

- Avoiding inappropriate antibiotic use in food animals.
- Tracking antibiotic use in different types of food animals.
- Stopping spread of *Campylobacter* among animals on farms.
- Improving food production and processing to reduce contamination.
- Educating consumers and food workers about safe food handling practices.

WHAT CDC IS DOING

- Tracking changes in antibiotic resistance through ongoing surveillance.
- Promoting initiatives that measure and improve antibiotic use in food animals.
- Determining foods responsible for outbreaks of *Campylobacter* infections.
- Supporting and improving local, state, and federal public health surveillance.
- Guiding prevention efforts by estimating how much illness occurs and identifying the sources of infection.
- Educating people about how to avoid *Campylobacter* infections.

WHAT YOU CAN DO

- **Clean.** Wash hands, cutting boards, utensils, sinks, and countertops.
- **Separate.** Keep raw meat, poultry, and seafood separate from ready-to-eat foods.
- **Cook.** Use a food thermometer to ensure that foods are cooked to a safe internal temperature.
- **Chill.** Keep your refrigerator below 40°F and refrigerate food that will spoil.
- Avoid drinking raw milk and untreated water.
- Report suspected illness from food to your local health department.
- Don't prepare food for others if you have diarrhea or vomiting.
- Be especially careful preparing food for children, pregnant women, those in poor health, and older adults.
- Consume safe food and water when traveling abroad.

ONLINE RESOURCES

National Antimicrobial Resistance Monitoring System
http://www.cdc.gov/narms

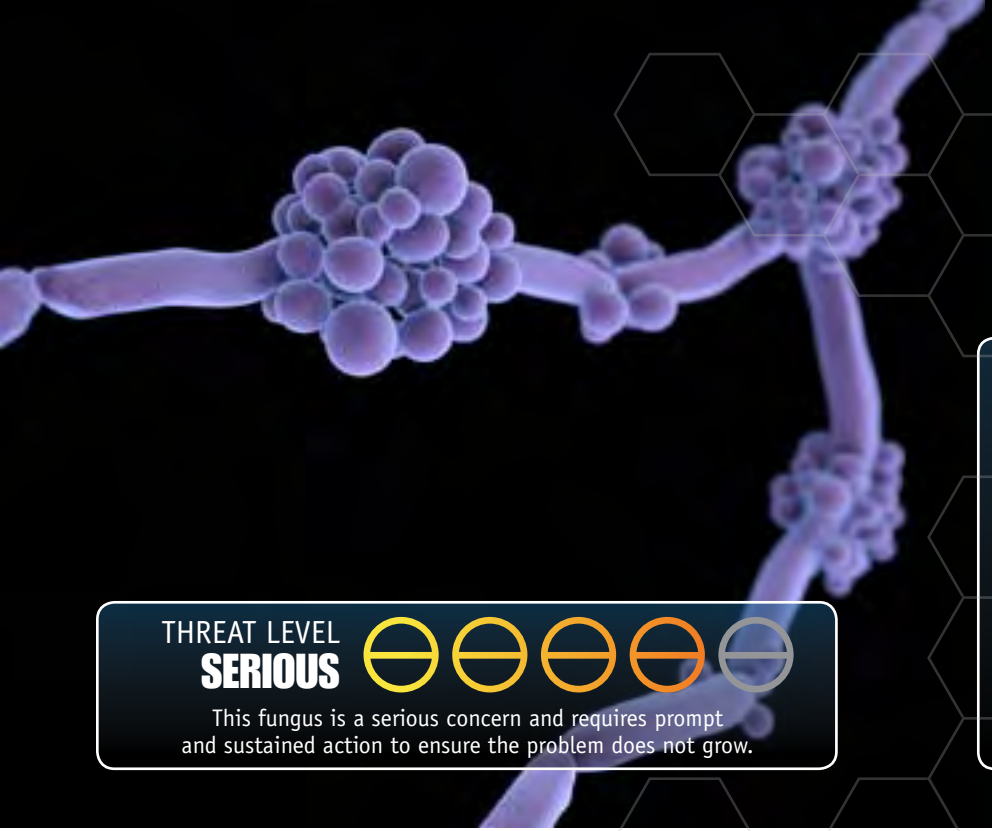
***Campylobacter* Information**
http://www.cdc.gov/nczved/divisions/dfbmd/diseases/campylobacter/

Traveler's Health
http://wwwnc.cdc.gov/travel/yellowbook/2012/chapter-2-the-pre-travel-consultation/travelers-diarrhea.htm

Vital Signs, June 2011: Making Food Safer to Eat
http://www.cdc.gov/VitalSigns/FoodSafety/

CS239559-B

FLUCONAZOLE-RESISTANT CANDIDA



THREAT LEVEL
SERIOUS

This fungus is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

3,400
FLUCONAZOLE-RESISTANT *CANDIDA* INFECTIONS

220
DEATHS

46,000
CANDIDA INFECTIONS PER YEAR

Candidiasis is a fungal infection caused by yeasts of the genus *Candida*. There are more than 20 species of *Candida* yeasts that can cause infection in humans, the most common of which is *Candida albicans*. *Candida* yeasts normally live on the skin and mucous membranes without causing infection. However, overgrowth of these microorganisms can cause symptoms to develop. Symptoms of candidiasis vary depending on the area of the body that is infected.

Candida is the fourth most common cause of healthcare-associated bloodstream infections in the United States. In some hospitals it is the most common cause. These infections tend to occur in the sickest of patients.

RESISTANCE OF CONCERN

- Some *Candida* strains are increasingly resistant to first-line and second-line antifungal treatment agents. Recent data demonstrate a marked shift among infections towards *Candida* species with increased resistance to antifungal drugs including azoles and echinocandins.
- CDC conducts multicenter surveillance for antifungal resistance in the United States, candidal infections, their economic impact, and possible areas where prevention and control strategies can be focused.

PUBLIC HEALTH THREAT

An estimated 46,000 healthcare-associated *Candida* infections occur among hospitalized patients in the United States each year. Roughly 30% of patients with bloodstream infections (candidemia) with drug-resistant *Candida* die during their hospitalization. CDC estimates that each case of *Candida* infection results in 3–13 days of additional hospitalization, and a total of $6,000–$29,000 in direct healthcare costs. Based on these estimates, we calculate resistant *Candida* infections may add millions of dollars in excess costs to U.S. healthcare expenditures each year.

	Percentage of Candida bloodstream isolates testing resistant	Estimated number of infections per year	Estimated number of deaths
Fluconazole-resistant *Candida* species	7%	3,400	220

For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

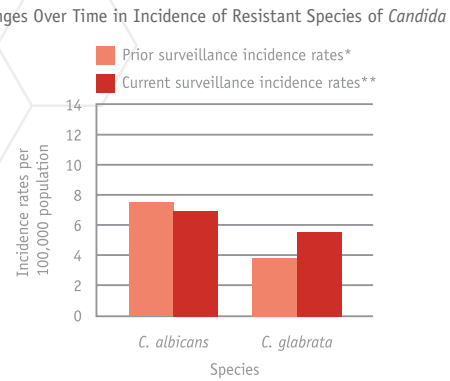
FIGHTING THE SPREAD OF RESISTANCE

Prevention strategies for candidemia are not well defined. Most infectious are thought to be caused by *Candida* that the patient carries on his or her own body. Therapy to prevent infections (antifungal prophylaxis) may be appropriate for some groups at high risk of developing *Candida* bloodstream infection, such as low-birth-weight infants. CDC recommendations for catheter care and handwashing can be helpful in reducing transmission in healthcare institutions.

WHAT CDC IS DOING

Prevention of significant morbidity and mortality from candidemia remains a challenge. Although antifungal prophylaxis has been shown to be effective in selected patient populations, there is still debate on the application of risk prevention tools and other prevention strategies. There is a continued need for surveillance of candidemia to develop and evaluate prevention strategies and to monitor for changes in incidence and resistance.

There is increasing incidence of *Candida* infections due to azole- and echinocandin-resistant strains.



*This accounts for data collected from Atlanta, GA from 1992-1993 and from Baltimore, MD from 1998–2000.
**This accounts for data collected from 2008–present.

ONLINE RESOURCES

CDC's candidiasis website
http://www.cdc.gov/fungal/candidiasis/

EXTENDED SPECTRUM β-LACTAMASE (ESBL) PRODUCING ENTEROBACTERIACEAE

26,000 DRUG-RESISTANT INFECTIONS

1,700 DEATHS

140,000 ENTEROBACTERIACEAE INFECTIONS PER YEAR

$40,000 IN EXCESS MEDICAL COSTS PER YEAR FOR EACH INFECTION

THREAT LEVEL **SERIOUS**

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Extended-spectrum β-lactamase is an enzyme that allows bacteria to become resistant to a wide variety of penicillins and cephalosporins. Bacteria that contain this enzyme are known as ESBLs or ESBL-producing bacteria. ESBL-producing Enterobacteriaceae are resistant to strong antibiotics including extended spectrum cephalosporins.

RESISTANCE OF CONCERN

Some Enterobacteriaceae are resistant to nearly all:

- penicillins
- cephalosporins

In these cases, the remaining treatment option is an antibiotic from the carbapenem family. These are drugs of last resort, and use of them is also contributing to resistance (see CRE fact sheet).

- Nearly 26,000 (or 19%) healthcare-associated Enterobacteriaceae infections are caused by ESBL-producing Enterobacteriaceae.
- Patients with bloodstream infections caused by ESBL-producing Enterobacteriaceae are about 57% more likely to die than those with bloodstream infections caused by a non ESBL-producing strain.

PUBLIC HEALTH THREAT

An estimated 140,000 healthcare-associated Enterobacteriaceae infections occur in the United States each year. CDC estimates that bloodstream infections caused by ESBL-containing Enterobacteriaceae result in upwards of $40,000 in excess hospital charges per occurrence. Approximately 26,000 infections and 1,700 deaths are attributable to ESBLs.

	Percentage of Enterobacteriaceae healthcare-associated infections resistant to extended spectrum cephalosporins	Estimated number of infections	Estimated number of deaths attributed
ESBL-producing *Klebsiella* spp.	23%	17,000	1,100
ESBL-producing *E. coli*	14%	9,000	600
Totals		26,000	1,700

For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

EXTENDED SPECTRUM β-LACTAMASE (ESBL) PRODUCING ENTEROBACTERIACEAE

FIGHTING THE SPREAD OF RESISTANCE

WHAT CDC IS DOING

- Tracking illness and identifying risk factors for drug-resistant infections using two systems, the National Healthcare Safety Network and the Emerging Infections Program.
- Providing outbreak support, such as staff expertise, prevention guidelines, tools, and lab assistance, to states and facilities.
- Developing tests and prevention recommendations to control drug-resistant infections.
- Helping medical facilities improve antibiotic prescribing practices.

WHAT YOU CAN DO

States and Communities Can:

- Know resistance trends in your region.
- Coordinate local and regional infection tracking and control efforts.
- Require facilities to alert each other when transferring patients with any infection.

Health Care CEOs, Medical Officers, and Other Healthcare Facility Leaders Can:

- Require and strictly enforce CDC guidance for infection detection, prevention, tracking, and reporting.
- Make sure your lab can accurately identify infections and alert clinical and infection prevention staff when these bacteria are present.
- Know infection and resistance trends in your facility and in the facilities around you.
- When transferring a patient, require staff to notify the other facility about all infections.
- Join or start regional infection prevention efforts.
- Promote wise antibiotic use.

Healthcare Providers Can:

- Know when and what types of drug-resistant infections are present in your facility and patients.
- Request immediate alerts when the lab identifies drug-resistant infections in your patients.
- Alert the other facility when you transfer a patient with a drug-resistant infection.
- Protect patients from drug-resistant infections.
- Follow relevant guidelines and precautions at every patient encounter.
- Prescribe antibiotics wisely.
- Remove temporary medical devices such as catheters and ventilators as soon as no longer needed.

Patients and Their Loved Ones Can:

- Ask everyone including doctors, nurses, other medical staff, and visitors, to wash their hands before touching the patient.
- Take antibiotics only and exactly as prescribed.

ONLINE RESOURCES

CDC's Heathcare-associated Infections(HAI) website
www.cdc.gov/hai

Healthcare-associated Infections (HAIs), Guidelines and Recommendations
www.cdc.gov/hicpac/pubs.html

CS239559-B

VANCOMYCIN-RESISTANT ENTEROCOCCUS (VRE)

20,000 DRUG-RESISTANT *ENTEROCOCCUS* INFECTIONS

1,300 DEATHS FROM DRUG-RESISTANT *ENTEROCOCCUS* INFECTIONS

66,000 *ENTEROCOCCUS* INFECTIONS PER YEAR

SOME *ENTEROCOCCUS* STRAINS ARE RESISTANT TO VANCOMYCIN

LEAVING FEW OR NO TREATMENT OPTIONS

THREAT LEVEL
SERIOUS

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Enterococci cause a range of illnesses, mostly among patients receiving healthcare, but include bloodstream infections, surgical site infections, and urinary tract infections.

RESISTANCE OF CONCERN

- *Enterococcus* often cause infections among very sick patients in hospitals and other healthcare-settings.
- Some *Enterococcus* strains are resistant to vancomycin, an antibiotic of last resort, leaving few or no treatment options.
- About 20,000 (or 30%) of *Enterococcus* healthcare-associated infections are vancomycin resistant.

PUBLIC HEALTH THREAT

An estimated 66,000 healthcare-associated *Enterococcus* infections occur in the United States each year. The proportion of infections that occur with a vancomycin resistant strain differs by the species of *Enterococcus;* overall 20,000 vancomycin-resistant infections occurred among hospitalized patients each year, with approximately 1,300 deaths attributed to these infections.

	Percent of all *Enterococcus* healthcare-associated infections resistant to vancomycin	Estimated number of infections	Estimated number of deaths attributed
Vancomycin-resistant *Enterococcus faecium*	77%	10,000	650
Vancomycin-resistant *Enterococcus faecalis*	9%	3,100	200
Vancomycin-resistant *Enterococcus* (species not determined)	40%	6,900	450
Totals		20,000	1,300

For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

VANCOMYCIN-RESISTANT ENTEROCOCCUS (VRE)

FIGHTING THE SPREAD OF RESISTANCE

WHAT CDC IS DOING

- Tracking illness and identifying risk factors for drug-resistant infections using two systems, the National Healthcare Safety Network and the Emerging Infections Program.
- Providing outbreak support such as staff expertise, prevention guidelines, tools, and lab assistance, to states and facilities.
- Developing tests and prevention recommendations to control drug-resistant infections.
- Helping medical facilities improve antibiotic prescribing practices.

WHAT YOU CAN DO

States and Communities can:

- Know resistance trends in your region.
- Coordinate local and regional infection tracking and control efforts.
- Require facilities to alert each other when transferring patients with any infection.

Healthcare CEOs, Medical Officers, and other Healthcare Facility Leaders can:

- Require and strictly enforce CDC guidance for infection detection, prevention, tracking, and reporting.
- Make sure your lab can accurately identify infections and alert clinical and infection prevention staff when these germs are present.
- Know infection and resistance trends in your facility and in the facilities around you.
- When transferring a patient, require staff to notify the other facility about all infections.
- Join or start regional infection prevention efforts.
- Promote wise antibiotic use.

Doctors and Nurses can:

- Know when and what types of drug-resistant infections are present in your facility and patients Request immediate alerts when the lab identifies drug-resistant infections in your patients.
- Alert the other facility when you transfer a patient with a drug-resistant infection.
- Protect patients from drug-resistant infections.
- Follow relevant guidelines and precautions at every patient encounter.
- Prescribe antibiotics wisely.
- Remove temporary medical devices such as catheters and ventilators as soon as no longer needed.

Patients and their loved ones can:

- Ask everyone including doctors, nurses, other medical staff, and visitors, to wash their hands before touching the patient.
- Take antibiotics only and exactly as prescribed.

ONLINE RESOURCES

Vancomycin-resistant Enterococci (VRE) in Healthcare Settings
http://www.cdc.gov/HAI/organisms/vre/vre.html

Healthcare-associated Infections (HAIs), Guidelines and Recommendations
www.cdc.gov/hicpac/pubs.html

CS239559-B

MULTIDRUG-RESISTANT PSEUDOMONAS AERUGINOSA

6,700 MULTIDRUG-RESISTANT *PSEUDOMONAS* INFECTIONS

440 DEATHS

51,000 *PSEUDOMONAS* INFECTIONS PER YEAR

THREAT LEVEL
SERIOUS

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Pseudomonas aeruginosa is a common cause of healthcare-associated infections including pneumonia, bloodstream infections, urinary tract infections, and surgical site infections.

RESISTANCE OF CONCERN

- Some strains of *Pseudomonas aeruginosa* have been found to be resistant to nearly all or all antibiotics including aminoglycosides, cephalosporins, fluoroquinolones, and carbapenems.
- Approximately 8% of all healthcare-associated infections reported to CDC's National Healthcare Safety Network are caused by *Pseudomonas aeruginosa*.
- About 13% of severe healthcare-associated infections caused by *Pseudomonas aeruginosa* are multidrug resistant, meaning several classes of antibiotics no longer cure these infections.

PUBLIC HEALTH THREAT

An estimated 51,000 healthcare-associated *Pseudomonas aeruginosa* infections occur in the United States each year. More than 6,000 (or 13%) of these are multidrug-resistant, with roughly 400 deaths per year attributed to these infections.

	Percentage of all *Pseudomonas aeruginosa* healthcare-associated infections that are multidrug-resistant	Estimated number of infections	Estimated number of deaths attributed
Multi-drug resistant *Pseudomonas aeruginosa*	13%	6,700	440

For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

MULTIDRUG-RESISTANT PSEUDOMONAS AERUGINOSA

FIGHTING THE SPREAD OF RESISTANCE

WHAT CDC IS DOING

- Identifying and tracking risk factors for drug-resistant infections using two systems, the National Healthcare Safety Network and the Emerging Infections Program.
- Providing outbreak support such as staff expertise, prevention guidelines, tools, and lab assistance, to states and facilities.
- Developing tests and prevention recommendations to control drug-resistant infections.
- Helping medical facilities improve antibiotic prescribing practices.

WHAT YOU CAN DO

States and Communities Can:

- Know resistance trends in your region.
- Coordinate local and regional infection tracking and control efforts.
- Require facilities to alert each other when transferring patients with any infection.

Health Care CEOs, Medical Officers, and Other Healthcare Facility Leaders Can:

- Require and strictly enforce CDC guidance for infection detection, prevention, tracking, and reporting.
- Make sure your lab can accurately identify infections and alert clinical and infection prevention staff when these bacteria are present.
- Know infection and resistance trends in your facility and in the facilities around you.
- When transferring a patient, require staff to notify the other facility about all infections.
- Join or start regional infection prevention efforts.
- Promote wise antibiotic use.

Healthcare Providers Can:

- Know when and what types of drug-resistant infections that are present in your facility and patients.
- Request immediate alerts when the lab identifies drug-resistant infections in your patients.
- Alert the other facility when you transfer a patient with a drug-resistant infection.
- Protect patients from drug-resistant infections.
- Follow relevant guidelines and precautions at every patient encounter.
- Prescribe antibiotics wisely.
- Remove temporary medical devices such as catheters and ventilators as soon as no longer needed.

Patients and Their Loved Ones Can:

- Ask everyone including doctors, nurses, other medical staff, and visitors, to wash their hands before touching the patient.
- Take antibiotics only and exactly as prescribed.

ONLINE RESOURCES

Healthcare-associated Infections (HAI)
www.cdc.gov/hai

Healthcare-associated Infections (HAIs), Guidelines and Recommendations
www.cdc.gov/hicpac/pubs.html

CS239559-B

DRUG-RESISTANT NON-TYPHOIDAL SALMONELLA

THREAT LEVEL
SERIOUS

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

100,000
DRUG-RESISTANT *SALMONELLA* INFECTIONS PER YEAR

1,200,000
SALMONELLA INFECTIONS PER YEAR

$365,000,000
IN MEDICAL COSTS PER YEAR

Non-typhoidal *Salmonella* (serotypes other than Typhi, Paratyphi A, Paratyphi B, and Paratyphi C) usually causes diarrhea (sometimes bloody), fever, and abdominal cramps. Some infections spread to the blood and can have life-threatening complications.

RESISTANCE OF CONCERN

Physicians rely on drugs, such as ceftriaxone and ciprofloxacin, for treating patients with complicated *Salmonella* infections. Resistant infections are more severe and have higher hospitalization rates. Non-typhoidal *Salmonella* is showing resistance to:

- ceftriaxone
- ciprofloxacin
- multiple classes of drugs

PUBLIC HEALTH THREAT

Non-typhoidal *Salmonella* causes approximately 1.2 million illnesses, 23,000 hospitalizations, and 450 deaths each year in the United States. Direct medical costs are estimated to be $365 million annually. CDC is seeing resistance to ceftriaxone in about 3% of non-typhoidal *Salmonella* tested, and some level of resistance to ciprofloxacin in about 3%. About 5% of non-typhoidal *Salmonella* tested by CDC are resistant to five or more types of drugs. Costs are expected to be higher for resistant than for susceptible infections because resistant infections are more severe, those patients are more likely to be hospitalized, and treatment is less effective.

	Percentage of all non-typhoidal *Salmonella**	Estimated number of illnesses per year	Estimated illnesses per 100,000 U.S. population	Estimated number of deaths per year
Ceftriaxone resistance	3%	36,000	12.0	13
Ciprofloxacin resistance or partial resistance	3%	33,000	10.9	12
Resistance to 5 or more antibiotic classes	5%	66,000	21.9	24
Any resistance pattern above	8%	100,000	34.1	38

*3-year average (2009–2011)
For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

DRUG-RESISTANT NON-TYPHOIDAL SALMONELLA

FIGHTING THE SPREAD OF RESISTANCE

Salmonella spreads from animals to people mostly through food. Antibiotic use in food animals can result in resistant *Salmonella*, and people get sick when they eat foods contaminated with *Salmonella*. Key measures to prevent resistant infections include:

- Avoiding inappropriate antibiotic use in food animals.
- Tracking antibiotic use in different types of food animals.
- Stopping spread of *Salmonella* among animals on farms.
- Improving food production and processing to reduce contamination.
- Educating consumers and food workers about safe food handling practices.

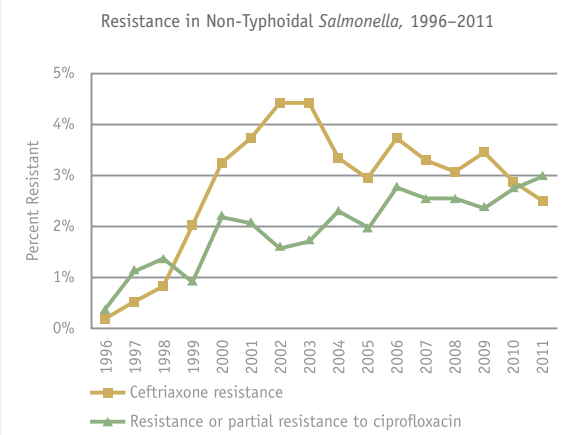
WHAT CDC IS DOING

- Tracking changes in antibiotic resistance through ongoing surveillance.
- Promoting initiatives that measure and improve antibiotic use in food animals.
- Determining foods responsible for outbreaks of *Salmonella* infections.
- Supporting and improving local, state, and federal public health surveillance.
- Guiding prevention efforts by estimating how much illness occurs and identifying the sources of infection.
- Educating people about how to avoid *Salmonella* infections.

WHAT YOU CAN DO

- **Clean.** Wash hands, cutting boards, utensils, and countertops.
- **Separate.** Keep raw meat, poultry, and seafood separate from ready-to-eat foods.
- **Cook.** Use a food thermometer to ensure that foods are cooked to a safe internal temperature.
- **Chill.** Keep your refrigerator below 40°F and refrigerate food that will spoil.
- Avoid drinking raw milk.
- Report suspected illness from food to your local health department.
- Don't prepare food for others if you have diarrhea or vomiting.
- Be especially careful preparing food for children, pregnant women, those in poor health, and older adults.

Drug resistance in non-typhoidal *Salmonella* continues to climb from 1996 levels.



For more information about data methods and references, please see appendix.

ONLINE RESOURCES

National Antimicrobial Resistance Monitoring System
http://www.cdc.gov/narms

Salmonella
http://www.cdc.gov/salmonella/index.html

Vital Signs, June 2011: Making Food Safer to Eat
http://www.cdc.gov/VitalSigns/FoodSafety/?pkw=vs_fs009

CS239559-B

DRUG-RESISTANT SALMONELLA SEROTYPE TYPHI

THREAT LEVEL
SERIOUS

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

3,800
DRUG-RESISTANT *SALMONELLA* TYPHI INFECTIONS PER YEAR IN THE U.S.

67%
OF *SALMONELLA* TYPHI INFECTIONS ARE DRUG RESISTANT

620
HOSPITALIZATIONS DUE TO *SALMONELLA* TYPHI PER YEAR IN THE U.S.

21,700,000 *SALMONELLA* TYPHI INFECTIONS WORLDWIDE

Salmonella serotype Typhi causes typhoid fever, a potentially life-threatening disease. People with typhoid fever usually have a high fever, abdominal pain, and headache. Typhoid fever can lead to bowel perforation, shock, and death.

RESISTANCE OF CONCERN

Physicians rely on drugs such as ceftriaxone, azithromycin, and ciprofloxacin for treating patients with typhoid fever. *Salmonella* serotype Typhi is showing resistance to:

- ceftriaxone
- azithromycin
- ciprofloxacin (resistance is so common that it cannot be routinely used)

PUBLIC HEALTH THREAT

Salmonella Typhi causes approximately 21.7 million illnesses worldwide. In the United States, it causes approximately 5,700 illnesses and 620 hospitalizations each year. Most illnesses occur in people who travel to some parts of the developing world where the disease is common. Travel-associated infections are more likely to be antibiotic resistant. CDC is seeing some level of resistance to ciprofloxacin in two-thirds of *Salmonella* Typhi tested. CDC has not yet seen resistance to ceftriaxone or azithromycin in the United States, but this has been seen in other parts of the world. Resistant infections are likely to cost more than susceptible infections because illness may last longer. Deaths in the United States are rare now, but before there were antibiotics, 10% to 20% of patients died.

	Percentage of all *Salmonella* Typhi*	Estimated number of illnesses per year	Estimated illnesses per 100,000 U.S. population	Estimated number of deaths per year
Resistance or partial resistance to ciprofloxacin	67%	3,800	1.3	<5

*3-year average (2009–2011)
For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

DRUG-RESISTANT SALMONELLA SEROTYPE TYPHI

FIGHTING THE SPREAD OF RESISTANCE

Salmonella serotype Typhi spreads from one person to another through food or water contaminated with feces. Typhoid fever is common in developing countries lacking safe water and adequate sanitation. Most U.S. cases are associated with travel to those countries. Sometimes the source is a carrier who is no longer ill, but is still infected. Key measures to prevent the spread of resistant infections include:

- Vaccinating people traveling to countries where typhoid fever is common.
- Consuming safe food and water when traveling in those countries.
- Improving access to clean water and sanitation for people living in those countries.
- Reporting changes in resistance to people who diagnose and treat patients with typhoid fever.
- Investigating cases of typhoid fever to identify and treat carriers.

WHAT CDC IS DOING

- Providing recommendations for travelers on vaccination, safe food, and clean water.
- Tracking and reporting changes in antibiotic resistance through ongoing surveillance.
- Determining settings and high-risk groups for resistant infections in the U.S. and other countries.
- Educating healthcare providers about specific resistance problems and the need to vaccinate travelers.
- Promoting safer water and sanitation in countries where typhoid fever is common.
- Building public health capacity in other countries to diagnose, track, and control typhoid fever.

ONLINE RESOURCES

National Antimicrobial Resistance Monitoring System
http://www.cdc.gov/narms

Typhoid Fever
http://www.cdc.gov/nczved/divisions/dfbmd/diseases/typhoid_fever/

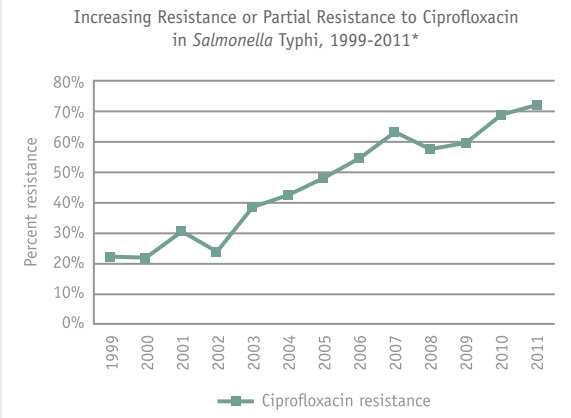
Traveler's Health "Traveler's Diarrhea"
http://wwwnc.cdc.gov/travel/yellowbook/2012/chapter-2-the-pre-travel-consultation/travelers-diarrhea.htm

WHAT YOU CAN DO

If you're traveling to a country where typhoid fever is common:

- Get vaccinated against typhoid fever before you depart.
- Choose foods and drinks carefully while traveling even if you are vaccinated. That means: boil it, cook it, peel it, or forget it.
  - Boil or treat water yourself.
  - Eat foods that are hot and steaming.
  - Avoid raw fruits and vegetables unless you peel them yourself.
  - Avoid cold food and beverages from street vendors.
- If you get sick with high fever and a headache during or after travel, seek medical care at once and tell the healthcare provider where you have traveled.

Drug resistance in *Salmonella* Typhi has jumped significantly—from about 20% in 1999 to more than 70% in 2011.



DRUG-RESISTANT SHIGELLA

27,000 DRUG-RESISTANT *SHIGELLA* INFECTIONS PER YEAR

500,000 *SHIGELLA* INFECTIONS PER YEAR

40 DEATHS PER YEAR

THREAT LEVEL **SERIOUS**

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Shigella usually causes diarrhea (sometimes bloody), fever, and abdominal pain. Sometimes it causes serious complications such as reactive arthritis. High-risk groups include young children, people with inadequate handwashing and hygiene habits, and men who have sex with men.

RESISTANCE OF CONCERN

Resistance to traditional first-line drugs such as ampicillin and trimethoprim-sulfamethoxazole has become so high that physicians must now rely on alternative drugs like ciprofloxacin and azithromycin to treat infections. Resistant infections can last longer than infections with susceptible bacteria (bacteria that can be treated effectively with antibiotics). *Shigella* is showing resistance to:

- ciprofloxacin
- azithromycin

	Percentage of all *Shigella**	Estimated number of illnesses per year	Estimated illnesses per 100,000 U.S. population	Estimated number of deaths per year
Ciprofloxacin resistance	2%	12,000	4.0	<5
Azithromycin resistance	3%	15,000	5.1	<5
Azithromycin or ciprofloxacin resistance	6%	27,000	9.1	<5

*Percentage of all isolates that were resistant in 2011.
For more information about data methods and references, please see technical appendix.

PUBLIC HEALTH THREAT

Shigella causes approximately 500,000 diarrheal illnesses, 5,500 hospitalizations, and 40 deaths each year in the United States. CDC is seeing resistance to ciprofloxacin in 1.6% of the *Shigella* cases tested and resistance to azithromycin in approximately 3%. Because initial treatment can fail, costs are expected to be higher for resistant infections.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

FIGHTING THE SPREAD OF RESISTANCE

Shigella spreads from one person to another in feces through direct contact, or through contaminated surfaces, food, or water. Antibiotic use in humans can result in resistant *Shigella* and hasten further spread. Key measures to prevent resistant infections include:

- Promoting thorough and frequent hand washing with soap, especially in child care centers, elementary schools, restaurants, and homes with small children.
- Using antibiotics to treat more severe *Shigella* infections and managing milder infections with fluids and rest.
- Reporting changes in resistance to healthcare providers.
- Detecting and controlling outbreaks of *Shigella* infections.
- Educating consumers and food workers about safe food handling practices.

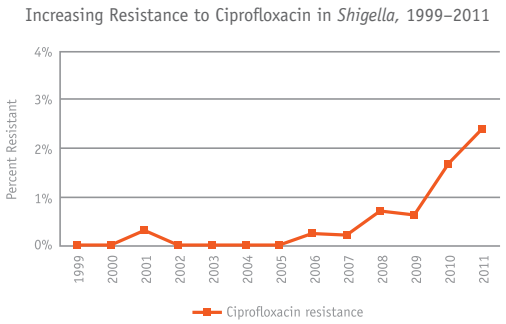
WHAT CDC IS DOING

- Tracking changes in antibiotic resistance through ongoing surveillance.
- Determining settings and high-risk groups for outbreaks of resistant infections.
- Educating healthcare providers about specific resistance problems.
- Promoting prudent antibiotic use and handwashing.

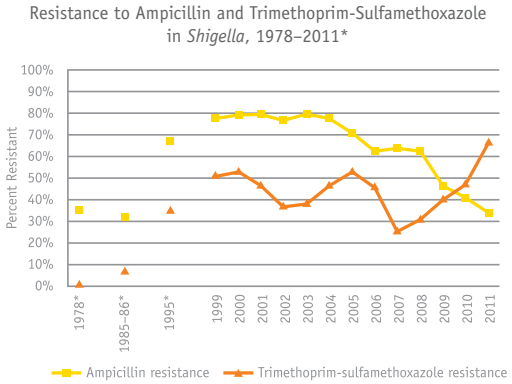
WHAT YOU CAN DO

- Don't prepare food for others if you have diarrhea or vomiting.
- Keep children who have diarrhea and who are in diapers out of child care settings and swimming pools.
- Avoid sexual behavior that is likely to transmit infection when you have diarrhea.
- Consume safe food and water when traveling abroad.

Drug-resistant *Shigella* has been making steady increases since 2006.



While resistance to ampicillin has decreased, *Shigella* continues to become more resistant to trimethoprim-sulfamethoxazole.



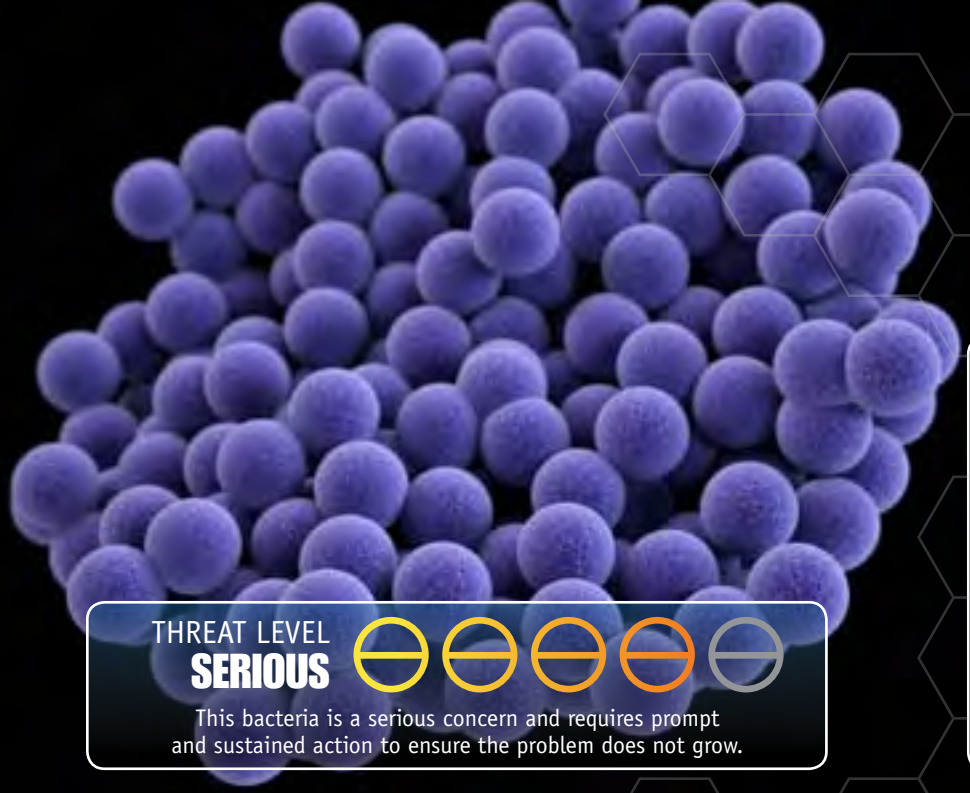
*Data for 1978-1995 were from three sentinel county surveys. Annual testing began in 1999.

ONLINE RESOURCES

National Antimicrobial Resistance Monitoring System
http://www.cdc.gov/narms

Shigellosis
http://www.cdc.gov/nczved/divisions/dfbmd/diseases/shigellosis/

Traveler's Health "Traveler's Diarrhea"
http://wwwnc.cdc.gov/travel/yellowbook/2012/chapter-2-the-pre-travel-consultation/travelers-diarrhea.htm



METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS (MRSA)

80,461 SEVERE MRSA INFECTIONS PER YEAR

11,285 DEATHS FROM MRSA PER YEAR

STAPH BACTERIA ARE A LEADING CAUSE OF **HEALTHCARE-ASSOCIATED INFECTIONS**

THREAT LEVEL **SERIOUS**

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Methicillin-resistant *Staphylococcus aureus* (MRSA) causes a range of illnesses, from skin and wound infections to pneumonia and bloodstream infections that can cause sepsis and death. Staph bacteria, including MRSA, are one of the most common causes of healthcare-associated infections.

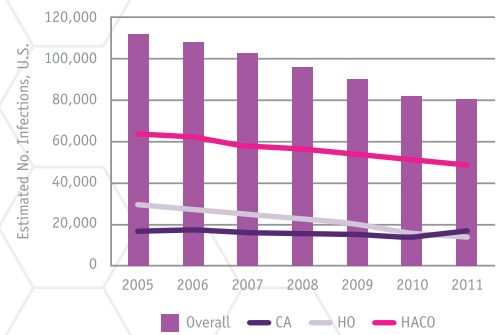
RESISTANCE OF CONCERN

Resistance to methicillin and related antibiotics (e.g., nafcillin, oxacillin) and resistance to cephalosporins are of concern.

PUBLIC HEALTH THREAT

CDC estimates 80,461 invasive MRSA infections and 11,285 related deaths occurred in 2011. An unknown but much higher number of less severe infections occurred in both the community and in healthcare settings.

Severe MRSA infections mostly occur during or soon after inpatient medical care.



For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS (MRSA)

FIGHTING THE SPREAD OF RESISTANCE

Although still a common and severe threat to patients, invasive MRSA infections in healthcare settings appear to be declining. Between 2005 and 2011 overall rates of invasive MRSA dropped 31%; the largest declines (54%) were observed among infections occurring during hospitalization. Success began with preventing central-line associated bloodstream infections with MRSA, where rates fell nearly 50% from 1997 to 2007.

During the past decade, rates of MRSA infections have increased rapidly among the general population (people who have not recently received care in a healthcare setting). There is some evidence that these increases are slowing, but they are not following the same downward trends as healthcare-associated MRSA.

WHAT CDC IS DOING

- Tracking illness and identifying risk factors for drug-resistant infections using two systems, the National Healthcare Safety Network and the Emerging Infections Program.
- Providing states and facilities with outbreak support such as staff expertise, prevention guidelines, tools, and lab assistance.
- Developing tests and prevention recommendations to control drug-resistant infections.
- Helping healthcare facilities improve antibiotic prescribing practices.

WHAT YOU CAN DO

States and Communities Can:

- Know resistance trends in your region.
- Coordinate local and regional infection tracking and control efforts.
- Require facilities to alert each other when transferring patients with any infection.

Healthcare CEOs, Medical Officers, and Other Healthcare Facility Leaders Can:

- Require and strictly enforce CDC guidance for infection detection, prevention, tracking, and reporting.
- Make sure your lab can accurately identify infections and alert clinical and infection prevention staff when these bacteria are present.
- Know infection and resistance trends in your facility and in the facilities around you.
- When transferring a patient, require staff to notify the other facility about all infections.
- Join or start regional infection prevention efforts.
- Promote wise antibiotic use.

Healthcare Providers Can:

- Know when and types of drug-resistant infections are present in your facility and patients.
- Request immediate alerts when the lab identifies drug-resistant infections in your patients.
- Alert the other facility when you transfer a patient with a drug-resistant infection.
- Protect patients from drug-resistant infections.
- Follow relevant guidelines and precautions at every patient encounter.
- Prescribe antibiotics wisely.
- Remove temporary medical devices such as catheters and ventilators as soon as no longer needed.

Patients and Their Loved Ones Can:

- Ask everyone, including doctors, nurses, other medical staff, and visitors, to wash their hands before touching the patient.
- Take antibiotics only and exactly as prescribed.

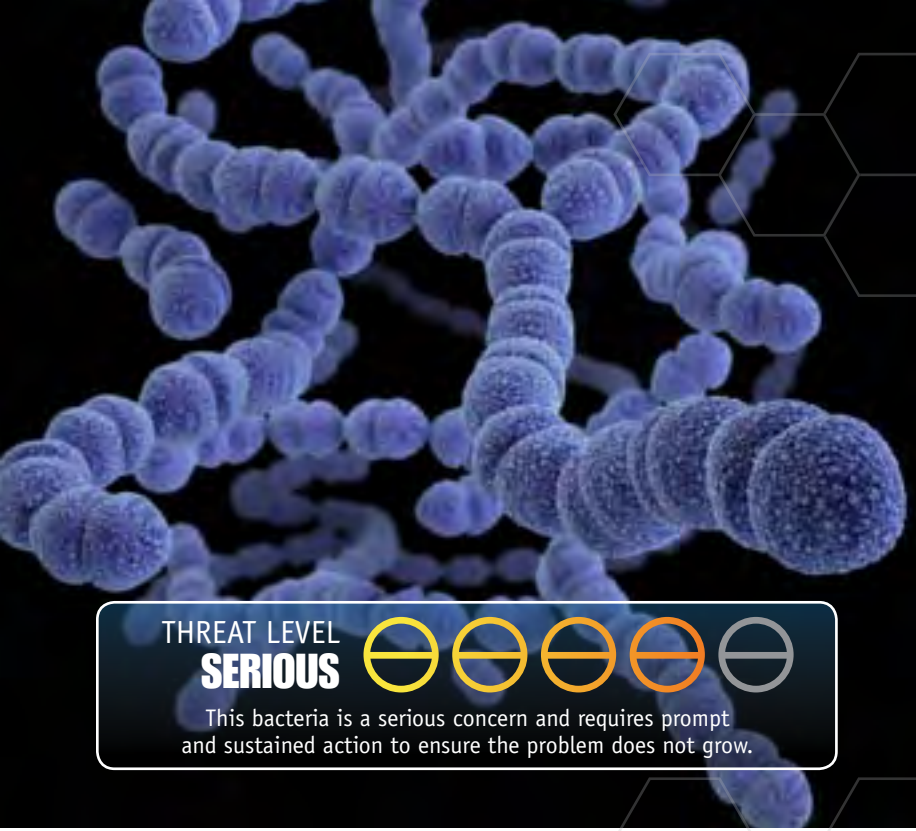
ONLINE RESOURCES

Resources CDC's MRSA website
www.cdc.gov/hai/mrsa

Prevention Guidelines for MRSA
www.cdc.gov/hicpac/pubs.html

Medscape/CDC Expert Commentaries about MRSA
http://www.medscape.com/partners/cdc/public/cdc-commentary

CS239559-B



DRUG-RESISTANT STREPTOCOCCUS PNEUMONIAE

1,200,000 DRUG-RESISTANT INFECTIONS PER YEAR

19,000 EXCESS HOSPITALIZATIONS

7,000 DEATHS

$96,000,000 IN EXCESS MEDICAL COSTS PER YEAR

THREAT LEVEL **SERIOUS**

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Streptococcus pneumoniae (S. pneumoniae, or pneumococcus) is the leading cause of bacterial pneumonia and meningitis in the United States. It also is a major cause of bloodstream infections and ear and sinus infections.

RESISTANCE OF CONCERN

S. pneumoniae has developed resistance to drugs in the penicillin and erythromycin groups. Examples of these drugs include amoxicillin and azithromycin (Zithromax, Z-Pak). *S. pneumoniae* has also developed resistance to less commonly used drugs.

PUBLIC HEALTH THREAT

Pneumococcal disease, whether or not resistant to antibiotics, is a major public health problem. Pneumococcal disease causes 4 million disease episodes and 22,000 deaths annually. Pneumococcal ear infections (otitis media) are the most common type of pneumococcal disease among children, causing 1.5 million infections that often result in antibiotic use. Pneumococcal pneumonia is another important form of pneumococcal disease. Each year, nearly 160,000 children younger than 5 years old see a doctor or are admitted to the hospital with pneumococcal pneumonia. Among adults, over 600,000 seek care for or are hospitalized with pneumococcal pneumonia. Pneumococcal pneumonia accounts for 72% of all direct medical costs for treatment of pneumococcal disease.

In 30% of severe *S. pneumoniae* cases, the bacteria are fully resistant to one or more clinically relevant antibiotics. Resistant infections complicate treatment and can result in almost 1,200,000 illnesses and 7,000 deaths per year. Cases of resistant pneumococcal pneumonia result in about 32,000 additional doctor visits and about 19,000 additional hospitalizations each year. The excess costs associated with these cases are approximately $96 million.

Invasive pneumococcal disease means that bacteria invade parts of the body that are normally sterile, and when this happens, disease is usually severe, causing hospitalization or even death. The majority of cases and deaths occur among adults 50 years or older, with the highest rates among those 65 years or older. Almost everyone who gets invasive pneumococcal disease needs treatment in the hospital.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

DRUG-RESISTANT STREPTOCOCCUS PNEUMONIAE

FIGHTING THE SPREAD OF RESISTANCE

Pneumococcal conjugate vaccine (PCV) is an effective tool to prevent infections. Vaccine use has not only reduced the burden of invasive pneumococcal disease, but it has also reduced antibiotic resistance by blocking the transmission of resistant *S. pneumoniae* strains. From 2000–2009, PCV7 provided protection against seven pneumococcal strains, and beginning in 2010 use of PCV13 expanded that protection to 13 strains. Achieving high vaccination coverage and encouraging appropriate antibiotic use will slow the spread of pneumococcal resistance. Using the right antibiotic at the right time is crucial.

WHAT CDC IS DOING

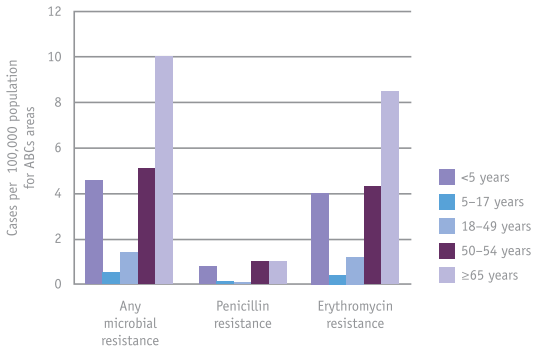
Through partnerships between CDC, state health departments, and universities, CDC is tracking *S. pneumoniae* through its Active Bacterial Core surveillance (ABCs). CDC is promoting appropriate antibiotic use among outpatient health care providers and the public through its Get Smart: Know When Antibiotics Work program. As part of this program, CDC hosts Get Smart About Antibiotic Week, an annual one week observance of the importance of appropriate antibiotic use and its impact on antibiotic resistance. CDC is also working with many partners in the U.S. to ensure that pneumococcal vaccines are available for children and that uptake is high.

WHAT YOU CAN DO

- Prevent infections by getting recommended vaccines and practicing good hand hygiene.
- Take antibiotics exactly as the doctor prescribes. Do not skip doses. Complete the prescribed course of treatment, even when you start feeling better.
- Only take antibiotics prescribed for you; do not share or use leftover antibiotics.
- Do not save antibiotics for the next illness. Discard any leftover medication once the prescribed course of treatment is completed.
- Do not ask for antibiotics when your doctor thinks you do not need them.

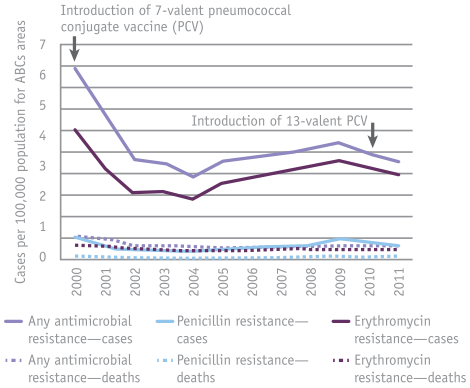
The very young and senior adults are most at risk for drug-resistant pneumococcal disease.

Cases of antibiotic-resistant invasive disease per 100,000 persons, by age group and resistance profile — Active Bacterial Core surveillance



Vaccination prevents spread of drug-resistant *S. pneumoniae* infections.

Cases and deaths per 100,000 population by resistance profile — ABCs areas, 2000–2011



In 2010, 13-valent pneumococcal conjugate vaccine (PCV13) replaced 7-valent pneumococcal conjugate vaccine (PCV7).

ONLINE RESOURCES

Pneumococcal Disease
www.cdc.gov/pneumococcal

Pneumococcal Vaccine Recommendations
http://www.cdc.gov/vaccines/vpd-vac/pneumo/in-short-both.htm#who

Get Smart: Know When Antibiotics Work Program
http://www.cdc.gov/getsmart/

Active Bacterial Core surveillance (ABCs)
http://www.cdc.gov/abcs/index.html

Drug-Resistant *Streptococcus pneumoniae* (DRSP) Surveillance Toolkit
http://www.cdc.gov/abcs/reports-findings/surv-manual.html

CS239559-B

DRUG-RESISTANT TUBERCULOSIS

1,042 DRUG-RESISTANT TUBERCULOSIS CASES IN 2011 (U.S.)

10,528 TUBERCULOSIS CASES IN 2011 (U.S.)

TUBERCULOSIS IS AMONG THE MOST COMMON INFECTIOUS DISEASES AND **FREQUENT CAUSES OF DEATH WORLDWIDE**

THREAT LEVEL **SERIOUS**

This bacteria is a serious concern and requires prompt and sustained action to ensure the problem does not grow.

Tuberculosis (TB) is among the most common infectious diseases and a frequent cause of death worldwide. TB is caused by the bacteria *Mycobacterium tuberculosis (M. tuberculosis)* and is spread most commonly through the air. *M. tuberculosis* can affect any part of the body, but disease is found most often in the lungs. In most cases, TB is treatable and curable with the available first-line TB drugs; however, in some cases, *M. tuberculosis* can be resistant to one or more of the drugs used to treat it. Drug-resistant TB is more challenging to treat — it can be complex and requires more time and more expensive drugs that often have more side effects. Extensively Drug-Resistant TB (XDR TB) is resistant to most TB drugs; therefore, patients are left with treatment options that are much less effective. The major factors driving TB drug resistance are incomplete or wrong treatment, short drug supply, and lack of new drugs. In the United States most drug-resistant TB is found among persons born outside of the country.

RESISTANCE OF CONCERN

- Resistance to antibiotics used for standard therapy
- Resistance to isoniazid (INH)
- Some TB is multidrug-resistant (MDR), showing resistance to at least INH and rifampicin (RMP), two essential first-line drugs
- Some TB is XDR TB, defined as MDR TB plus resistance to any fluoroquinolone and to any of the three second-line injectable drugs (i.e., amikacin, kanamycin, capreomycin)

	Number of cases	Cases per 100,000 U.S. population	Percent of all TB cases in U.S.
Any first-line resistance	1,042	0.33	10%
INH resistance	740	0.24	7%
MDR TB	124	0.04	1%
XDR TB	6	0.0019	<1%
Deaths caused by antibiotic-resistant TB	50		

For more information about data methods and references, please see technical appendix.

PUBLIC HEALTH THREAT

Of a total of 10,528 cases of TB in the United States reported in 2011, antibiotic resistance was identified in 1,042, or 9.90%, of all TB cases.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

FIGHTING THE SPREAD OF RESISTANCE

Health care providers can help prevent drug-resistant TB by quickly suspecting and diagnosing cases, following recommended treatment guidelines, monitoring patients' response to treatment, and ensuring therapy is completed. Additional drug-resistant TB prevention measures include implementing effective infection control procedures that help limit exposure to known drug-resistant TB patients in settings such as hospitals, prisons, or homeless shelters.

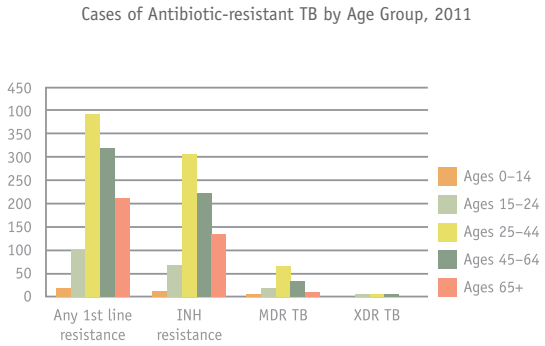
WHAT CDC IS DOING

CDC conducts ongoing surveillance for drug-resistant TB in all 50 states and the District of Columbia using the National Tuberculosis Surveillance System (NTSS). The TB Genotyping Information Management System (TBGIMS), a Web-based system designed to improve access and dissemination of genotyping information nationwide, complements the ongoing surveillance for drug- resistant TB by linking genotyping results to surveillance data. In 2009, CDC implemented the Molecular Detection of Drug Resistance Service (MDDR), a national clinical referral service which provides rapid confirmation of MDR and XDR TB. Molecular drug-resistant testing enhances but does not replace culture or conventional drug-susceptibility testing.

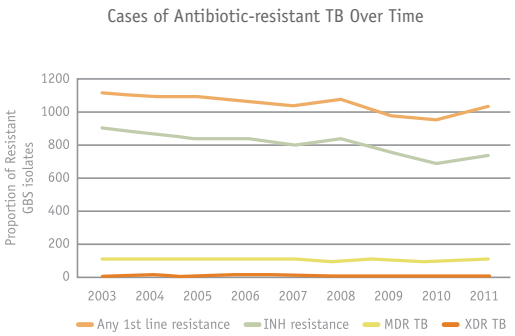
Other CDC activities directed at preventing spread of drug-resistant TB include funding of five TB Regional Training and Medical Consultation Centers (RTMCCs) from 2013–2017. The RTMCCs are regionally assigned to cover all 50 states and the U.S. territories. One of the primary purposes of each RTMCC is to provide medical consultation to TB programs and medical providers, particularly for complex, drug-resistant cases. Additionally, the RTMCCs offer trainings that provide information on diagnosing and treating drug-resistant TB.

Additionally, CDC international activities include studies to improve first and second line antibiotic use in patients with drug-resistant TB.

Antibiotic resistance occurs most often among those aged 25-44.



The number of TB cases with isoniazid resistance or any first-line antibiotic resistance declined from 2003 through 2011. However, both types of resistance had increases in cases in 2011. Multidrug-resistant TB has been fairly consistent over this same time period



ONLINE RESOURCES

http://www.cdc.gov/tb/

http://www.cdc.gov/tb/topic/drtb/default.htm

http://www.cdc.gov/tb/publications/factsheets/drtb/mdrtb.htm

http://www.cdc.gov/tb/topic/drtb/xdrtb.htm

http://www.cdc.gov/tb/statistics/reports/2011/default.htm

http://www.cdc.gov/tb/topic/Laboratory/mddr.htm

http://www.aphl.org/aphlprograms/infectious/tuberculosis/Pages/default.aspx

http://www.tbcontrollers.org/

http://www.who.int/tb/publications/mdr_surveillance/en/index.html

CS239559-B

THREAT LEVEL
CONCERNING

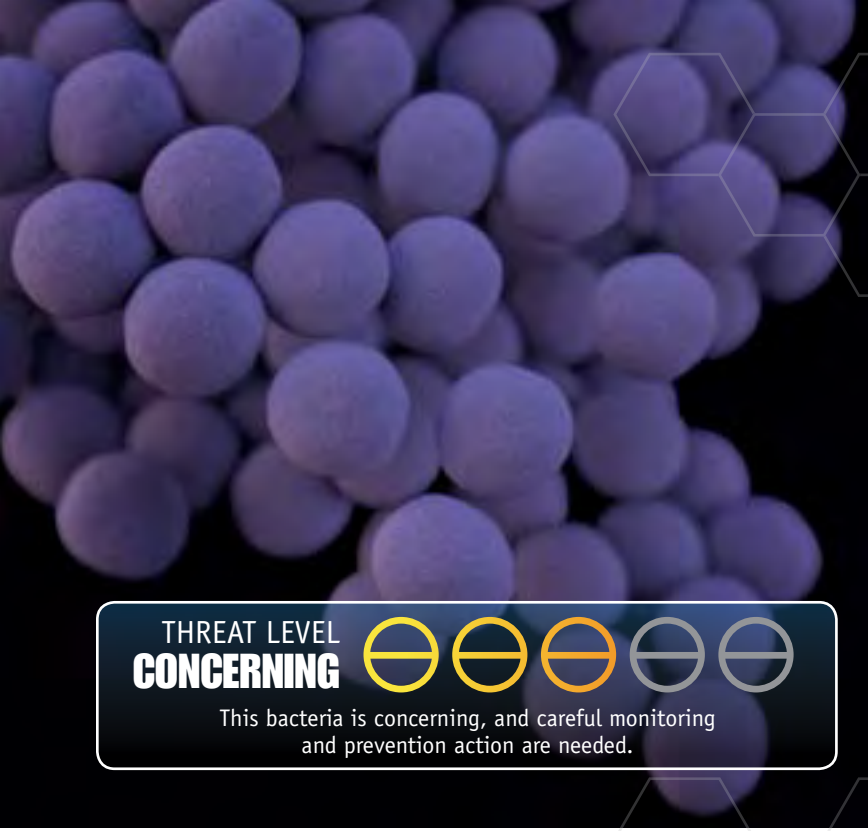
These bacteria are concerning, and careful monitoring and prevention action are needed.

MICROORGANISMS WITH A THREAT LEVEL OF CONCERNING

Vancomycin-resistant ***Staphylococcus aureus*** **(VRSA)**

Erythromycin-resistant **Group A *Streptococcus***

Clindamycin-resistant **Group B *Streptococcus***



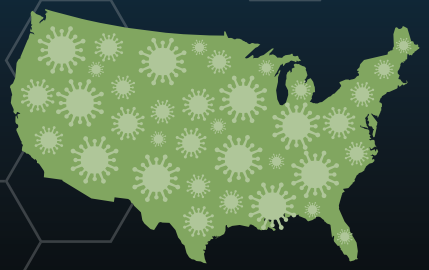
VANCOMYCIN-RESISTANT STAPHYLOCOCCUS AUREUS

THREAT LEVEL
CONCERNING

This bacteria is concerning, and careful monitoring and prevention action are needed.

13 CASES

IN **4** STATES SINCE 2002



SOME STAPHYLOCOCCUS STRAINS ARE RESISTANT TO VANCOMYCIN
LEAVING FEW OR NO TREATMENT OPTIONS

Staphylococcus aureus is a common type of bacteria that is found on the skin. During medical procedures when patients require catheters or ventilators or undergo surgical procedures, *Staphylococcus aureus* can enter the body and cause infections. When *Staphylococcus aureus* becomes resistant to vancomycin, there are few treatment options available because vancomycin-resistant *S. aureus* bacteria identified to date were also resistant to methicillin and other classes of antibiotics.

RESISTANCE OF CONCERN

In rare cases, CDC has identified *Staphylococcus aureus* that is resistant to vancomycin, the antibiotic most frequently used to treat serious *S. aureus* infections.

PUBLIC HEALTH THREAT

A total of 13 cases of vancomycin-resistant *Staphylococcus aureus* (VRSA) have been identified in the United States since 2002.

VRSA infection continues to be a rare occurrence. A few existing factors seem to predispose case patients to VRSA infection, including:

- Prior MRSA and enterococcal infections or colonization
- Underlying conditions (such as chronic skin ulcers and diabetes)
- Previous treatment with vancomycin

	Number of cases	Cases per 100,000 U.S. population	Percentage of all *Genus species* cases in U.S.	Number of deaths	Deaths per 100,000 U.S. population
Vancomycin-resistant *Staphylococcus aureus*	13	N/A	N/A	0	N/A

For more information about data methods and references, please see technical appendix.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

VANCOMYCIN-RESISTANT STAPHYLOCOCCUS AUREUS

FIGHTING THE SPREAD OF RESISTANCE

WHAT CDC IS DOING

- Confirming cases after being notified by local public health authorities.
- Providing states and facilities with outbreak support such as staff expertise, prevention guidelines, tools, and lab assistance.
- Developing tests and prevention recommendations to control drug-resistant infections.
- Helping medical facilities improve antibiotic prescribing practices.

WHAT YOU CAN DO

States and Communities Can:

- Know resistance trends in your region.
- Coordinate local and regional infection tracking and control efforts.
- Require facilities to alert each other when transferring patients with any infection.

Healthcare CEOs, Medical Officers, and Other Healthcare Facility Leaders Can:

- Require and strictly enforce CDC guidance for infection detection, prevention, tracking, and reporting.
- Make sure your lab can accurately identify infections, and alert clinical and infection prevention staff when these bacteria are present.
- Know infection and resistance trends in your facility and in the facilities around you.
- When transferring a patient, require staff to notify the other facility about all infections.
- Join or start regional infection prevention efforts.
- Promote wise antibiotic use.

Healthcare Providers Can:

- Know when and what types of drug-resistant infections are present in your facility and patients.
- Request immediate alerts when the lab identifies drug-resistant infections in your patients.
- Alert the other facility when you transfer a patient with a drug-resistant infection.
- Treat wounds aggressively.
- Use vancomycin responsibly.
- Protect patients from drug-resistant infections.
  - Follow relevant guidelines and precautions at every patient encounter.
  - Prescribe antibiotics wisely.
  - Remove temporary medical devices such as catheters and ventilators as soon as no longer needed.

Patients and Their Loved Ones Can:

- Ask everyone, including doctors, nurses, other medical staff, and visitors, to wash their hands before touching the patient.
- Take antibiotics only and exactly as prescribed.

ONLINE RESOURCES

Vancomycin-Intermediate/Resistant Staphylococcus (VISA/VRSA) in Healthcare Settings
http://www.cdc.gov/HAI/organisms/visa_vrsa/visa_vrsa.html

Healthcare-associated Infections (HAIs), Guidelines and Recommendations
www.cdc.gov/hicpac/pubs.html

CS239559-B

ERYTHROMYCIN-RESISTANT GROUP A STREPTOCOCCUS

1,300 DRUG-RESISTANT GROUP A STREP INFECTIONS PER YEAR

160 DEATHS

1–2.6 MILLION STREP THROAT INFECTIONS PER YEAR

GROUP A STREP IS THE LEADING CAUSE OF **NECROTIZING FASCIITIS ("FLESH-EATING" DISEASE)**

THREAT LEVEL **CONCERNING**

This bacteria is concerning, and careful monitoring and prevention action are needed.

Group A *Streptococcus* (GAS) causes many illnesses, including pharyngitis (strep throat), streptococcal toxic shock syndrome, necrotizing fasciitis ("flesh-eating" disease), scarlet fever, rheumatic fever, and skin infections such as impetigo.

RESISTANCE OF CONCERN

GAS has developed resistance to clindamycin and a category of drugs called macrolides. Macrolides include erythromycin, azithromycin and clarithromycin. GAS has also developed resistance to a less commonly used drug—tetracycline. Of these, resistance to erythromycin and the other macrolide antibiotics is of the most immediate concern.

PUBLIC HEALTH THREAT

Each year in the United States, erythromycin-resistant, invasive GAS causes 1,300 illnesses and 160 deaths.

GAS is a leading cause of upper respiratory tract infections such as strep throat. There are 1-2.6 million cases of strep throat in the U.S. each year. These bacteria are also the leading cause of necrotizing fasciitis, an invasive disease that can be fatal in 25%–35% of cases. Invasive disease means that bacteria invade parts of the body that are normally sterile. When this happens, disease is usually very severe, causing hospitalization or even death. Those at highest risk for invasive disease are the elderly, those with skin lesions, young children, people in group living situations such as nursing homes, and those with underlying medical conditions, such as diabetes.

Penicillin is the recommended first-line treatment for GAS infections. Amoxicillin is a type of penicillin that is often used to treat strep throat. Currently, GAS is not resistant to treatment with penicillin. If resistance to penicillin emerges, it would severely compromise treatment of invasive GAS infections. For people who are allergic to penicillin, two of the alternative antibiotics, azithromycin and clarithromycin, can be used to treat strep throat. In fact, azithromycin is prescribed more commonly than penicillin. Of GAS bacterial samples tested at CDC from 2010 and 2011, 10% were erythromycin-resistant (and therefore resistant to other macrolides such as azithromycin and clarithromycin), while 3.4% were clindamycin-resistant. Increasing resistance to erythromycin will complicate treatment of strep throat, particularly for those who cannot tolerate penicillin.

A more current concern is the increase in bacteria that show the genetic potential for becoming resistant to clindamycin. Clindamycin has a unique role in treatment of severe GAS infections. For severe, life-threatening infections, like necrotizing fasciitis and toxic shock syndrome, a combination of penicillin and clindamycin is recommended for treatment.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

FIGHTING THE SPREAD OF RESISTANCE

Encouraging appropriate antibiotic use, including using the right antibiotic at the right time, and for the right amount of time, is crucial to preventing the spread of drug-resistant GAS. Doctors should adhere to the recommended antibiotics for treating GAS infections, including using penicillin or amoxicillin whenever possible.

WHAT CDC IS DOING

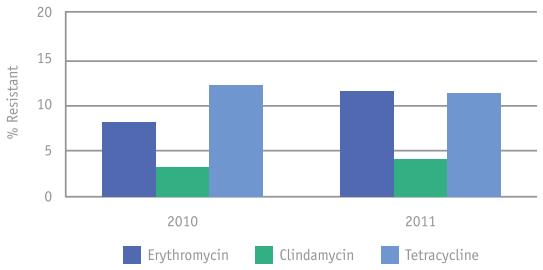
CDC has collaborated with the Infectious Diseases Society of America to update guidance on diagnosing strep throat and selecting antibiotics to treat it. These guidelines reinforce appropriate use of antibiotics for this common illness. CDC is also promoting appropriate antibiotic use among outpatient healthcare providers and the public through its Get Smart: Know When Antibiotics Work program. As part of this program, CDC hosts Get Smart About Antibiotics Week, an annual one-week observance of the importance of appropriate antibiotic use and its impact on antibiotic resistance. Through partnerships between CDC, state health departments, and universities, CDC is tracking GAS through Active Bacterial Core surveillance (ABCs).

WHAT YOU CAN DO

- Prevent infections by practicing good hand hygiene.
- Take antibiotics exactly as the doctor prescribes. Do not skip doses. Complete the prescribed course of treatment, even when you start feeling better.
- Only take antibiotics prescribed for you. Do not share or use leftover antibiotics.
- Do not save antibiotics for the next illness. Discard any leftover medication once the prescribed course of treatment is completed.
- Do not ask for antibiotics when your doctor thinks you do not need them.

Rates of resistance to two core antibiotics continue to increase for group A strep.

Prevalence of erythromycin, clindamycin and tetracycline resistance among group A streptococcal isolates, CDC's Active Bacterial Core surveillance (ABCs), 2010–2011



ONLINE RESOURCES

Active Bacterial Core surveillance (ABCs)
http://www.cdc.gov/abcs/index.html

Get Smart: Know When Antibiotics Work Program
http://www.cdc.gov/getsmart/

Group A Strep
http://www.cdc.gov/ncidod/dbmd/diseaseinfo/groupastreptococcal_g.htm

Necrotizing Fasciitis
http://www.cdc.gov/features/necrotizingfasciitis/

Strep Throat
http://www.cdc.gov/features/strepthroat/

Scarlet Fever
http://www.cdc.gov/features/scarletfever/

CLINDAMYCIN-RESISTANT GROUP B STREPTOCOCCUS

7,600 DRUG-RESISTANT GROUP B STREP INFECTIONS

440 DEATHS

27,000 SEVERE CASES OF GBS IN 2011

GROUP B STREP IS THE LEADING CAUSE OF
SERIOUS BACTERIAL INFECTIONS IN NEWBORNS

THREAT LEVEL
CONCERNING

This bacteria is concerning, and careful monitoring and prevention action are needed.

Group B *Streptococcus* (GBS) is a type of bacteria that can cause severe illnesses in people of all ages, ranging from bloodstream infections (sepsis) and pneumonia to meningitis and skin infections.

RESISTANCE OF CONCERN

GBS has developed resistance to clindamycin and erythromycin. GBS that are resistant to erythromycin will also be resistant to azithromycin. Recently, the very first cases with resistance to vancomycin have been detected among adults. These cases are extremely rare and also very concerning since vancomycin is the most commonly used drug for treatment of potentially resistant gram-positive infections in adults. Strains with decreasing responsiveness to treatment with penicillin drugs have been described but remain very rare. Resistance to clindamycin is of the most immediate clinical concern, although the other forms of resistance are worrisome.

PUBLIC HEALTH THREAT

Each year in the United States, clindamycin-resistant Group B Strep causes an estimated 7,600 illnesses and 440 deaths.

In the United States, GBS is the leading cause of serious bacterial infections in newborns, including bloodstream infections, meningitis, and pneumonia. When these GBS infections occur in the first 7 days of life, they are known as early-onset disease. To prevent early-onset disease in newborns, antibiotics are given during labor and delivery to mothers who test positive for GBS (tested at 35–37 weeks of pregnancy with a vaginal/rectal swab) and to those who have other risk factors for passing GBS to their newborns.

GBS also is one of the most common causes of meningitis and other severe infections in infants from 7 days to 3 months old (late-onset disease). GBS is also an increasing cause of bloodstream infections, pneumonia, skin and soft tissue infections, and bone and joint infections in adults, especially among pregnant women, the elderly, and people with certain medical conditions such as diabetes.

CDC estimates from preliminary data that 27,000 cases of severe GBS disease, such as blood infections or meningitis, occurred in 2011, causing 1,575 deaths. Forty-nine percent of GBS isolates (samples) tested were erythromycin-resistant, and 28% were clindamycin-resistant. Although the incidence of early-onset disease has been decreasing, the proportion of GBS infections resistant to erythromycin and clindamycin has increased steadily since 2000.

Resistance to the penicillin drug class could threaten the success of strategies to prevent early-onset disease and lead to treatment failures since penicillin drugs are the top choice for treating GBS. Additionally, the increasing resistance to recommended second-line drugs, clindamycin and erythromycin, limits prevention and treatment for patients with GBS who are allergic to penicillin.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

CLINDAMYCIN-RESISTANT GROUP B STREPTOCOCCUS

FIGHTING THE SPREAD OF RESISTANCE

Doctors should test all pregnant women for GBS at 35–37 weeks of pregnancy and adhere to the recommended antibiotics during labor and delivery for prevention of early-onset disease. Broad efforts to promote appropriate use of antibiotics in outpatient and inpatient settings will also help minimize the spread of resistance among GBS bacteria.

WHAT CDC IS DOING

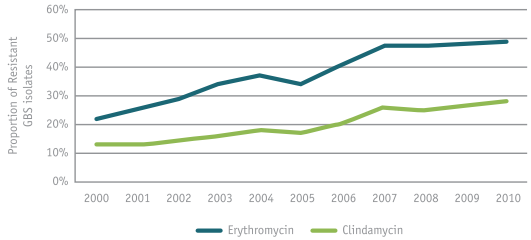
CDC, in collaboration with professional associations, has developed evidence-based Guidelines for the Prevention of Perinatal Group B Streptococcal Disease. These guidelines discuss diagnosis and management, and recommendations are provided regarding antibiotic choices and dosing. They also support GBS screening for all pregnant women at 35–37 weeks of pregnancy and use of antibiotics during labor and delivery to prevent newborn infection. Through partnerships between CDC, state health departments, and universities, CDC is tracking GBS through its Active Bacterial Core surveillance (ABCs). This program monitors antibiotic resistance and has contributed to the detection of the very first cases in the U.S. of vancomycin-resistant GBS, as well as tracking of susceptibility trends of other antibiotics important for treatment of GBS. CDC is promoting appropriate antibiotic use among outpatient health care providers and the public through its Get Smart: Know When Antibiotics Work program.

WHAT YOU CAN DO

- Pregnant women should talk to their doctor or nurse about their GBS status and let them know of any medication allergies during a checkup.
- When women get to the hospital or birthing center for delivery, they should remind their doctor or nurse if they have GBS and if they are allergic to any medications.
- Practice appropriate antibiotic use whenever you see a doctor or are prescribed an antibiotic for any condition:
  - Take antibiotics exactly as the doctor prescribes. Do not skip doses. Complete the prescribed course of treatment, even when you start feeling better.
  - Only take antibiotics prescribed for you. Do not share or use leftover antibiotics.
  - Do not save antibiotics for the next illness. Discard any leftover medication once the prescribed course of treatment is completed.
  - Do not ask for antibiotics when your doctor thinks you do not need them.

Group B strep continues to become more resistant to two major antibiotics, leaving those allergic to first line drugs in jeopardy.

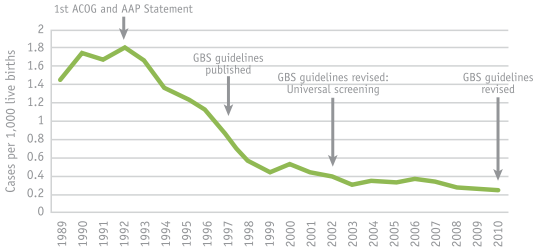
Proportion of Group B *Streptococcus* isolates resistant to erythromycin and clindamycin—Active Bacterial Core surveillance (ABCs), 2000-2010*



*Most recent data available.

Early-onset group B strep disease has declined by 80% since the introduction of evidence-based prevention strategies.

Incidence of Early-Onset Disease Caused by Group B *Streptococcus*—Active Bacterial Core surveillance (ABCs), 1989–2010



ACOG = American College of Obstetricians and Gynecologists, AAP = American Academy of Pediatrics

ONLINE RESOURCES

Group B Strep (GBS)
http://www.cdc.gov/groupbstrep/about/index.html

Active Bacterial Core surveillance (ABCs)
http://www.cdc.gov/abcs/index.html

EXTENDED SPECTRUM β-LACTAMASE PRODUCING ENTEROBACTERIACEAE

TECHNICAL APPENDIX

Technical Appendix

Clostridium difficile

Methods

National estimates of the number of *Clostridium difficile (C. difficile)* infections (CDI) requiring hospitalization or in already hospitalized patients were obtained from the data submitted through the Emerging Infections Program's *C. difficile* surveillance in 2011, of 34 counties in 10 U.S. states (http://www.cdc.gov/hai/eip/cdiff_techinfo.html). During 2011, a total of 15,452 CDI cases were identified across the participating sites. Data on hospitalization following CDI or at the time of infection were obtained for all cases from 8 of 10 U.S. states and from a random sample of 33% from cases from the other 2 states. The sampled cases were used to estimate total number of hospitalizations in the 2 states where sampling was performed. The national estimates were made using 2011 population estimates from U.S. Census Bureau adjusting for age, gender and race distribution of the American population.[1] Approximately 18% of cases were reported without a race value. Multiple imputation was used to estimate the missing race based on the data that are available and the results were summarized. The *C. difficile* attributable mortality was estimated from death certificate data.[2] Trends on deaths related to *C. difficile* were obtained from the CDC's National Center for Health Statistics.[3] Estimates were rounded to two significant digits.

References

1 Lessa FC, Mu, Y, Cohen J, Dumyati G, Farley MM, Winston L, Kast K, Holzbauer S, Meek J, Beldavs S, McDonald LC, Fridkin SK. Presented at the IDWeek 2012, Annual Meeting of the Infectious Disease Society of America, Society for Healthcare Epidemiology, Pediatric Infectious Disease Society, and HIV Medical Association; San Diego, October 2012.

2 Hall AJ, Curns AT, McDonald LC, Parashar UD, Lopman BA. The Roles of *Clostridium difficile* and Norovirus Among Gastroenteritis-Associated Deaths in the United States, 1999-2007. Clin Infect Dis. 2012 Jul;55(2):216–23.

3 Kochanek KD, Xu J, Murphy SL, Miniño AM, Kung HC. Deaths: Preliminary Data for 2009. National Vital Statistics Report.

Technical Appendix

Carbapenem-Resistant Enterobacteriaceae

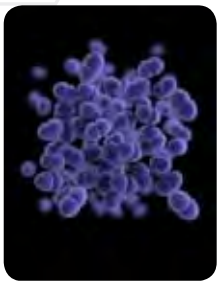
Multidrug-Resistant *Acinetobacter*

Fluconazole-Resistant *Candida*

Extended Spectrum B-lactamase producing Enterobacteriaceae (ESBLs)

Vancomycin-Resistant *Enterococcus* (VRE)

Multidrug-Resistant *Pseudomonas aeruginosa*



Methods

National estimates of the number of healthcare-associated infections (HAIs) with Enterobacteriaceae, *Pseudomonas aeruginosa, Candida*, *Acinetobacter,* or Enterococci were obtained from a 2011 survey of 11,282 patients in 183 hospitals in 10 different states, among whom 452 were identified with at least one HAI for a total of 504 HAIs (some patients had >1 HAI).

Many assumptions were made in deriving national estimates, using these 452 patients, and adjusting for age and length of stay using the 2010 Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. For 2011, an estimated 647,985 patients had at least one HAI, resulting in an estimated 721,854 HAIs.[1] 481 pathogens were reported among the 504 HAIs detected; 50 *K. pneumonia* or *K. oxytoca* (9.9%), 47 *E. coli* (9.3%), 46 *Enterococci spp.* (9.1%), 36 *P. aeruginosa* (7.1%), 34 *Candida spp.* (6.7%), 8 *Acinetobacter spp.* (1.6%). For each pathogen, the pathogen-specific annual estimate was obtained by multiplying this proportion (of all HAIs) by the national HAI estimate (721,854). Next, the estimated no. of resistant infections was obtained by multiplying the respective pathogen-specific national estimate by the proportion of pathogens reported as non-susceptible to the antimicrobial of interest from other CDC data systems. For Enterobacteriaceae, *Pseudomonas aeruginosa, Acinetobacter,* and Enterococci this was CDC's National Healthcare Safety Network and includes the mean percent non-susceptible across the device and procedure-associated HAIs reported during 2009–2010[2]; see individual fact sheets in this report for percent resistance for each pathogen.

For *Candida* by the proportion of *Candida* species testing non-susceptible to fluconazole that were submitted to CDC for confirmatory testing as part of the Emerging Infections Program Surveillance of *Candida* bloodstream infections during 2008-2011.[3] In this program a total of 2,675 *Candida* species isolates associated with bloodstream infections were submitted as part of the EIP population-based surveillance in 2 US cities, azole resistance was identified in 165 cases, or 7%.

The number of deaths attributable to the antimicrobial-resistant healthcare-associated infection was determined by multiplying the estimated number of resistant infections by 6.5%, an overall estimate of attributable mortality from antibiotic-resistant hospital-onset infections previously determined.[4] This estimate accounts for the overall distribution of the different types of infections commonly caused by antibiotic-resistant pathogens in hospitalized patients and is generally much lower than the crude mortality observed in many of these patients owing to their severe underlying disease status. Definitions of multidrug resistance used in this analysis are published elsewhere.[2] The proportion of U.S. hospitals reporting carbapenem-resistant Enterobacteriaceae was derived as reported elsewhere.[5] Estimates were rounded to two significant digits.

References

1 Magill SS, Edwards JR, Bamberg W, Beldavs Z, Dumyati G, Kainer M, Lynfield R, Maloney M, McAllister-Hollod L, Nadle J, Ray SR, Thompson DL, Wilson LE, Fridkin SK. Presented at the IDWeek 2012, Annual Meeting of the Infectious Disease Society of America, Society for Healthcare Epidemiology, Pediatric Infectious Disease Society, and HIV Medical Association; San Diego, October 2012.

2 Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, Kallen A, Limbago B, Fridkin S; National Healthcare Safety Network (NHSN) Team and Participating NHSN Facilities. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009–2010. Infect Control Hosp Epidemiol. 2013 Jan;34(1):1–14

3 Cleveland AA, Farley MM, Harrison LH, Stein B, Hollick R, Lockhart SR, Magill SS, Derado G, Park BJ, Chiller TM. Changes in incidence and antifungal drug resistance in candidemia: results from population-based laboratory surveillance in Atlanta and Baltimore, 2008–2011. Clin Infect Dis. 2012 Nov 15;55(10):1352–61.

4 Roberts RR, Hota B, Ahmad I, Scott RD 2nd, Foster SD, Abbasi F, Schabowski S, Kampe LM, Ciavarella GG, Supino M, Naples J, Cordell R, Levy SB, Weinstein RA. Hospital and societal costs of antimicrobial-resistant infections in a Chicago teaching hospital: implications for antibiotic stewardship. Clin Infect Dis. 2009 Oct 15;49(8):1175–84

5 Centers for Disease Control and Prevention (CDC). Vital Signs: Carbapenem-resistant Enterobacteriaceae. MMWR Morb Mortal Wkly Rep. 2013 Mar 8;62(9):165–70.

Technical Appendix

Neisseria gonorrhoeae

Methods

Estimates of the number of gonococcal infections with any resistance pattern, reduced susceptibility to cephalosporins or azithromycin, or resistance to tetracycline are reported. They are derived by multiplying an estimate of the annual number of gonococcal infections in the United States[1] by the prevalence of reduced susceptibility or resistance among urethral *Neisseria gonorrhoeae* isolates collected and tested by the Gonococcal Isolate Surveillance Project (GISP) during 2011.[2]

Many assumptions were made in deriving the estimates. Data from the National Health and Nutrition Examination Survey (NHANES) provided accurate gonorrhea prevalence estimates, although NHANES only measures urogenital infections and does not include oropharyngeal or rectal infections. The average duration of infection, used to calculate incidence, was based on expert opinion, due to an absence of published data. Also, estimates of resistance in GISP are nationally representative. However, compared to the regional distribution of reported gonococcal infections, GISP relatively over-samples patients from the West Coast, where resistance has traditionally first emerged in the United States. The Clinical Laboratory Standards Institute categorizes susceptibility to cefixime and ceftriaxone as minimum inhibitory concentrations (MICs) ≤0.25 µg/ml.[3] For this analysis, isolates with cefixime MICs ≥0.25 µg/ml were considered to have reduced cefixime susceptibility, and isolates with ceftriaxone MICs ≥0.125 µg/ml were considered to have reduced ceftriaxone susceptibility. An azithromycin MIC ≥2.0 µg/ml was considered to have reduced azithromycin susceptibility, and a tetracycline MIC ≥2.0 µg/ml was considered resistant. Resistance to any antimicrobial includes resistance to penicillin (MIC ≥ 2 µg/ml), tetracycline, ciprofloxacin (MIC ≥ 1µg/ml), or spectinomycin (MIC ≥ 128 µg/ml), or reduced susceptibility to the cephalosporins or azithromycin.

GISP, established in 1986, is a sentinel surveillance system with partners that include CDC, sexually transmitted disease clinics at 25–30 sentinel sites, and 5 regional laboratories in the United States.[4] Gonococcal isolates are collected from up to the first 25 men diagnosed with gonococcal urethritis at each sentinel site each month. Antimicrobial susceptibility testing is performed using agar dilution for a panel of antimicrobials that includes penicillin, tetracycline, ciprofloxacin, spectinomycin, cefixime, ceftriaxone, and azithromycin.

References

1 Satterwhite CL et al. Sexually transmitted infections among US women and men: prevalence and incidence estimates, 2008. Sex Transm Dis 2013;40(3):187–93.

2 CDC. Sexually transmitted diseases surveillance 2011. Atlanta: U.S. Department of Health and Human Services; 2012.

3 Clinical and Laboratory Standards Institute. Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Third Informational Supplement. CLSI document M100-S23. Wayne, PA; Clinical and Laboratory Standards Institute; 2013; 33(1):100–102.

4 CDC GISP website: http://www.cdc.gov/std/GISP.

Technical Appendix

Drug-Resistant *Campylobacter*

Methods

Estimates of the number of illnesses and deaths from infections with *Campylobacter* resistant to ciprofloxacin or azithromycin are reported. They were derived by multiplying an estimate of the annual number of *Campylobacter* illnesses or deaths in the United States[1] by the average prevalence of resistance among *Campylobacter* tested by the National Antimicrobial Resistance Monitoring System (NARMS) during the years 2009–2011. Resistance breakpoints from the NARMS 2011 Human Isolates Report were used.[2]

Many assumptions were made in deriving the estimates. The estimated number of illnesses from resistant *Campylobacter* was divided by the U.S. population and multiplied by 100,000 to calculate the estimated number of illnesses from resistant infections per 100,000 people. The U.S. population in 2006 (approximately 299 million people) was used for the calculations because the estimated number of *Campylobacter* illnesses in the United States was based on this population.[1] The sentinel county survey data displayed in Figure 1 was previously reported.[3]

References

1 Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis 2011;17:7–15.

2 CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): Human Isolates Final Report, 2011. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2013.

3 Gupta A, Nelson JM, Barrett TJ, et al. Antimicrobial Resistance among *Campylobacter* Strains, United States, 1997–2001. Emerg Infect Dis 2004;10:1102-9.

Technical Appendix

Drug-Resistant Non-Typhoidal *Salmonella*

Methods

Estimates of the number of illnesses and deaths from infections with non-typhoidal *Salmonella* resistant to ceftriaxone, resistant or partially resistant to ciprofloxacin, or resistant to five or more antibiotic classes are reported. They were derived by multiplying an estimate of the annual number of non-typhoidal *Salmonella* illnesses or deaths in the United States[1] by the average prevalence of resistance among non-typhoidal *Salmonella* isolates tested by the National Antimicrobial Resistance Monitoring System (NARMS) during the years 2009–2011. Resistance breakpoints from the NARMS 2011 Human Isolates Report were used.[3] For ciprofloxacin, isolates with intermediate susceptibility results (minimum inhibitory concentration of 0.12–0.5 µg/ml) were considered partially resistant.

Many assumptions were made in deriving the estimates. The estimated number of illnesses from resistant *Salmonella* was divided by the U.S. population and multiplied by 100,000 to calculate the estimated number of illnesses from resistant *Salmonella* per 100,000 population. The U.S. population in 2006 (approximately 299 million people) was used for the calculations because the estimated number of non-typhoidal *Salmonella* illnesses in the United States was based on this population.[1] The methods used to estimate the direct medical costs for *Salmonella* infections were previously reported.[2]

References

1 Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis. 2011;17:7–15.

2 CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): Human Isolates Final Report, 2011. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2013.

3 CDC. Vital Signs: Incidence and Trends of Infection with Pathogens Transmitted Commonly Through Food—Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 1996–2010. MMWR 2011;60:749–55.

Technical Appendix

Drug-Resistant *Salmonella* Serotype Typhi

Methods

An estimate of the number of illnesses and deaths from *Salmonella* serotype Typhi resistant or partially resistant to ciprofloxacin was derived by multiplying an estimate of the annual number of illnesses or deaths from typhoid fever in the United States[1] by the average prevalence of ciprofloxacin resistance or partial resistance among *Salmonella* Typhi isolates tested by the National Antimicrobial Resistance Monitoring System (NARMS) during 2009–2011. Resistance breakpoints from the NARMS 2011 Human Isolates Report were used.[2] For ciprofloxacin, isolates with intermediate susceptibility results (minimum inhibitory concentration of 0.12–0.5 µg/ml) were considered partially resistant.

Many assumptions were made in deriving the estimates. The estimated number of illnesses from ciprofloxacin resistant or partially resistant *Salmonella* Typhi was divided by the U.S. population and multiplied by 100,000 to calculate the estimated number of illnesses from resistant or partially resistant infections per 100,000 people. The U.S. population in 2006 (approximately 299 million people) was used for the calculations because the estimated number of typhoid fever illnesses in the United States was based on this population. Worldwide case estimates[3] and pre-antibiotic era mortality[4] are from published sources.

References

1 Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis 2011;17(1):7–15.

2 CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): Human Isolates Final Report, 2011. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2013.

3 Crump JA, Mintz ED. Global trends in typhoid and paratyphoid fever. Clin Infect Dis 2010;50(2):241-6.Heymann DL, editor. Control of Communicable Diseases Manual. 19th ed. Washington DC: American Public Health Association; 2008.

4 Heymann DL, editor. Control of Communicable Diseases Manual. 19th ed. Washington DC: American Public Health Association; 2008.

Technical Appendix

Drug-Resistant *Shigella*

Methods

Estimates of the number of illnesses and deaths from infections with *Shigella* resistant to azithromycin or ciprofloxacin are reported. They were derived by multiplying an estimate of the annual number of *Shigella* illnesses or deaths in the United States[1] by the prevalence of resistance among *Shigella* tested by the National Antimicrobial Resistance Monitoring System (NARMS) in 2011, the year azithromycin testing began. Resistance breakpoints from the NARMS 2011 Human Isolates Report were used.[2] As clinical azithromycin breakpoints have not been established for *Shigella,* the values used here were based on epidemiological cut-off values used in the NARMS report. Isolates with azithromycin minimal inhibitory concentrations of ≥32 µg/ml were considered resistant.

Many assumptions were made in deriving these estimates. The estimated number of illnesses from resistant *Shigella* was divided by the U.S. population and multiplied by 100,000 to calculate the estimated number of illnesses from resistant infections per 100,000 people. The U.S. population in 2006 (approximately 299 million people) was used for the calculations because the estimated number of *Shigella* illnesses in the United States was based on this population.[1] The sentinel county survey data displayed were previously reported.[3,4,5]

References

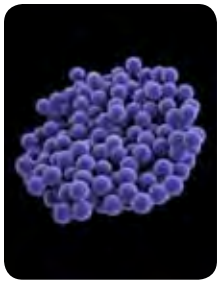
1 Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis 2011;17:7–15.

2 CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): Human Isolates Final Report, 2011. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2013.

3 Tauxe RV, Puhr ND, Wells JG, Hargrett-Bean N, Blake PA. Antimicrobial resistance of *Shigella* isolates in the USA: the importance of international travelers. J Infect Dis 1990;162:1107–11.

4 CDC. National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS): 2003 Human Isolates Final Report. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2006.

5 Sivapalasingam S, Nelson JM, Joyce K, et al. High prevalence of antimicrobial resistance among *Shigella* isolates in the United States tested by the National Antimicrobial Resistance Monitoring System from 1999 to 2002. Antimicrob Agents Chemother 2006;50:49–54.



Technical Appendix

Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Methods

National estimates of the number of invasive MRSA healthcare-associated infections (HAIs) were derived from the Emerging Infection Program/Active Bacterial Core Surveillance[1] for Invasive MRSA using data reported for infections occurring during 2011 (http://www.cdc.gov/abcs/reports-findings/surv-reports.html). During 2011, 4,872 reports of invasive MRSA (isolates of MRSA cultured from a normally sterile site and identified by a participating clinical laboratory) were received from the 9 participating program sites (population of 19,393,677). Reports include both healthcare-associated infections and community-associated infections, but are limited to invasive infections (approximately 85% are bloodstream infections).

Estimates were made using National Center for Health Statistics bridged-race vintage 2011 post-censal file and U.S. renal data systems, adjusting for race, age, gender, and receipt of dialysis. Mortality includes all-cause mortality during hospitalization, and estimates were adjusted in similar fashion as infection estimates. Approximately 18% of cases were reported without a race value, multiple imputation was used to estimate the missing race based on the data that are available and the results were summarized. Regarding device and procedure-associated infections with MRSA, the proportion of facilities reporting at least one *S. aureus* HAI reported as MRSA for each HAI type was obtained from CDC's National Healthcare Safety Network Antimicrobial Resistance Report 2009–2010.[2] Estimates were rounded to two significant digits.

References

1 Kallen AJ, Mu Y, Bulens S, Reingold A, Petit S, Gershman K, Ray SM, Harrison LH, Lynfield R, Dumyati G, Townes JM, Schaffner W, Patel PR, Fridkin SK; Active Bacterial Core surveillance (ABCs) MRSA Investigators of the Emerging Infections Program. Health care-associated invasive MRSA infections, 2005–2008. JAMA. 2010

2 Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, Kallen A, Limbago B, Fridkin S; National Healthcare Safety Network (NHSN) Team and Participating NHSN Facilities. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009–2010. Infect Control Hosp Epidemiol. 2013 Jan;34(1):1–14

Technical Appendix

Vancomycin-Resistant *Staphylococcus aureus*

Methods

Vancomycin resistant *S. aureus* (VRSA) have been a nationally notifiable condition since 2004.[1] The national estimate of the number of VRSA cases is derived from individual case reports and confirmation at the Centers for Disease Control and Prevention (CDC). All reported VRSA are submitted to CDC for confirmatory antimicrobial susceptibility with reference broth microdilution.[2] Vancomycin resistance in *S. aureus* is defined as an MIC ≥ 16 ug/ ml. All isolates meeting this criterion are further characterized with PCR to detect known resistance mechanisms. All 13 U.S. VRSA identified to date have carried the *vanA* resistance determinant.[3]

References

1 http://wwwn.cdc.gov/nndss/document/nndss_event_code_list_2013.pdf

2 CSLI. 2012. Performance Standards for Antimicrobial Susceptibility Testing; Twenty-second Informational Supplement. Clinical and Laboratory Standards Institute, Wayne, PA

3 http://www.cdc.gov/HAI/settings/lab/vrsa_lab_search_containment.html

Technical Appendix

Drug-Resistant *Streptococcus pneumoniae*

Methods

Trends in the incidence of antibiotic-resistant invasive pneumococcal disease per 100,000 persons are from Active Bacterial Core surveillance (ABCs), which is part of CDC's Emerging Infections Program (EIP) network.[1] ABCs conducts surveillance for invasive bacterial infections, including *Streptococcus pneumoniae*, at 10 sites located throughout the United States representing a population of approximately 30 million persons. Isolates are collected on ≥90% of all cases (approximately 3200 isolates per year) and sent to reference laboratories for susceptibility testing to eighteen different antibiotics using Clinical and Laboratory Standards Institute (CLSI) methods. Estimates of invasive pneumococcal disease are also from ABCs.[2]

Estimates of the burden of antibiotic resistant pneumococcal disease are derived from three sources. First, numbers of cases were estimated by applying the rate for full resistance to clinically relevant drugs (i.e. penicillin, ceftriaxone, cefotaxime, erythromycin, levofloxacin, tetracycline, trimethoprim/sulfamethoxazole) in 2011 (30%) to estimates of cases of all *S. pneumoniae* infections (4 million) as estimated by Huang and colleagues.[3] Numbers of deaths were estimated by applying the rate of full resistance to a clinically relevant drug (33%) to the total number of deaths from pneumococcal disease.[3] Excess pneumococcal pneumonia visits, hospitalizations, and costs were estimated using the previous overall burden estimates[3] but consideration of the burden of disease that would have occurred in the absence of resistance to penicillin, erythromycin, and levofloxacin.[4]

References

1 CDC. Active Bacterial Core Surveillance Methodology (2012). http://www.cdc.gov/abcs/index.html [Accessed 5/23/2013].

2 CDC. Active Bacterial Core Surveillance (ABCs) Report, Emerging Infections Program network, *Streptococcus pneumoniae* (2011). http://www.cdc.gov/abcs/reports-findings/survreports/spneu11.pdf [Accessed 5/23/2013].

3 Huang SS, Johnson KM, Ray GT, et al. Healthcare utilization and cost of pneumococcal disease in the United States. Vaccine 2011;29(18):3398-412.

4 Murphy CR, Finkelstein JA, Ray GT, Moore MR, Huang SS. Attributable Healthcare Utilization and Cost of Pneumonia due to Drug-Resistant *Streptococcus pneumoniae*. In: IDWeek; 2012 October 19, 2012; San Diego, CA: Infectious Diseases Society of America; 2012.

Technical Appendix

Erythromycin-Resistant Group A *Streptococcus*

Methods

Estimates of the proportion of GAS isolates resistant to erythromycin, clindamycin and tetracycline are from isolates collected through Active Bacterial Core surveillance (ABCs), which is part of CDC's Emerging Infections Program (EIP) network.[1] ABCs conducts surveillance for invasive bacterial infections, including GAS, at 10 sites located throughout the United States representing a population of approximately 32 million people. Isolates are collected on ~80% of all cases (approximately ~1000 isolates per year) and sent to reference laboratories for susceptibility testing to twelve different antibiotics using Clinical and Laboratory Standards Institute (CLSI) methods.

Cases and deaths were estimated by applying 2011 resistant rate to erythromycin (10%, see Strep Group A *Streptococcus* pathogen page) to total cases (13300) and total deaths (1,550) reported in the 2011 report of the Active Bacteria Core surveillance (ABCs).[2]

References

1 CDC, Active Bacterial Core Surveillance Methodology (2012). http://www.cdc.gov/abcs/index.html [Accessed 5/23/2013].

2 http://www.cdc.gov/abcs/reports-findings/survreports/gas11.html

Technical Appendix

Clindamycin-Resistant Group B *Streptococcus*

Methods

Estimates of the proportion of GBS isolates resistant to erythromycin and clindamycin are from isolates collected through Active Bacterial Core surveillance (ABCs), which is part of CDC's Emerging Infections Program (EIP) network.[1] ABCs conducts surveillance for invasive bacterial infections, including GBS, at 10 sites located throughout the United States representing a population of approximately 32 million persons. Isolates are collected currently from 7 of these states, from ~85% of the cases in these states (approximately ~1500 isolates per year) and sent to reference laboratories for susceptibility testing to twelve different antibiotics using Clinical and Laboratory Standards Institute (CLSI) methods. Estimates of severe disease are also from ABCs.[2]

Cases and deaths were estimated by applying the 2010 overall resistant rate to clindamycin (28%) from the ABCs antimicrobial susceptibilities report[3] to total cases (27,000) and total deaths (1,575) reported in the 2011 ABCs GBS surveillance report.[2]

References

1 CDC. Active Bacterial Core Surveillance Methodology (2012). http://www.cdc.gov/abcs/index.html [Accessed 5/23/2013].

2 CDC. Active Bacterial Core Surveillance (ABCs) Report, Emerging Infections Program network, Group B *Streptococcus* (2011). http://www.cdc.gov/abcs/reports-findings/survreports/gbs11.pdf [Accessed 7/23/2013].

3 CDC. Antimicrobial Susceptibilities Among Group B *Streptococcus* Isolates, Active Bacterial Core Surveillance (ABCs) (2010). http://www.cdc.gov/abcs/reports-findings/survreports/gbs10-suscept.html [Accessed 7/23/2013].

GLOSSARY

Active Bacterial Core surveillance (ABCs): A core component of CDC's Emerging Infections Programs network (EIP), a collaboration between CDC, state health departments, and universities. ABCs is an active laboratory- and population-based surveillance system that tracks invasive bacterial pathogens of public health importance. It currently operates among 10 EIP sites across the United States, representing a population of approximately 41 million persons. At this time, ABCs conducts surveillance for six pathogens: group A and group B *Streptococcus* (GAS, GBS), *Haemophilus influenzae, Neisseria meningitidis, Streptococcus pneumoniae,* and methicillin-resistant *Staphylococcus aureus* (MRSA).

Adverse drug event: When therapeutic drugs (example, antibiotics) have harmful effects; when someone has been harmed by a medication.

Aminoglycoside: A type of antibiotic that destroys the functioning of gram-negative bacteria. Increased resistance to aminoglycosides has made them less useful.

Antibiotic: Type of medicine made from mold or bacteria that kills or slows the growth of other bacteria. Examples include penicillin and streptomycin.

Antibiotic class: A grouping of antibiotics that are similar in how they work and how they are made.

Antibiotic growth promotion: Giving farm animals antibiotics to increase their size in order to produce and sell more meat.

Antibiotic resistance: The result of bacteria changing in ways that reduce or eliminate the effectiveness of antibiotics. Antibiotic resistance is one type of antimicrobial resistance.

Antibiotic stewardship: Coordinated efforts and programs to improve the use of antimicrobials. For example, facilities with antibiotic stewardship programs have made a commitment to always use antibiotics appropriately and safely—only when they are needed to prevent or treat disease, and to choose the right antibiotics and to administer them in the right way in every case.

Antimicrobial: A general term for the drugs, chemicals, or other substances that either kill or slow the growth of microorganisms. Among the antimicrobial agents in use today are antibacterial drugs (which kill bacteria), antiviral agents (which kill viruses), antifungal agents (which kill fungi), and antiparisitic drugs (which kill parasites).

Antimicrobial resistance: The result of microorganisms changing in ways that reduce or eliminate the effectiveness of drugs, chemicals, or other agents used to cure or prevent infections. In this report, the focus is on antibiotic resistance, which is one type of antimicrobial resistance.

Azithromycin: A macrolide antibiotic used to treat infections caused by gram-positive bacteria and infections such as respiratory tract and soft-tissue infections.

Azoles: A large class of drugs developed to treat fungal infections.

Bacteria: Single-celled organisms that live in and around us. Bacteria can be helpful, but in certain conditions can cause illnesses such as strep throat, ear infections, and bacterial pneumonia.

Bacteriology: The study of bacteria.

Beta (β)-lactamase enzyme: A chemical produced by certain bacteria that can destroy some kinds of antibiotics.

Broad-spectrum antibiotic: An antibiotic that is effective against a wide range of bacteria.

Carbapenem: A type of antibiotic that is resistant to the destructive beta-lactamase enzyme of many bacteria. Carbapenems are used as a last line of defense for many bacteria, but increased resistance to carbapenems has made them less useful.

Cefixime: A cephalosporin antibiotic that is resistant to the destructive beta-lactamase enzyme of many bacteria.

Ceftriaxone: A cephalosporin antibiotic that is resistant to the destructive beta-lactamase enzyme of many bacteria.

Cephalosporin: Cephalosporins are a class of antibiotics containing a large number of drugs. Some more recently developed cephalosporins are resistant to the destructive beta-lactamase enzyme produced by many bacteria.

Ciprofloxacin: A broad-spectum fluoroquinolone antibiotic that is important in treating serious bacterial infections, especially when resistance to older antibiotic classes is suspected.

Clindamycin: An antibiotic used to treat certain types of bacterial infections, including infections of the lungs, skin, blood, female reproductive organs, and internal organs.

Conjugate vaccine: A vaccine in which an antigen is attached to a carrier protein from the same microorganism. This approach enhances the immunological response to the vaccine and thereby enhances the overall effectiveness of the vaccine.

Echinocandins: A class of drugs developed to treat fungal infections.

EIP: The Emerging Infections Program network is a national resource for surveillance, prevention, and control of emerging infectious diseases. It was established in 1995. The EIP is a network of 10 state health departments and their collaborators in local health departments, academic institutions, other federal agencies, and public health and clinical laboratories; infection preventionists; and healthcare providers.

Endogenous flora: Bacteria that naturally reside in or on the body.

Epidemiology: The study of diseases to find out who is affected, how disease is spread, trends in illnesses and deaths, what behaviors or other risk factors might put a person at risk, and other information that can be used to develop prevention strategies. Epidemiologists use surveys and surveillance systems to track illnesses, and they often investigate disease outbreaks.

Erythromycin: An antibiotic used to treat certain infections caused by bacteria, such as bronchitis, diphtheria, Legionnaires' disease, pertussis (whooping cough), pneumonia, rheumatic fever, sexually transmitted diseases, and infections of the ear, intestine, lung, urinary tract, and skin. It is also used before some surgery or dental work to prevent infection.

Extended-spectrum antibiotic: An antibiotic that has been chemically modified to attack additional types of bacteria, usually those that are gram-negative.

Extensively drug-resistant (XDR): Resistance to nearly all drugs that would be considered for treatment. Exact definitions for XDR differ for each type of bacteria.

Fluconazole: An antifungal drug in the azole class.

Fluoroquinolones: Broad-spectrum antibiotics that play an important role in treatment of serious bacterial infections, especially hospital-acquired infections and others in which resistance to older antibacterial classes is suspected. Increasing resistant to fluoroquinolones is making them less effective.

Fungus: A single-celled or multicellular organism. Fungi can be opportunistic pathogens (such as aspergillosis, candidiasis, and cryptococcosis) that cause infections in people with compromised immune systems, such as cancer patients, transplant recipients, and people with HIV/AIDS. Fungi can also be or pathogens (such as the endemic mycoses, histoplasmosis and coccidioidomycosis, and superficial mycoses) that cause infections in healthy people. Fungi are used to develop antibiotics, antitoxins, and other drugs used to treat various diseases.

GISP: The Gonococcal Isolate Surveillance Project was established in 1986 to monitor U.S. trends in antimicrobial susceptibilities of strains of *Neisseria gonorrhoeae,* the type of bacteria that causes gonorrhea. The goal of GISP is to establish a rational basis for the selection of drugs used to treat gonorrhea. GISP is a collaborative project between selected sexually transmitted disease clinics, five regional laboratories, and CDC.

HAIs: Healthcare-associated infections are those that occur in hospitals, outpatient clinics, nursing homes, and other facilities where people receive care.

Hand hygiene: The practice of cleaning hands. This practice protects against infection and illness.

Hypervirulent: Increased ability to cause severe disease, relapse rates, and death.

Invasive disease: A disease that can spread within the body to healthy tissue.

Isolate/bacterial isolate: A pure culture or sample of bacteria used to study their properties.

Isoniazid (INH): A first-line drug used to treat tuberculosis. Strains of tuberculosis resistant to INH and rifampin are considered to be multidrug resistant.

Macrolide: A type of antibiotic used to treat infections caused by gram-positive bacteria and infections such as respiratory tract and soft-tissue infections. Macrolides are often used

in people allergic to penicillin, but resistance to macrolides is increasing and has made them less useful.

Methicillin: An antibiotic derived from penicillin. It was previously used to treat bacteria such as *Staphylococcus aureus*.

Microbiology: The study of microorganisms.

Microorganism: Organisms so small that a microscope is required to see them. This term includes bacteria, fungi, parasites, and viruses.

Morbidity: The number of people who are infected with a specified illness in a given time period.

Mortality: The number of people who die in a given time from a specified illness.

MRSA: Methicillin-resistant *Staphylococcus aureus* is used to describe any strain of *S. aureus* that is resistant to all types of penicillin (not just methicillin) as well as cephalosporin.

Multidrug-resistant (MDR): Microorganisms that are resistant to multiple classes of antimicrobials. The exact number of drugs that a microorganism is resistant to varies depending on the infection or pathogen.

NARMS: The National Antimicrobial Resistance Monitoring System monitors antimicrobial resistance in foodborne and other enteric bacteria, including *Salmonella, Campylobacter, Shigella, Escherichia coli* O157, and *Vibrio* (non-*V. cholerae*). NARMS is a collaboration among CDC, the U.S. Food and Drug Administration (FDA), the U.S. Department of Agriculture (USDA), and state and local health departments.

Narrow-spectrum antibiotic: An antibiotic that is active against a limited range of bacteria.

NHSN: CDC's National Healthcare Safety Network is the nation's most widely used healthcare-associated infection tracking system. NHSN provides facilities, states, regions, and the nation with data needed to identify problem areas, measure progress of prevention efforts, and ultimately eliminate healthcare-associated infections. In addition, NHSN allows healthcare facilities to track blood safety errors and important healthcare process measures such as healthcare personnel influenza vaccine status and infection control adherence rates.

Outbreak: When a group of people develop the same illness around the same time, and the number of people affected is higher than normal. Outbreak investigations are conducted to identify what exposure the affected people had in common.

Pan drug-resistance (PDR): Resistance to all drugs that would be considered for treatment. Exact definitions for PDR differ for each bacteria.

Penicillins: A class of antibiotics including amoxicillin, methicillin, piperacillin and other drugs based on the first true antibiotic discovered in 1928 by Dr. Alexander Fleming. Increased resistance has made many types of penicillins less useful.

Pneumonia: An inflammatory condition of the lungs affecting primarily the microscopic air

sacs known as alveoli. It is usually caused by infection with viruses or bacteria, and typical symptoms include a cough, chest pain, fever, and difficulty breathing.

Reservoir: A person, animal, insect, plant, or other host that is carrying a pathogen (for example, bacteria or fungi) that causes infectious diseases. Some pathogens have animal reservoirs (to survive, they need animal hosts). Others pathogens have human reservoirs (to survive, they need human hosts).

Resistant bacteria: Microorganisms that have changed in ways that reduce or eliminate the effectiveness of drugs, chemicals, or other agents to cure or prevent infections.

Rifampin: A first-line drug used to treat tuberculosis. Strains of tuberculosis resistant to isoniazid (INH) and rifampin (RMP) are considered to be multidrug resistant.

Strain/bacterial strain: A strain is a genetic variant or subtype of a microorganism (for example, a flu strain is a subtype of the flu virus). Some strains of bacteria are resistant to antibiotics, and others are not. When bacteria become resistant to antibiotics, they can share their resistance with other bacteria to create new resistant bacterial strains.

Superinfection: An infection following a previous infection, especially when caused by microorganisms that are resistant or have become resistant to the antibiotics used earlier.

Surveillance: The ongoing systematic collection and analysis of data. Surveillance systems that monitor infectious diseases provide data that can be used to develop actions to prevent infectious diseases.

Susceptible bacteria: When antibiotics are effective at killing or stopping the growth of a certain bacteria, the bacteria is known as susceptible to antibiotics. Susceptible infections are infections that can be treated effectively with antibiotics.

Systemic agents: Drugs that travel through the bloodstream and reach cells throughout the body.

Tetracyclines: A class of broad-spectrum antibiotics including tetracycline, doxycycline, minocycline, and other drugs. Increased resistance has made many types of tetracyclines less useful.

Vaccine: A product that produces immunity in a person's body and therefore protects them from an infectious disease. Vaccines are administered through shots, by mouth, and by aerosol mist.

Vancomycin: A drug that is frequently used to treat methicillin-resistant *Staphylococcus aureus* infections and that is also effective against other bacteria.

Virus: A strand of DNA or RNA in a protein coat that must get inside a living cell to grow and reproduce. Viruses cause many types of illness. For example, varicella virus causes chickenpox, and the human immunodeficiency virus (HIV) causes acquired immune deficiency syndrome (AIDS).

ACKNOWLEDGEMENTS

Many people in the CDC Office of Infectious Diseases (OID) contributed to this report. Their efforts are acknowledged below in alphabetical order.

National Center for Emerging Zoonotic and Infectious Diseases (NCEZID)

Beth Bell
Michael Bell
Anna Bowen
Chris Braden
Mary Brandt
Allison Brown
Ann Burkhardt
Denise Cardo
Tom Chiller
Angela Ahlquist Cleveland
Nicole Coffin
Michael Craig
Laura Eastham
Jason Folster
Scott Fridkin
Peter Gerner-Smidt
Patricia Griffin
Rosa Herrera
Martha Iwamoto
John Jernigan
Valerie Johnson
Marsha Jones
Cecilia Joshi
Maria Karlsson
Beth Karp
Fernanda Lessa
Shawn Lockhart
Shelley Magill
Cliff McDonald
Felicita Medalla
Martin Meltzer
Eduardo Mendez
Eric Mintz
Azizeh Nuriddin
John O'Connor
Benjamin Park
Jean Patel
Dana Pitts
Jared Reynolds
Scott Santibanez
Doug Scott
Elizabeth Skillen
Steve Solomon
Arjun Srinivasan
Robert Tauxe
Abbigail Tumpey
Michael Washington
Jean Whichard
Rachel Wolf

National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP)

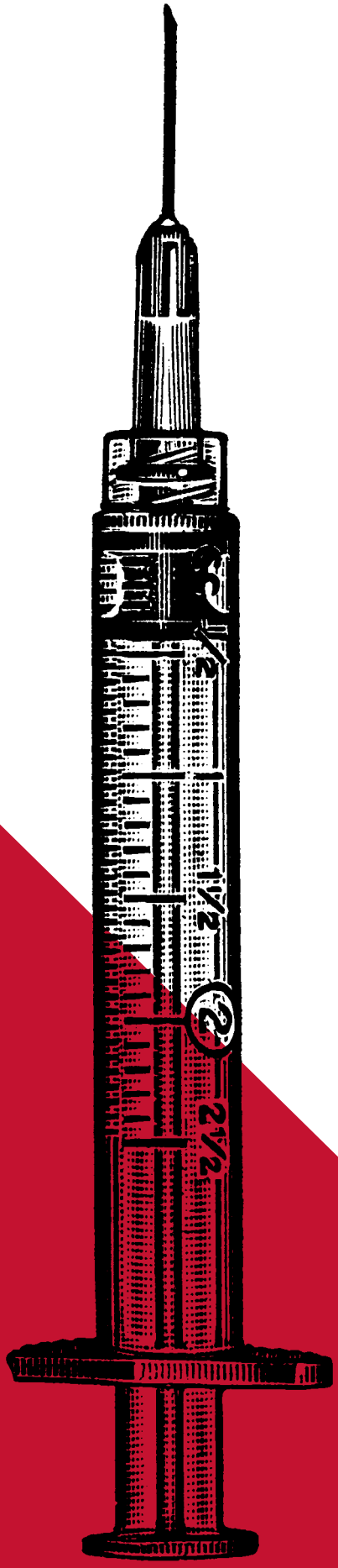
Gail Bolan
Peter Cegielski
Harrell Chesson
Ann Cronin
Thomas Gift
Robert Kirkcaldy
Michael Iademarco
Suzanne Marks
Roque Miramontes
Rachel Powell
Robert Pratt
Maria Fraire Sessions
Wanda Walton
Hillard Weinstock
Jonathan Wortham

National Center for Immunization and Respiratory Diseases (NCIRD)

Ryan Gierke
Steve Hadler
Rana Hajjeh
Lauri Hicks
Lindsay Kim
Gayle Langley
Matt Moore
Alison Patti
Stephanie Schrag
Chris Van Beneden
Emily Weston
Cynthia Whitney
Jonathan Wortham

CS239559-B

Antimicrobial Resistance and Human Health



A Report of the Pew Commission on Industrial Farm Animal Production

TOPIC:

Industrial Farm Animal Production, Antimicrobial Resistance and Human Health

Ellen K Silbergeld, PhD
Lance Price, PhD
Jay Graham, PhD

CONTENTS

Staff Summary	ii
Introduction	vi
Problem Definition	2
Microbiological Issues in Industrial Food Animal Production	6
The Science of AMR	8
The Role of IFAP in AMR	14
Health and Societal Impacts of AMR	32
Risk Assessments of AMR	36
References	40
Glossary	46
About PCIFAP	48

PCIFAP Staff Summary of Antimicrobial Resistance, and Human Health

The Pew Commission on Industrial Farm Animal Production was established by a grant from The Pew Charitable Trusts to the Johns Hopkins Bloomberg School of Public Health. The two-year charge to the Commission was to study the public health, environmental, animal welfare, and rural community problems created by concentrated animal feeding operations and to recommend solutions.

The problem of antimicrobial resistance (AMR) is growing in the United States and worldwide. The questions posed by the Commission were several: What is the scope of the AMR problem? What is the contribution of industrial animal agriculture to the problem? What is the history of and reasons for the use of antimicrobials in animal agriculture? What can or should be done about AMR, from the standpoint of animal agriculture?

It is difficult to calculate the scope of the AMR problem as it relates to animal agriculture because of the types of surveillance that are in place and the way that AMR is transmitted between bacteria. Only certain infectious bacteria are tracked by the Centers for Disease Control and Prevention (CDC) and state and local health agencies. Other types of bacteria, some infectious and some not, are not tracked, so only a certain cross section of the possible resistant microbes are seen by the tracking agencies. This is a problem because of the way resistance is spread between capable bacteria. These bacteria have a small "cassette" of genes that they transmit to each other in one piece. These cassettes can contain resistance to more than one antimicrobial, rendering formerly unexposed or nonresistant bacteria suddenly resistant to multiple kinds of antimicrobials. In addition, bacteria that are not tracked can still

transmit resistance elements. For example, many bacteria live in the human digestive tract or on human skin. These are not normally harmful (and are often helpful) and are not monitored. However, these harmless bacteria may still be capable of passing resistance to other bacteria that *are* harmful, or could then *become* harmful.

Exposure of bacteria to antimicrobials exerts a selective pressure, killing susceptible bacteria and allowing resistant ones to survive and reproduce. Sir Alexander Fleming, the father of antibiotics, described the phenomena of antibiotic resistance and suggested in the 1940s that extensive use of antibiotics would cause bacteria to develop resistance, and further pointed out that new antibiotics would be necessary to combat this on a regular basis. While it is difficult to measure what percent of resistance is caused by antimicrobial use in agriculture, as opposed to other settings, it can be assumed that the wider the use of antibiotics, the greater the chance for the development of antibiotic resistance.

Antibiotics were first used in the early 1950s as a growth promoter in food animals. As "resistance" developed and the antibiotics lost their ability to promote growth in the animal, new generations of antibiotics and antimicrobials were used. Today, estimates vary on the amounts of antimicrobials that are used in food animal production, as well as the amounts that are used nontherapeutically versus therapeutically.

Antimicrobials can save lives of humans and animals, but must be used judiciously given their biological properties. The greater the amount of antimicrobials present in the general environmental pool, the greater the

pressure for the development of resistance within many different bacterial populations. Animal agriculture industry representatives have recognized this in statements to the Commission. This report was commissioned to expand on these concepts.

By releasing this technical report, the Commission acknowledges that the author/authors fulfilled the request of the Commission on the topics reviewed. This report does not reflect the position of the Commission on these, or any other, issues. The final report of the Commission, and the recommendations included in it, represents the consensus position of the Commission.

Introduction

As a complex and important part of the US economy and landscape, the industrial production of animals for human food presents many issues of relevance to human health, including infectious pathogens. This background report will review one topic in depth: the role of industrial food animal production (IFAP) in the increasingly serious public health problem of antimicrobial resistance (AMR) in human pathogens. Industrial food animal production is defined in terms of both organization and methods: economically and structurally, IFAP is an integrated enterprise in which many aspects of food animal production are controlled by one entity; methodologically, it is a high throughput production system of animals for human food consumption, including poultry, swine, and cattle, in which animals of one species are raised in large groups in confinement in houses or enclosures under highly defined conditions of lighting, feed supply, and other aspects of animal husbandry (Martinez 2002).

Close contact between humans and the animals we grow for food has always been a source of transmissible pathogens between humans and animals among rural communities. Likewise, food-borne diseases have always been associated (if not recognized) with food products derived from animals (including meats, eggs, and milk) as a consequence of contamination throughout the processes of slaughter, butchering, storage, and preparation of consumable foods. In addition, domesticated animals have always (like humans) contaminated their environments —including fields and watersheds—through their wastes.

These traditional risks have been recognized for centuries. What is under consideration by the Pew Commission is how the *new* intensive methods of food animal production may both reduce and intensify these traditional risks as well as introduce new risks to both animal and human health. From this perspective, two aspects of IFAP are relevant to consider: the confinement of large numbers of animals for most and, in some cases, for all of their lifetimes, and new formulations of animal feeds.

Confinement of large populations of animals has several impacts on pathogen risks: first, close contact of large numbers of host animals facilitates the evolution and exchange of viruses, bacteria, and microparasites; second, stresses induced by confinement may increase the likelihood of infection and illness in animal populations; and third, these large populations produce large amounts of waste, which can exceed traditional methods of management. These impacts are not limited to the conditions of confinement and animal husbandry practices; however, they are in many cases exacerbated by practices common to the IFAP in the US.

Feed formulation influences pathogen risks because the feeds supplied to confined animal populations are significantly different from the unsupplemented foraged feeds of grains and grasses traditionally available to poultry, swine, or cattle (with relatively minimal supplementation by minerals or other substances). These feeds have been modified to meet the conditions of confined environments and also in response to research on animal growth and nutrition. The major goals in feed development have been twofold: to ensure healthy and uniform animals, and to reduce the costs of food animal production by reducing both the time needed to reach market weight for each species and the efficiency of feed conversion or the amount of food intake required to achieve this weight. In modern animal feeds, there is extensive recycling of animal fats and proteins through rendering, additions of industrial and animal wastes, and the addition of antimicrobials (AMS), including arsenicals, as feed additives (reviewed by Sapkota et al. 2007). *This latter innovation, which began more than 50 years ago in the US, has introduced a new public health risk into the context of food animal production,—the selection of antimicrobial -resistant bacteria.* Because of the importance of this issue for public health, its high profile, and its specificity for IFAP, this topic will be discussed in greatest depth in this background paper.

Problem Definition

Antimicrobial resistance is one of the major public health crises of our time. The discovery of AMs and their application to clinical medicine are among the triumphs of twentieth century pharmacology and medicine. This triumph has been eroded with the rise and spread of antimicrobial resistance, and it has been suggested that we are entering the "post antibiotic age" of medicine (Falagas and Bliziotis 2007). Antimicrobial-resistant bacterial infections now account for much of the problem of emerging infectious disease worldwide (Okeke, Laxminarayan et al. 2005; Velge, Cloeckaert et al. 2005; Seybold, Kourbatova et al. 2006; Erb, Sturmer et al. 2007; Laxminarayan 2007). In some cases, selection for resistance also results in more virulent strains, as in the case of *E. coli* and *S. aureus* (Ohlsen, Ziebuhr et al. 1998; Johnson, Kuskowski et al. 2005; Mora, Blanco et al. 2005; Stevens, Ma et al. 2007).

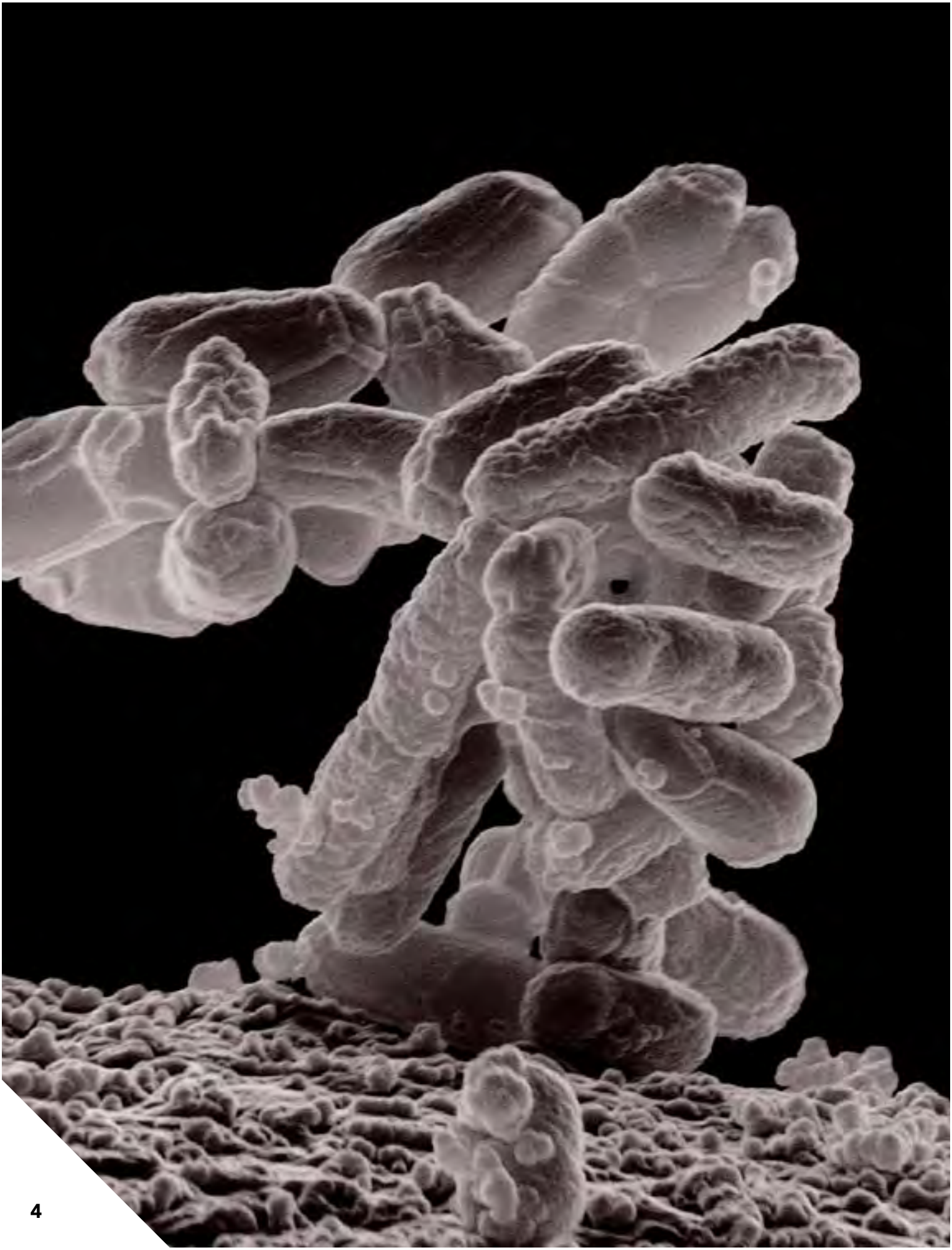
AMR infections are often more difficult to treat and are associated with increased morbidity and risks of death (Travers and Barza 2002). The burden of these poorly controllable infections on health care systems has been evaluated by the Organization for Economic Co-operation and Development (OECD) (OECD 2003), among others. A comprehensive review of the topic, including a discussion of method for computing loss of economic productivity, was recently published by Smith et al. (Smith, Yago et al. 2005). In addition to the direct costs of increased hospital stays and increased costs of treatment (which may increase costs of individual patient care by sixfold (Capitano, Leshem et al. 2003)), there are major cost impacts on the health care system to monitor and prevent spread of resistant infections, which have not been fully calculated (Laxminarayan 2007).

The scope and scale of AMR have been well characterized by Levy (Levy 1998; Levy and Marshall 2004). Information from the US government National Antimicrobial Resistance Monitoring System (NARMS) covers analyses of isolates from food, animals, and humans; this is available online (www.cdc.gov/narms). However, it is difficult to obtain data on trends in AMR from this source, given variability in sampling, or to test associations with antimicrobial use, or to draw associations between food, animals, and humans. Moreover, there are few studies in which the origin of food contamination is fully traced; in some cases for fruits and vegetables (as discussed below), this may be related to waste contamination and a secondary impact of antimicrobial use in food animals.

Longitudinal studies confirm the increasing severity of AMR (Erb, Sturmer et al. 2007). Specific analyses, using longitudinal data from clinical isolates collected by the same research group in the same setting, demonstrate increasing temporal trends in AMR in several pathogens, as shown on the following page in a study from Philadelphia (Lautenbach, Strom et al. 2004). Similar trends were observed for *P. mirabilis* and *K. pneumoniae*. These data underscore the increasing severity of the drug resistance crisis such that attention to all preventable sources of resistance pressure requires consideration.

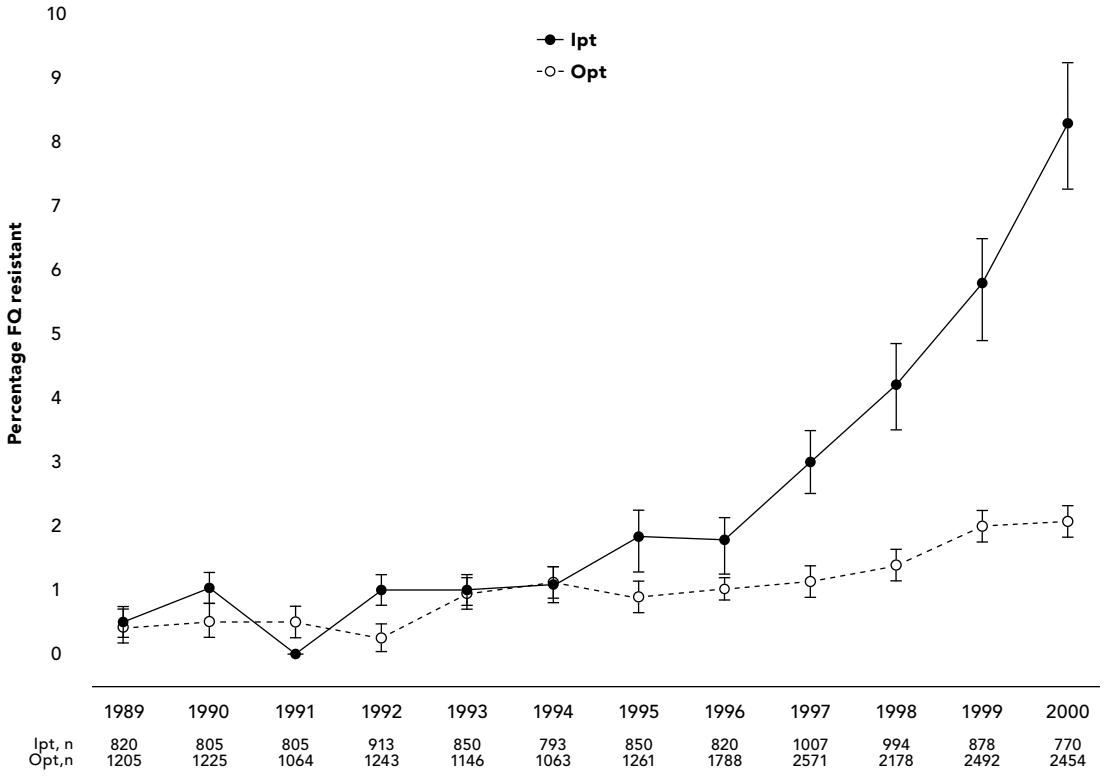
Estimates of AMR based upon analyses of persons with disease may significantly undercount the true prevalence of AMR exposure in the general population. In a study of *incoming* patients at a tertiary care hospital in Boston from 1998/9 to 2002/3, the likelihood of multidrug resistance in *E. coli* increased from 2% to almost 20% (Pop-Vicas and D'Agata 2005). A major study of *E. coli* isolated from newly hospitalized subjects not diagnosed with infectious disease reported that 20% of the isolates were resistant to fluoroquinolones, approximately twice the rates found by the same group in studies of hospital patients with diagnosed bacterial disease (Lautenbach, Tolomeo et al. 2006). Moreover, analyses based solely upon testing of pathogenic bacteria may miss the significance of increasing "reservoirs of resistance" in commensal (or nonpathogenic) organisms (Alekshun and Levy 2006). This broader view of microbial ecology and gene flow is an important issue for both science and policy (Summers 2002).

The issue for consideration by the Pew Commission is to consider the appropriate policy response to an evaluation of the contribution of antimicrobial use in food animal production to the national and global crisis of antimicrobial resistance. Because of its importance to public health, antimicrobial resistance (AMR) is one of the most important public health issues related to IFAP, recognizing the difficulty in assessing the associations between food animal production and AMR or to determine the fraction of AMR infections



that are attributable to food animal production. To assist the Commission in this task, this White Paper provides an overview of AMR in the context of microbiological issues in IFAP and then presents a brief review of the evidence base relevant to the issue of AMR and IFAP. The discussion includes information from the US and other countries; a global perspective is appropriate since AMR bacteria and resistance genes can be transferred globally through the movement of people, food, animals, and via wind and water.

Figure 1: Prevalence of fluoroquinolone resistance in *E. coli* isolates from inpatients (Ipt) and outpatients (Opt) in Philadelphia, from 1989 to 2000. Approximately 60% of the samples were from inpatients and 40% from outpatients over this period.



Problem Definition:

Antimicrobial[1] resistance (AMR) is defined as changes in microbial biology that occur in response to antimicrobials and that reduce or block the effectiveness of drugs, chemicals, or other agents to cure or prevent infections. AMR is determined by *in vitro* tests of strain-specific cultures in which survival of the bacterial isolates is tested under conditions of increasing AM concentrations. The *in vitro* concentration at which bacterial survival is significantly affected is then compared to benchmarks that signify impacts on clinical efficacy; thus the MIC (minimum inhibitory concentrations) values are set by the NCCLS (National Committee for Clinical Laboratory Standards) to reflect a level of resistance that is likely to compromise the efficacy of AM treatment in an infected patient (Ginocchio 2002; NCCLS 2006).

[1]antimicrobial refers to a category of agents, including both natural compounds (sometimes referred to as antibiotics) as well as synthetic chemicals

Microbiological Issues in Industrial Food Animal Production

At the outset, it should be recognized that the production of animals for human food has always involved public health risks related to microbial exposure. In addition to the traditional risks of disease from microbial contamination of food, IFAP has introduced a new risk related to practices in animal feeding.

From time immemorial, animals have been the source of some of the pathogens that can cause diseases in human populations (Orriss 1997; Bengis, Leighton et al. 2004; Fevre, Bronsvoort et al. 2006). In the process of domesticating animals into herds as livestock, we have over time created denser populations, in closer proximity to humans, with accompanying problems of waste management and increased likelihood of animal-human-animal microbial exchange and for pathogen mutation. These traditional risks have been recognized for centuries. We continue to be challenged by newly emerging zoonoses such as transmissible encephalopathies (mad cow disease), SARS, Nipah virus infection, and avian influenza—all diseases caused by pathogens that are predominantly carried by animals we raise or hunt for consumption.

Risks of zoonotic disease are greatly intensified by the changes in the scale of animal husbandry (Fevre, Bronsvoort et al. 2006). Large numbers of animal hosts in close contact facilitate the exchange and speed up the evolutionary transformation of pathogens (Saenz, Hethcote et al. 2006). Because of the confined conditions of IFAP, animal health and the health of humans involved in animal husbandry are at risk due to intensified exposures to a range of zoonotic pathogens, including macro- and microparasites, viruses, and bacteria. In addition, domesticated animals held in confinement are unavoidably exposed to their wastes. Farmers and farm workers in the confined spaces of animal houses containing thousands of animals are at increased risks of exposure to microbes and biotoxins. Air emissions from animal houses can release pathogens from the house into the ambient environment. Finally, and probably of greatest importance to public health, these large populations of animals produce large volumes of waste, which, because of the regional intensification of production, greatly exceed the capacity of traditional methods of management through their use as fertilizers of nearby soils. There are no requirements in the US for predisposal treatment of animal wastes (such as composting under controlled conditions). Pathogens, including bacteria and viruses, survive in animal wastes for extensive periods of time and can be recovered in soils that have been "amended" by these wastes (Gerba and Smith 2005).

Likewise, human food products derived from animals (including meat, eggs, and milk) have always presented microbial risks to human health. Slaughterhouses, until recently, were grossly unhygienic as described in 1906 by Upton Sinclair—rivaled probably only by hospitals prior to the 20th century as breeding grounds for virulent pathogens. From farm to market, there was little control over microbial contamination (and replication) at any stage. Meat products were sold in markets with no refrigeration, preservation, or containment; in addition, live animals were often sold at markets where slaughtering occurred at the place and time of sale—as it still does in many countries of the world.

With the recognition of the food-borne origin of many infectious diseases, and the realization that improvements in hygiene at the farm were essential to the control of animal diseases as well, great advances have been made in hygienic practices since the early 20th century, particularly with the advent in 1995 of a new philosophy of "farm to fork" and a systems approach to hygiene called Hazard Analysis and Critical Control Point (HACCP) in the US (Billy and Wachsmuth 1997). The endorsement of these principles by national and international agencies around the world and the adoption of food and phytosanitary standards by the World Trade Organization have in many cases extended these practices internationally. In an age of the global market basket, where consumers in the US purchase foods from international sources, this is a critical element in food safety (Naimi, Wicklund et al. 2003).

The application of HACCP in animal slaughtering and processing has reduced many risks of food contamination; however, new risks may not be effectively managed by older approaches (Morris 2003). While modern food processing plants have been greatly enhanced by the effective application of HACCP principles, the cost of failure is magnified by their high throughput and the highly efficient national distribution system of food, both of which facilitate the widespread propagation of food-borne risks.

The Science of AMR

Understanding the scientific events in antimicrobial resistance is important to an evaluation of the contribution of IFAP to this public health issue. *The first scientific principle is that from the perspective of fundamental biology and evolution, selection of AM resistance in response to exposure to AMs is inevitable; moreover, the prevalence and rates of resistance in bacteria are proportional to the degree of exposure to antimicrobials.* Microbes have evolved highly effective mechanisms to respond to environmental pressures, such as temperature change, oxygen concentrations, nutrient availability, and toxin exposure, including antimicrobial agents (AMs). Thus, exposure of bacteria to sublethal concentrations of AMs inevitably results in the selection of resistant strains, and under conditions of continued AM pressure, resistant strains will propagate and spread. Because most AMs are derived from natural products, bacteria have acquired, through evolution, biochemical responses to resist AM attack; and AMR can be observed in the absence of any deliberate human use of AMs. Because of the speed of bacterial reproduction, these changes can be expressed with great efficiency. Thus, through an evolutionary process of microbial response to the pressure of antimicrobial agents, resistance is an inevitable consequence of antimicrobial use, and it is not surprising that observations of resistance came soon after the identification and isolation of the first natural antimicrobial substance.

The second important scientific principle is that bacterial resistance to antimicrobials involves both genetic and nongenetic changes, of which the former have more serious implications for public health. Nongenetic changes typically involve enhanced activity or upregulation of physiological processes such as membrane transport pumps that extrude harmful agents, including antimicrobials. However, the capacity of these response mechanisms is limited, and usually bacteria express only low-level resistance as a consequence. Genetically encoded changes are more serious because these can usually confer higher-level resistance to specific agents and because they can be transferred among bacteria. Since most AMs are derived from fungal and other natural sources, bacteria have evolved in the presence of these toxins (Wright 2007), and it is therefore not surprising that, even in the absence of antimicrobial pressure, there are sources of resistance encoded by specific genes within the community repertoire of bacterial genomes. In the presence of selection pressure by an AM, bacterial populations quickly evolve to a resistant phenotype (Smith, Harris et al. 2002; Tenover 2006). The speed of this evasion process is hastened by two factors: the rapid rate of bacterial reproduction and the ability of bacteria to transfer genetic information among organisms even across broad phylogenetic categories.

Resistance spread. *The third important scientific principle is that bacteria can share resistance through the transfer of genes that encode resistance.* Resistance is a trait expressed by specific bacteria and can result from new mutations that occur spontaneously in bacteria due to their rapid rate of cell division or from the selection of resistance genes already present within a bacterial colony. In the presence of antimicrobial pressure, strains that express resistance traits through spontaneous mutation are favored in terms of survival, and they will rapidly supplant susceptible strains in microbial populations. But in addition, and potentially of greatest significance for

public health, bacteria have a third mechanism of rapid evolution towards a resistant phenotype through the sharing of genes that encode resistance. By this process, resistance can be propagated within and among bacterial strains, species, and genera, including commensals (nonpathogenic) and pathogens, by mobile genetic elements including plasmids, transposons, integrons, gene cassettes, and bacteriophages. In contrast to chromosomal-based resistance determinants, these transfers account for more than 95% of antibiotic resistance (Nwosu 2001). These events have been detected in resistant *E. coli* isolated from consumer meat products (Sunde and Norstrom 2006). This finding is of particular concern because integrons can transfer multiple resistance genes at a time (Zhang, Lin et al. 2003; Zhang, Sahin et al. 2006).

Bacteria operate at the community level in terms of responding to stress, and therefore they have developed mechanisms to share genetic information, often across broad species divisions. Because it is the community response that is crucial (Summers 2002; Heuer, Hammerum et al. 2006), genetic change in response to AM pressure is not dependent upon reproduction or cell division, as is the case for most higher organisms. Bacteria can exchange genetic information across broad classes by several mechanisms, as shown on the following pages. These mechanisms are in many cases enhanced by stressors such as AM pressures that can enhance the rates and efficiency of genetic recombination.

Microbiologists now refer to "reservoirs of resistance" in recognition of the fact that it is the *community* of genetic resources that determines the rate and propagation of resistance (Salyers and Shoemaker 2006). *The existence of these "reservoirs of resistance" has a considerable impact on how we conceptualize and deal with the challenge of AMR associated with food animal production.* Until recently, the focus of public health concern was on specific patterns of resistance in specific pathogens of concern, such as quinpristin/dalfopristin (Q/D) resistance in *Enterococcus faecium*. However, since genes for these and other resistance traits can be exchanged from a commensal or nonpathogenic species, such as *E. coli* in the gut of a patient being treated for campylobacteriosis, the "one bug one drug" definition of the scope of concern is increasingly recognized as inadequate (Summers 2002; Summers 2006). The contribution of agricultural AM use to environmental reservoirs of resistance has been documented for both poultry and swine (Nandi, Maurer et al. 2004; Jensen, Jakobsen et al. 2006).

The incorporation of these new perspectives into policy and risk assessment is of great importance. Aspects of this issue (such as the importance of commensals) have been considered by the FDA in its rulings on fluoroquinolones (Bartholomew, Vose et al. 2005). It is not clear how this will be utilized in evaluating other related issues.

Persistence of resistance. *The fourth important scientific principle is that resistance may continue even after AMs are no longer present.* As noted above, the microbial community can serve as a resource, or reservoir, of resistance genes. Earlier theories of microbial genetics assumed that this was unlikely to be a long-term phenomenon since the expression of resistance was thought to cost the organism (in terms of increased energy requirements, susceptibility to other stressors, or decreased reproductive rates) such that in the absence of AM pressure, its occurrence was rare. Current research has cast doubt on the concept of a "cost of resistance" (Salyers and Amabile-Cuevas 1997). While the prevalence of resistant strains markedly decreases when antimicrobials are no longer present, this is not always the case for several reasons. First, in some cases, resistant organisms may outcompete susceptible strains: for example, *Campylobacter jejuni* that are resistant to fluoroquinolones have greater ability to colonize the guts of animals, resulting in a selective advantage over wild strains in competing for the ecological niche of the host.

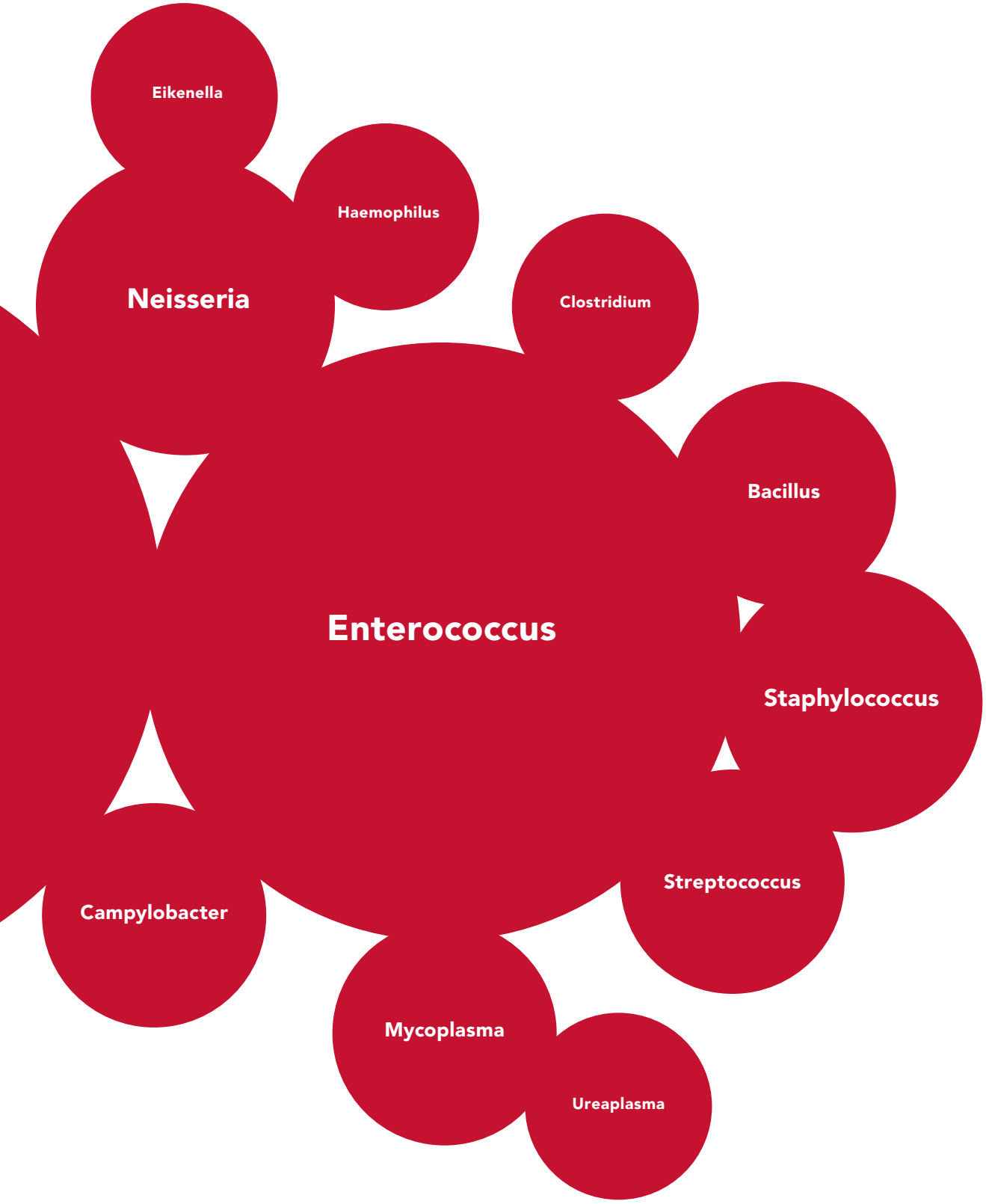
Second, resistance may also persist due to the clustering of resistance genes on the same transposable elements such that eliminating only one antimicrobial may not reduce the prevalence of the cluster (Aarestrup, Agerso et al. 2000). Such events have been observed in the setting of swine farms (Gebreyes and Thakur 2005). Third, it may in some cases be "cheaper" for a resistant bacterial strain to acquire an additional genetic change that reduces the biological cost of resistance rather than to revert genetically and phenotypically to the "wild" or susceptible state (Levin, Perrot et al. 2000; Wright 2007). Finally, it may be the case that AM pressure is now so widespread, due to multiple uses of AMs for many purposes, that there is a community benefit of maintaining the genetic reservoir of resistance such that the frequency of genetic mutations encoding resistance has increased.

Empirical evidence supports this: even after the removal of AMs from animal feeds, researchers in Europe have reported on the persistence of resistant pathogens in animal houses, wastes, and food products from several types of food animals (Sorum, Johnsen et al. 2006). Similar findings are reported by Price et al. (Price, Johnson et al. 2005; Price, Graham et al. 2007; Price, Lackey et al. 2007) on the continuing prevalence of fluoroquinolone-resistant *Campylobacter* in chicken products sold in US supermarkets, after voluntary actions by producers and the FDA ban on fluoroquinolone use in poultry production.

The History of Antimicrobial Resistance

Bacteria acquired the genetic and physiological tools to resist antimicrobials long before scientists isolated and identified these natural agents in the early 20th century (Wright 2007). Because many antimicrobials are natural products of fungi and other organisms, bacteria have evolved these mechanisms over millions of years, and thus it is possible to detect AMR in bacteria that have not been exposed to our uses of AMs in medicine or agriculture. Antimicrobial resistance was evident from the early history of penicillin. The isolation of the first naturally occurring antimicrobial (penicillin) in the 1930s ushered in a major change in clinical and veterinary medicine, and food animal production as well. With the discovery of natural antimicrobial compounds, the balance seemed at last to be tipped against the pathogens, but victory was short-lived. Even in the laboratory, Fleming observed that his bacterial cultures quickly demonstrated resistance to penicillin, and in 1945, he warned that the misuse of penicillin could lead to selection of resistant forms of bacteria (Levy 1998). Fleming suggested that resistance to penicillin could be conferred in two ways—either through changes in the bacterial cell wall, which was the target of penicillin action, or through the selection of bacteria expressing mutant proteins capable of degrading penicillin. Unfortunately, in the early period of its use, penicillin was available orally to the public without prescription until the mid 1950s. By 1946, one hospital reported that 14% of the strains of staphylococci isolated from sick patients were penicillin resistant (Barber, Hayhoe et al. 1949). By the 1950s, this same hospital reported that 59% of the strains of staphylococci were penicillin resistant.

Figure 2: Genetic exchange among bacterial species (Adapted from Levy and Miller, 1989).


Eikenella
Haemophilus
Neisseria
Clostridium
Bacillus
Enterococcus
Staphylococcus
Streptococcus
Campylobacter
Mycoplasma
Ureaplasma

The Role of IFAP in AMR

All uses of AMs contribute to the likelihood that bacteria will be resistant to AM drugs. The focus on IFAP is justified by three factors:

- the nontherapeutic and prophylactic uses of antimicrobials as feed additives (as distinct from therapy; see below) set the stage for selection of resistant strains;
- the antimicrobial drugs currently used as feed additives represent many of the critically important classes of AMs, and resistance to one AM results in resistance to all drugs in the same class;
- the amounts of AMs utilized in modern food animal production dwarf the amounts used in clinical and veterinary medicine.

A wide range of AM drugs are permitted for use in food animal production in the US and many other countries (Sarmah, Meyer et al. 2006). As shown in Table 1, these drugs represent all the major classes of clinically important pharmacotherapies, from penicillin to third generation compounds. In addition, arsenicals are also permitted for use as growth promotants and for enhancing skin quality (Roxarsone and arsanilic acid). In some cases, new AMs have been licensed for agricultural use in advance of approvals for clinical use. In the case of quinpristin-dalfopristin (virginiamycin), this practice resulted in the emergence of resistance prior to eventual clinical registration, thus demonstrating how feed additive use can compromise the potential utility of a new tool in fighting infectious disease in humans (Kieke, Borchardt et al. 2006). For existing drugs, Smith et al. (Smith, Harris et al. 2002) calculated that agricultural use can significantly shorten the "useful life" of antimicrobials for combating human or animal disease.

Table 1. Antimicrobials registered for use as feed additives in Australia, Denmark, European Union (EU), Canada, and the United States (Data from Sarmah et al. 2006).

Countries	Group/Class	Antimicrobial	Usage
Australia	Arsenicals	3-nitro-arsonic acid	Pigs, poultry
	Glycopeptides	Avoparcin	Pigs, meat poultry, cattle
	Macrolides	Kitasamycin	Pigs
		Oleandomycin	Cattle
		Tylosin	Pigs
	Polyethers (ionophores)	Lasalocid	Cattle
		Monensin (data available)	
		Narasin	Cattle
		Salinomycin	Pigs, cattle
	Polypeptides	Bacitracin	Meat poultry
	Quinoxalines	Olaquindox (data available)	Pigs
	Streptogramins	Virginiamycin	Pigs, meat poultry
	Others	Flavophospholiphol or Bambermycin	Pigs, poultry, cattle
European Union	Glycopeptides	Avoparcin	Banned, 1997
	Macrolides	Tylosin	Pigs
		Spiramycina	Turkeys, chickens, calves, lambs, pigs
	Oligosaccharides	Avilamycin	Pigs, chickens, turkeys
	Polyethers (ionophores)	Monensin	Cattle (growth promotion)
		Salinomycin	Pigs
	Polypeptides	Bacitracin	Turkeys, laying hens, chickens (growth promotion), calves, lambs, pigs
	Streptogramins	Virginiamycin	Turkeys, laying hens, cattle (growth promotion), calves, sows, pigs
	Others	Flavophospholiphol or Bambermycin	Turkeys, laying hens, other poultry, calves, pigs, rabbits, cattle (growth promotion)
Canada	Aminoglycosides	Neomycin	Cattle
	Lincosamides	Lincomycin hydrochloride	Breeder chickens
	Macrolides	Erythromycin	Chicken (broiler, breeder)
		Tylosin	Sheep
	Penicillins	Penicillin G	Chicken (broiler, breeder)
		Potassium	Turkey
		Penicillin G procaine	Chicken, turkey, sheep
	Tetracyclines	Chlortetracycline	Chicken (layer, breeder)
		Oxytetracycline	Turkey, swine, cattle, sheep
	Sulfonamides	Sulfamethazine	Pigs, cattle
	Ionophores	Lasolocid sodium	Cattle
		Monensin	Cattle
		Narasin	Pigs
		Salinomycin sodium	Pigs, cattle

Table 1. Antimicrobials registered for use as feed additives in Australia, Denmark, European Union (EU), Canada, and the United States (Data from Sarmah et al. 2006).

Countries	Group/Class	Antimicrobial	Usage
Canada	Polypeptides	Bacitracin	Chicken, pigs, turkey
	Glycolipids	Bambermycin	Turkey, breeder chickens
	Quinoxalines	Carbadox	Pigs
	Others	Arsanilic acid	Broiler, turkey, pigs
USA	Arsenicals	Arsenilic acid	Poultry
		Roxarsone, cabarsone	Poultry
	Polypeptides	Bacitracin	Cattle, pigs, poultry
	Glycolipids	Bambermycin	Pigs, poultry
	Tetracyclines	Tetracycline	Pigs
		Chlortetracycline	Cattle, pigs, poultry
		Oxytetracycline	Cattle, pigs
	Elfamycine	Efrotomycin	Pigs
	Macrolides	Erythromycin	Cattle
		Oleandomycin	Chicken, turkey
		Tylosin	Cattle, pigs, chicken
		Tiamulin	Pigs
	Lincosamides	Lincomycin	Pigs
	Polyethers (ionophores)	Monensin	Cattle
		Lasalocid	Cattle
	Penicillins	Penicillin	Poultry
	Quinoxalines	Carbadox	Pigs
	Streptogramins	Virginiamycin	Swine
	Sulfonamides	Sulfamethazine	Cattle, pigs
		Sulfathiazole	Pigs

Many of these antimicrobials are widely used in US livestock production, as shown in the figures below from the USDA (USDA/APHIS 2003). The most recent data reported to be available to the USDA are from 1994–5. Depending upon stage of growth, feeds with antimicrobials were supplied to between 38% and 70% of pigs in the US and between 30% and 58% of cattle raised in feedlots (with higher percentages in the larger operations). A broad range of antimicrobials was supplied to these cattle, with 45% of operations using chlortetracycline and 42% using tylosin. Similar data were published on antimicrobial use in poultry, based upon reporting by poultry production units (defined as a set of farms served by one feed mill) as shown in Figure 2D (Chapman and Johnson 2002).

Figure 2A. Use of antimicrobials in swine production, by route of administration and by type of pig (Data from USDA/APHIS 2003).

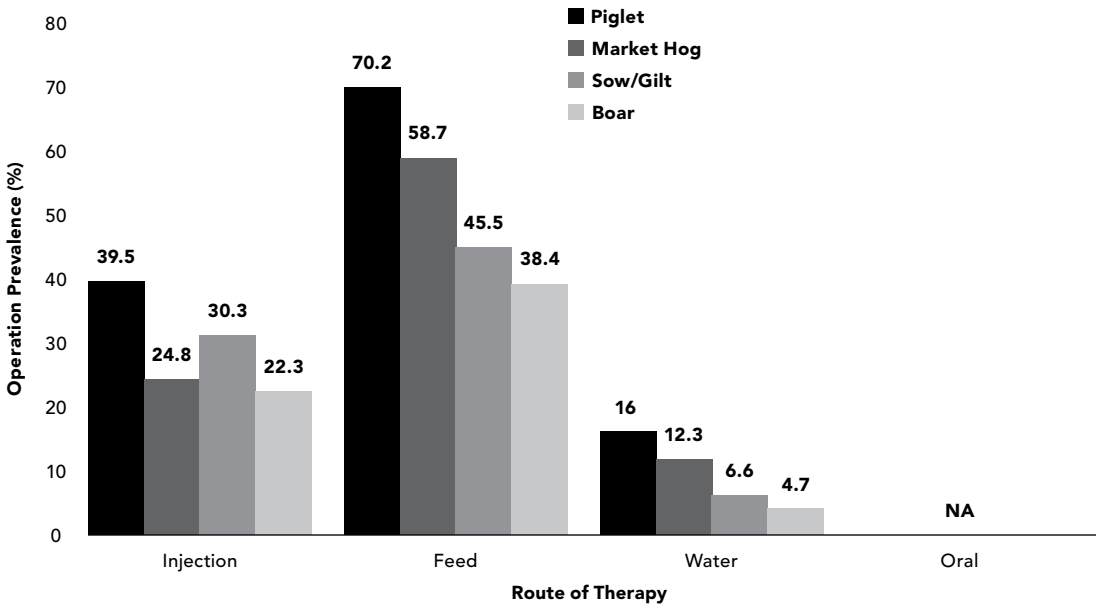


Figure 2B. Antimicrobials used in feed or water for cattle fed in feedlots (Data from USDA/APHIS 2003).

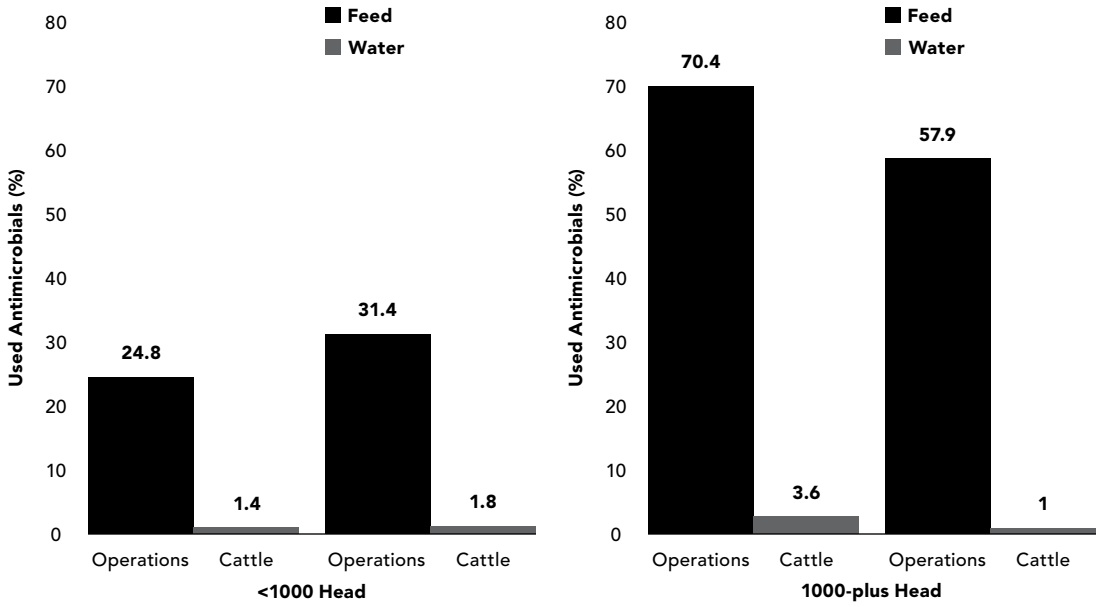


Figure 2C. Types of antimicrobials utilized in feed or water supplied to cattle in larger feedlots (1000-plus head) (Data from USDA/APHIS 2003).

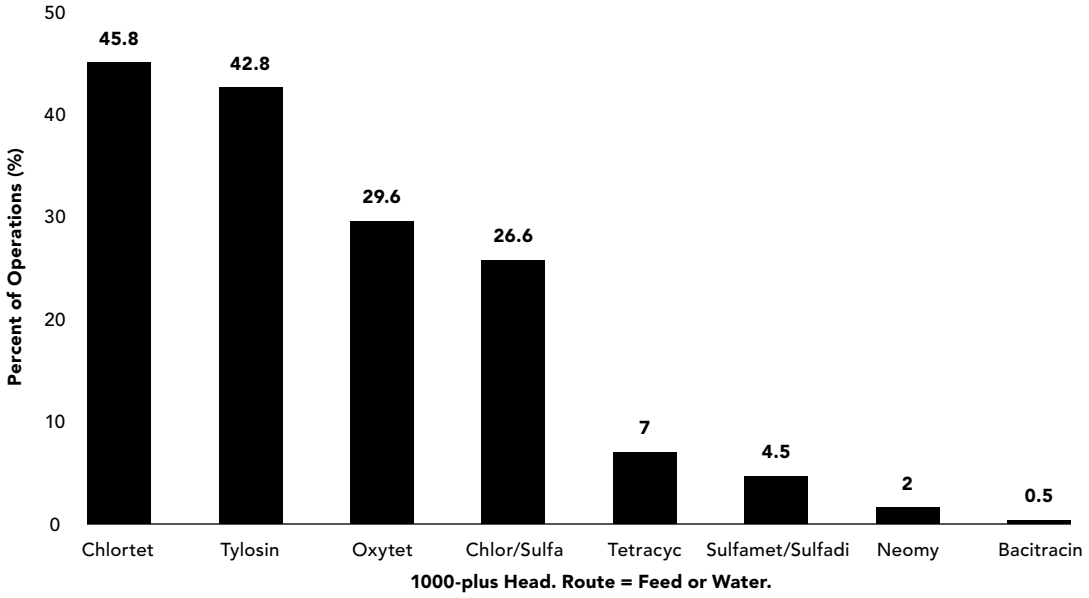


Figure 2D. Average reported use of antimicrobials as feed additives in broiler poultry production, from 1995–2000 (Data from Chapman and Johnson 2002).

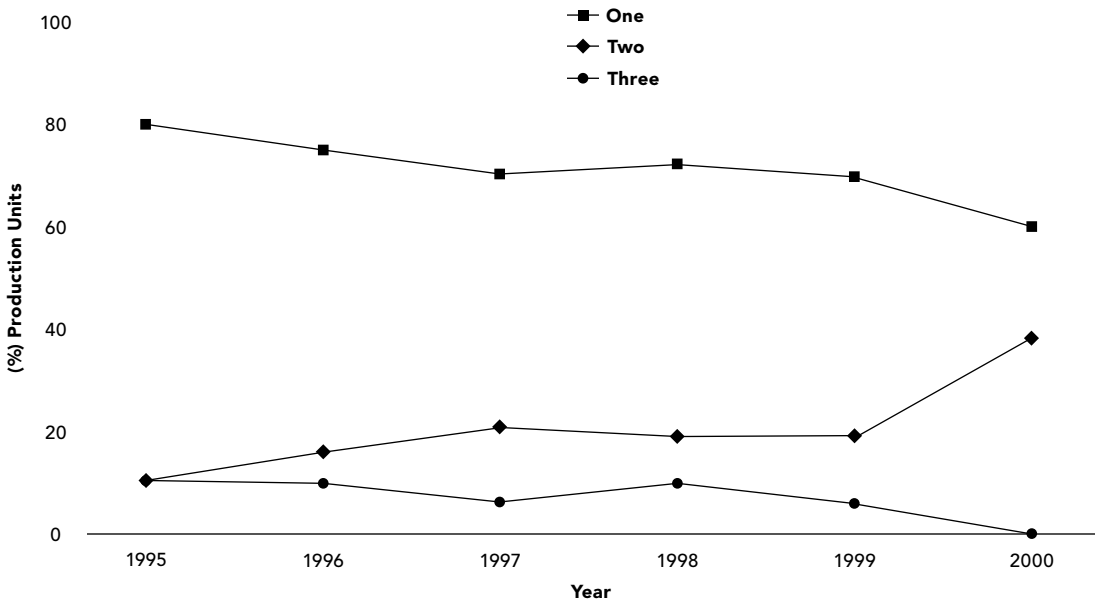


Table 2. Prevalence of multiple antimicrobial use in broiler feeds (Chapman and Johnson 2002). BAC = bacitracin; BAM = bambermycin; LIN = lincomycin; TYL = tylosin; VIR = virginiamycin.

One antibiotic		Two antibiotics		Three antibiotics	
Antibiotic	**%PU**	**Antibiotic**	**%PU**	**Antibiotics**	**%PU**
BAC	13.7	BAC, VIR	37.8	BAC, BAM, VIR	5.0
BAM	3.0	BAC, BAM	16.0	BAC, BAM, LIN	1.8
LIN	3.1	BAC, LIN	9.3	FLA, VIR, LIN	0.7
VIR	2.0	BAC, TYL	3.1	BAC, VIR, LIN	0.6
–	–	VIR, BAM	2.5	–	–

As with cattle, several antimicrobials were used in feeds for broilers, with 37% reporting use of bacitracin and virginiamycin, as shown in Table 2 above (Chapman and Johnson 2002).

There is a lack of publicly available validated information on the volume of AM use as feed additives in IFAP in the US and many other countries. In the EU, several countries collaborate in data collection and publication through the Veterinary Antibiotic Usage and Resistance Surveillance Working Group (VANTURES). However, there are still limitations on data availability in the EU; for example, in the Netherlands, information on antimicrobials in feeds for growth promotion is not under veterinary authorization and not disclosed by feed manufacturers (MARAN 2002). In contrast, Denmark has maintained a publicly available national database of AM use for more than 10 years (DANMAP 2000). In the US, there are unresolved debates over the proportion of AM use in agriculture for this purpose, as compared to human and veterinary medicine. Most estimates suggest that nontherapeutic, agricultural use accounts for between 60% and 80% of total AM production in the US (Mellon et al. 2001) and, until recently, in the EU as well (Teuber 2001). These estimates are contested by industry sources (e.g., Animal Health Institute in the US). Global use is increasing as the IFAP model of production is adopted in other countries (Sarmah, Meyer et al. 2006). Information on the amounts of AMs utilized as feed additives in the US is not available since feed formulations are considered confidential business information under US law. Because of the relatively greater transparency of the Union of Concerned Scientists (UCS) calculation methods, some authorities have utilized those estimates (e.g., US EPA, APUA, etc.), but validated use information from the industry would be of great value in evaluating the relative importance of different uses of AM in agriculture as well as in clinical and veterinary medicine. *Because of the importance of obtaining reliable and accurate information on AM use in agriculture, the PCIFAP may consider recommendations to improve access and transparency of data on this topic.*

The Union of Concerned Scientists, a nongovernmental organization, utilized the registration data published by the FDA and animal census figures from USDA (Mellon et al. 2001). The Animal Health Institute, an industry trade organization, published data based upon information from its members. These two estimates are shown in Figure 3.

One source of controversy arises from the problems in distinguishing between therapeutic and nontherapeutic uses. The use of AMs for treatment and prevention of animal diseases is an important component for ensuring the health and well-being of domesticated animals. However, the addition of antimicrobials to feeds is claimed to be prophylactic as well as growth promoting. The World Organisation for Animal Health (OIE), NCCLS, and others divide medical use into different categories of use by purpose as shown in Table 3.

There is some controversy over the validity of distinctions made in practice between prophylaxis and metaphylaxis and concerns that growth promotion is sometimes claimed to be prophylactic (see, for instance, (Phillips, Casewell et al. 2004)). Interestingly, the World Health Organization (WHO) in its report on antimicrobial resistance and agricultural antimicrobial use does not include metaphylaxis in its list of definitions (surveillance standards for AMR downloadable from http://www.who.int.emc).

Like appropriate clinical use of AMs, the appropriate use of antibiotics in veterinary medicine, to treat or prevent disease, can also contribute to AMR. There has been some discussion as to whether the veterinary need for AMs is increased by the conditions of confined animal husbandry. As discussed in detail in other Commission reports, broiler poultry and other birds raised for meat are customarily housed on bedding or litter that is not cleaned after each flock; swine raised in confinement are often housed on slatted floors above cesspits that hold their wastes; dairy and beef cattle are also sometimes exposed to their wastes in feedlots and milking barns.

It is the use of AMs in feeds for food animal production that has raised the greatest concerns in terms of driving selection for resistance as discussed above. *The key differences characterizing use of AMs as feed additives are: addition of AMs in the absence of specific medical purpose; administration in feeds provided ad libitum and thus without control over dose; and application at rates that result in exposures that are insufficient to kill bacteria.* The focus of public health concerns on AMs in animal feeds is based on the following: first, in many cases, AMs are administered throughout the lifetime or for most of the lifetime of the animals; second, AMs are delivered to the entire flock

through additions to feed; third, the concentrations of AMs are sufficiently low and uncontrolled such that doses to individual animals are likely to be subtherapeutic; and fourth, the use of AMs as feed additives involves many of the major classes of AMs useful in clinical and veterinary medicine. There is evidence to indicate that this use compromises the efficacy of AMs used in the US and throughout the world, and for this reason, the WHO, together with the Food and Agriculture Organization (FAO) and OIE, convened several international expert work groups and conferences since 1997 on the issue of agricultural antimicrobial use and AMR. At that time, an expert work group made the following recommendations:

- the use of any antimicrobial growth promoters should be terminated if they are used as human therapeutics, or known to select for cross-resistance to antimicrobials used in human medicine;
- no antimicrobial should be administered to a food animal unless it has been evaluated and authorized by competent national authorities;
- a systematic approach aiming at replacing growth-promoting antimicrobials with safer nonantimicrobial alternatives should be established;
- national authorities should maintain records of export/import figures of bulk chemicals with potential antimicrobial use as such information is vital for quantitative assessments of the medical risks related to the use of antimicrobials in livestock production;
- national authorities should continue to monitor and review levels of antimicrobial agent residues in food from animal sources and ensure compliance with national standards.

(surveillance standards for AMR downloadable from http://www.who.int.emc).

These principles have been repeatedly referenced, for example, in the WHO Global Strategy for the Containment of Antimicrobial Resistance (2001; WHO/CDS/CSR/RDS 2001.2a).

Figure 3: Estimated antimicrobial use in food animal production (in millions of pounds).

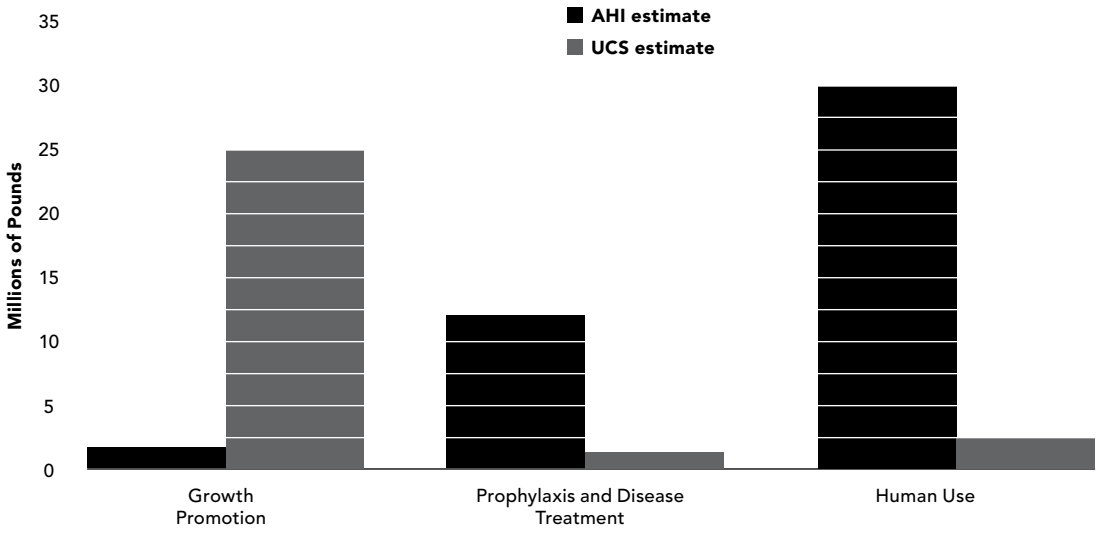


Table 3: Definitions of antimicrobial use in veterinary medicine.

Therapy:	administration to an animal or animals showing clinical disease
Control:	administration to a group of animals in which rates of disease or death have exceeded a baseline
Prophylaxis:	administration to healthy animals at risk of disease but without signs of disease or infection
Metaphylaxis:	the timely mass medication of large groups of animals in the presence of disease in some animals
Growth Promotion:	administration, usually in feed, to improve growth or other physiological performance

How did AMs enter industrial food animal production?

The history of the use of AMs in IFAP has been examined by several, including a recent paper by Graham et al. (Graham, Boland et al. 2007). Most accounts indicate that wastes from pharmaceutical fermentation processes were utilized as protein sources in feeds late in the 1940s (NRC 1999). Empirical observation, followed by relatively limited experiments (Stokstad and Jukes 1958-1959; Jukes 1979), indicated that these unpurified additions appeared to enhance growth rates without increasing food consumption. Further experimentation demonstrated that the observed effect was due to AMs, and from the period from 1947 to 1955, there was active investigation of different AMs for this valued property. It is noteworthy that even in the early literature two phenomena were observed: increased hygiene produced the same results in terms of productivity, and the efficacy of each AM appeared to attenuate over time. For that reason, the food-producing industry has sought, and obtained until recently, permission from regulatory authorities in the US register many AMs for use as growth promoters.

Associations between IFAP AM use in feeds and AMR in human pathogens

Extensive literature exists on the prevalence of antimicrobial resistance in both commensal and pathogenic bacteria in association with AM use in food animal production. The major papers on this topic have been reviewed in the annotated bibliography provided to the Commission. There is substantial evidence that the use of AMs in animal feeds is associated with the presence of AMR bacteria in the animal environment, that is, in the guts of animals (including cows, pigs, and poultry), in their feces, and in containers and confinements in which they are held (Mathew, Upchurch et al. 1998; Aarestrup, Agerso et al. 2000; Joseph, Hayes et al. 2001; Wegener 2003; Hayes, English et al. 2004; Boerlin, Travis et al. 2005; Berge, Moore et al. 2006; Donaldson, Straley et al. 2006). The causal role of AMs has been clearly demonstrated in studies where dairy cattle, pigs, and poultry have been raised with and without AM additives to feed (Aarestrup, Seyfarth et al. 2001; Halbert, Kaneene et al. 2006; Ray, Warnick et al. 2006). AMR bacteria have been isolated from environmental samples in and near production facilities, including air, water, and soils (Chee-Sanford, Aminov et al. 2001; Nwosu 2001; Jensen, Agerso et al. 2002; Chapin, Rule et al. 2005; Anderson and Sobsey 2006; Gibbs, Green et al. 2006; Schmitt, Stoob et al. 2006).

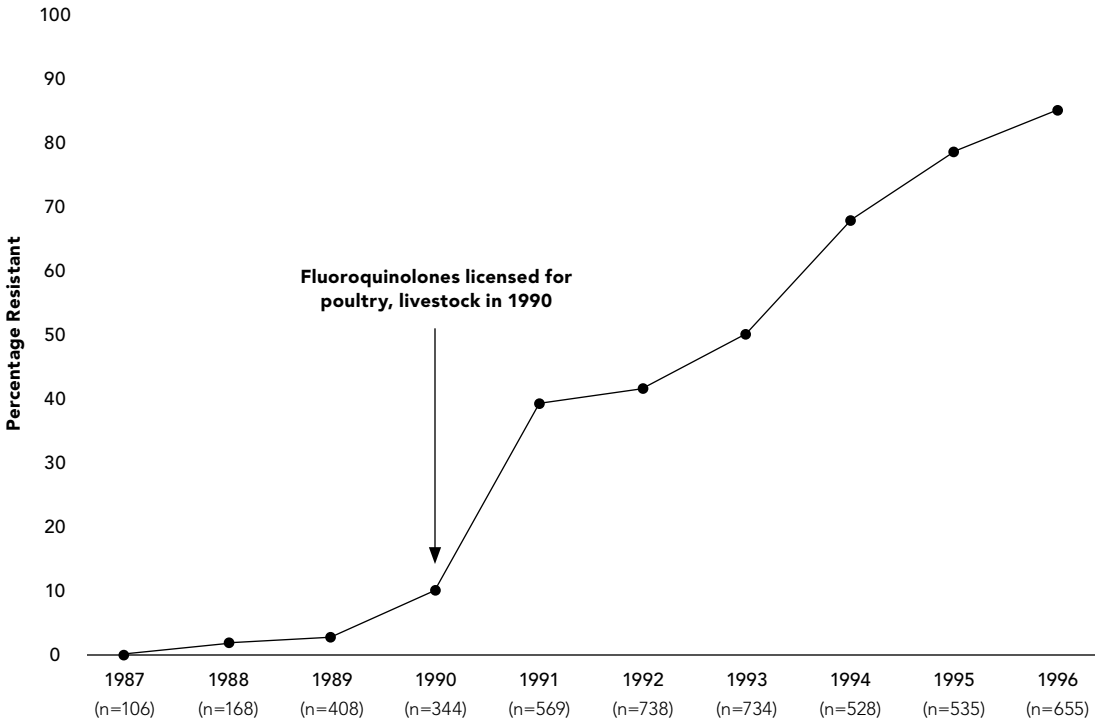
In order to review the large body of literature on the presence of AMR bacteria resulting in both food-borne and environmental exposures, this review focuses on four types of studies. The first type is ecological, that is, studies that have followed the prevalence of AMR after changes in agricultural antibiotic use (either introduction or removal of specific drugs). The second type is cross-sectional, that is, studies of specific groups in close contact with food animal production settings where antibiotics are used (such as farmers and farm families) as well as the presence of AMR bacteria in animals, animal houses, animal wastes, and the environment. A third type of study has examined the prevalence of AMR in bacteria isolated from consumer products produced by conventional producers (i.e., using antibiotics) and those produced by organic and other producers not using antibiotics. A fourth type of study has attempted to develop models, based upon molecular microbiology and evolutionary theory, to discern the contribution of agricultural antimicrobial use on risks of human infection by AMR pathogens.

Evidence for food-borne exposures to AMR

Repeated studies by FDA and others have reported on the high prevalence of AMR in pathogenic bacteria isolated from consumer food products in the US, and there is an extensive literature on the topic from the EU and many other countries (e.g., Emborg, Andersen et al. 2003; Johnson, Kuskowski et al. 2005). Simjee et al. (Simjee, White et al. 2002), from the FDA, conducted one of the more comprehensive surveys of antibiotic resistance in consumer poultry products (turkey and chicken) in the US. Enterococcus isolates were tested for antibiotic resistance, with an emphasis on resistance to virginiamycin and quinpristin-dalfopristin. The streptogramins are commonly used to treat infections that are resistant to older antibiotics. The presence of specific streptogramin-resistant genes was assessed using Pulsed Field Gel Electrophoresis (PFGE) and Polymerase Chain Reaction (PCR). Over 80% of non *faecalis* enterococci were resistant to streptogramins. In addition, a high prevalence of resistance to penicillin, tetracycline, and erythromycin in enterococci was also found. Between 75% and 100% of *E. faecium* isolates were resistant to these antibiotics. The FDA has reported similar findings for meat products as well (White, Zhao et al. 2001; Hayes, English et al. 2003). Correlations among Q/D resistance in *E. faecium* isolates have been drawn between humans, farm animals, and grocery store meats in the US (Donabedian, Perri et al. 2006).

There have also been studies demonstrating associations between AM use in animal feeds and AMR bacteria isolated from US consumer food products (Price, Johnson et al. 2005; Luangtongkum, Morishita et al. 2006). It is noteworthy that in both studies the conventionally produced meats and poultry were not less likely to carry pathogens; producers and the drug industry have sometimes claimed that the nontherapeutic use of AMs in food animal production in some way reduces pathogen carriage.

Figure 4. Trends in prevalence of fluoroquinolone (FQ) resistance in clinical isolates of Campylobacter jejuni in Spain, examined for resistance from 1987 to 1996. As indicated, before the approval of FQ use in poultry and livestock production, resistance was relatively rare (<10%); after approval, the prevalence of resistance rose quickly (Data from Smith, in Nachamkin 2000).



Ecological evidence: studies of temporal trends

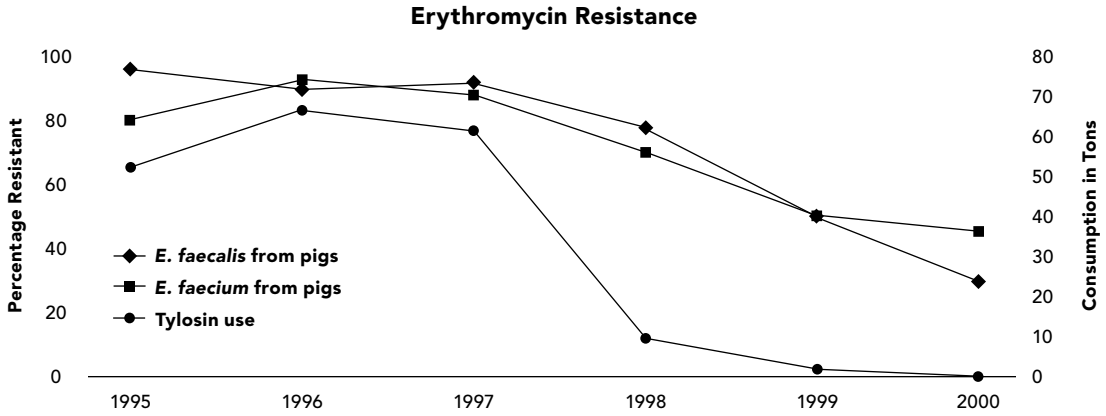
These studies utilize data collected at different time points and often from different sources. With these limitations, it can be concluded that, taken together, the data provide additional evidence for the role of agricultural AM use in changes in the prevalence of AMR on the farm, in consumer food products, and in the general population. Although causal inferences may be contested (Radostits 2004), the studies are consistent with an association between registration of AMs for agricultural use and increasing risks of AMR in bacterial isolates from human populations. The use of vancomycin and pristinamycin in swine production was associated with increased prevalence of AMR enterococci in humans in the Netherlands (van den Bogaard et al. 1997). A sharp increase in drug-resistant Campylobacter infection in the US was associated with AM use in IFAP in an analysis by the CDC (Gupta, Nelson et al. 2004; Collignon 2005). In Spain, where fluoroquinolones were introduced into poultry production in 1993, the rates of resistance in human isolates quickly rose to over 80% (Nachamkin 2000), (Figure 4); separate studies reported that by 2000 approximately 99% of poultry- associated Campylobacter isolates were fluoroquinolone resistant (Garau, Xercavins et al. 1999; Saenz, Zarazaga et al. 2001).

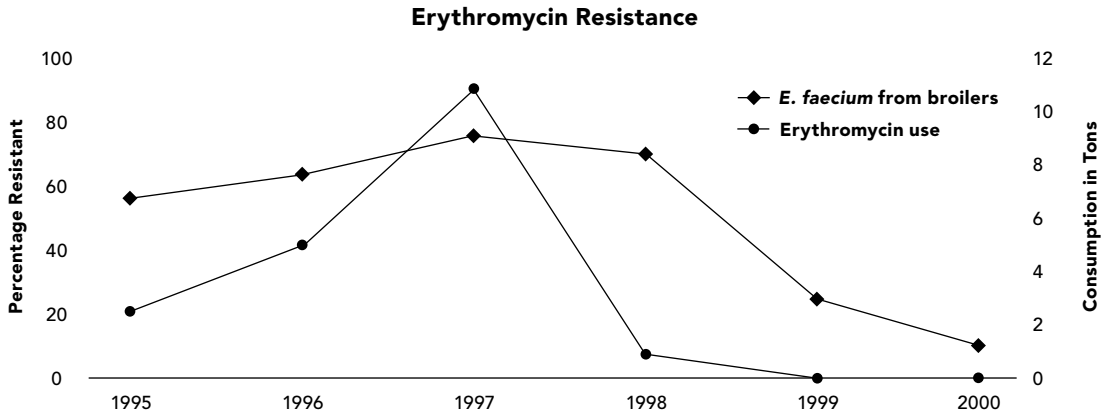
In a study by the CDC on trends in resistant Campylobacter, no isolates from US hospital patients were found to be resistant to fluoroquinolones prior to 1991, before this family of compounds was permitted in poultry production by the FDA; after this time, there has been a steady increase in the prevalence of resistance ((Gupta, Nelson et al. 2004) comment by (Collignon 2005)). In contrast, the relatively low rate of fluoroquinolone resistance in clinical isolates in Australia has been attributed to the ban on use of this drug in agriculture (Unicomb, Ferguson et al. 2006). Similar data were found in studies of isolates from poultry and humans in Norway (Norstrom, Hofshagen et al. 2006) and the Netherlands (Endtz, Ruijs et al. 1991).

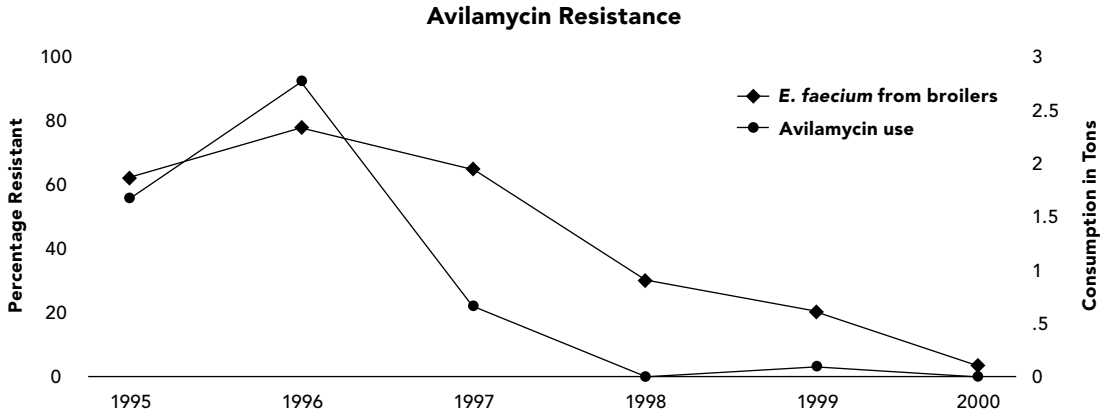
Some of the most powerful temporal data are drawn from surveillance of both antimicrobial use in agriculture and trends in resistance in bacterial isolates from several sources, carried out in Europe prior to and following the ban on feed additive use of antimicrobials. For example, studies carried out in Denmark over this period have demonstrated a rapid and parallel decrease in antimicrobial use and the prevalence of antibiotic-resistant *E. faecium* recovered from pigs or broilers, as shown in Figure 5 (Aarestrup, Seyfarth et al. 2001). A similar pattern of decreases in vancomycin resistance in poultry isolates was observed in Taiwan after a ban on avoparcin in 2000 (Lauderdale, Shiau et al. 2007).

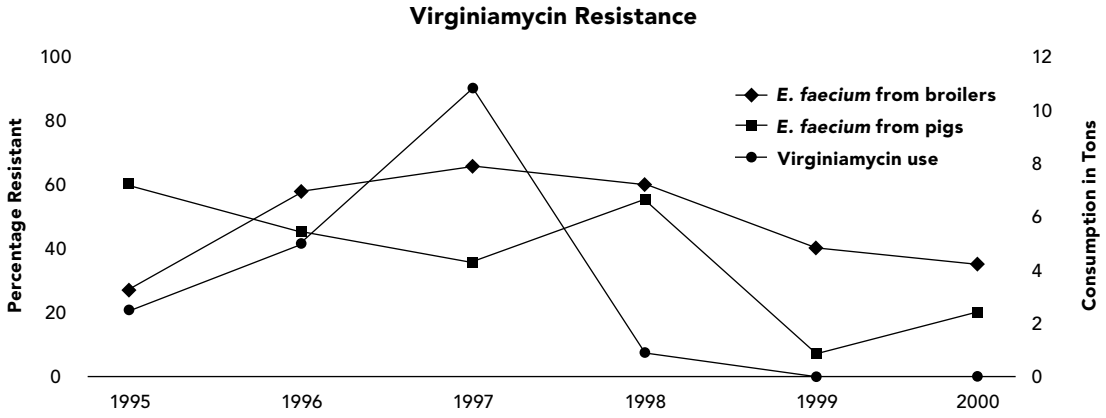
Until recently, there has been no examination of large-scale data on the actual effect of AMs in any food animal production system (NRC 1999). Graham et al. (Graham, Boland et al. 2007) recently addressed this using data from a large-scale real-world experiment carried out by researchers at Perdue Corporation, who conducted the largest study of AMs as growth promoters in broiler poultry (Engster, Marvil et al. 2002). They found that the positive impacts of AMs as feed additives were very small and the marginal benefit (in terms of growth rates, feed conversion efficiency, uniformity of the flock, and reduced illness or other losses) did not offset the cost of purchasing AMs for addition to feeds. These findings suggest that since the early 1950s innovations and improvements in poultry production—such as selective breeding, managed environments, and developments in feed formulation—may have replaced the production benefits reported earlier as associated with AMs as feed additives. Studies of poultry and swine production in the US and Europe indicate that the assumed benefits of AMs as growth promoters can be achieved by improved cleanliness of animal houses (Emborg, Ersboll et al. 2001; Engster, Marvil et al. 2002; Miller, Algozin et al. 2003).

Figure 5. The impact of banning antimicrobials from animal feeds on the prevalence of erythromycin, vancomycin, avilamycin and virginiamycin resistance in *E. faecium* and *E. faecalis* isolates from pigs and broilers in Denmark (Aarestrup, Seyfarth et al. 2001).








Virginiamycin Resistance
Percentage Resistant
Consumption in Tons
100
80
60
40
20
0
12
10
8
6
4
2
0
1995
1996
1997
1998
1999
2000
E. faecium from broilers
E. faecium from pigs
Virginiamycin use

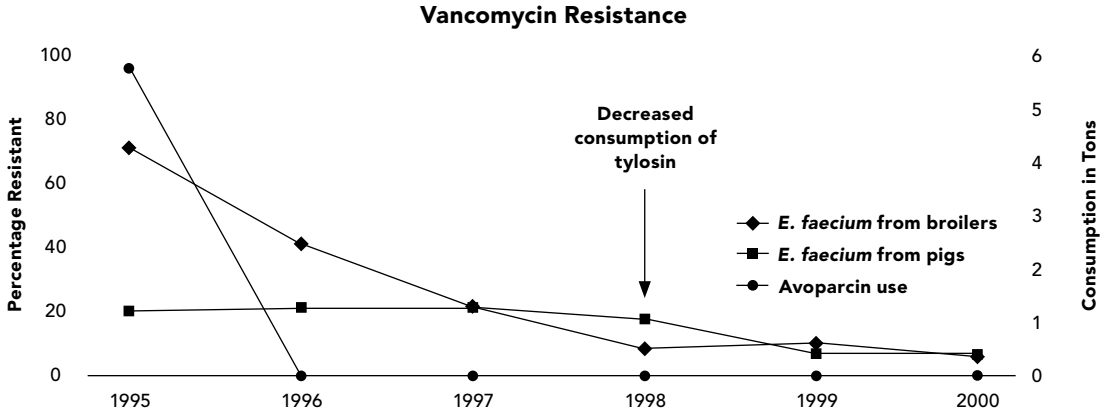
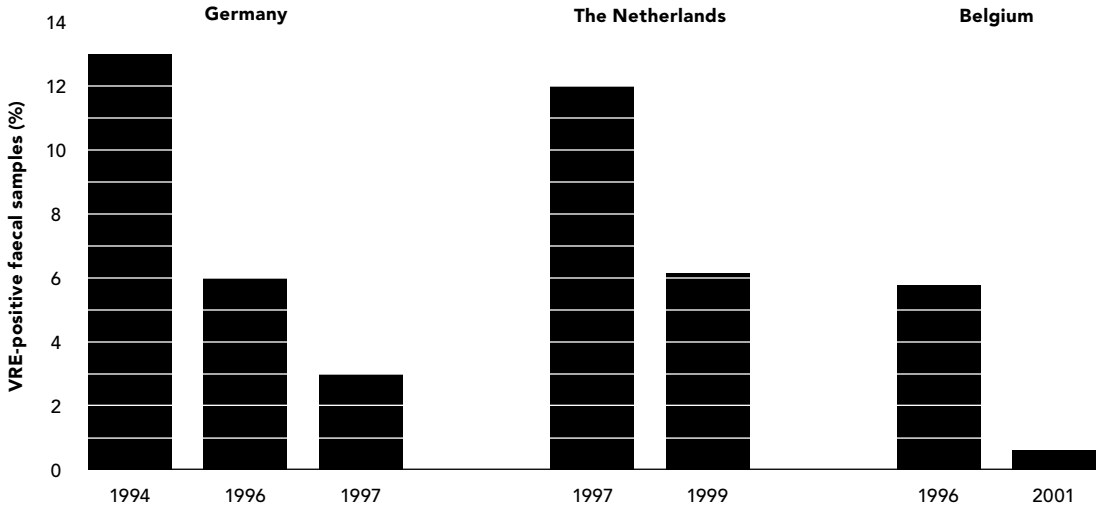

Vancomycin Resistance
Percentage Resistant
Consumption in Tons
100
80
60
40
20
0
6
5
4
3
2
1
0
1995
1996
1997
1998
1999
2000
Decreased consumption of tylosin
E. faecium from broilers
E. faecium from pigs
Avoparcin use

Figure 6. The impact of banning avoparcin from animal feeds on the prevalence of VRE in stool culture samples collected from healthy human subjects in the Netherlands and Germany and in hospitalized patients in Belgium (Klare, Badstubner et al. 1999).



Current Opinion in Microbiology

The prevalence of resistant-enterococci isolates from human subjects also declined in the EU over the same period (Klare, Badstubner et al. 1999; Wegener 2003). As shown in Figure 6, the carriage of vancomycin-resistant enterococci (VRE) in human isolates from Germany, the Netherlands, and Belgium declined over the period after banning avoparcin use as a feed additive.

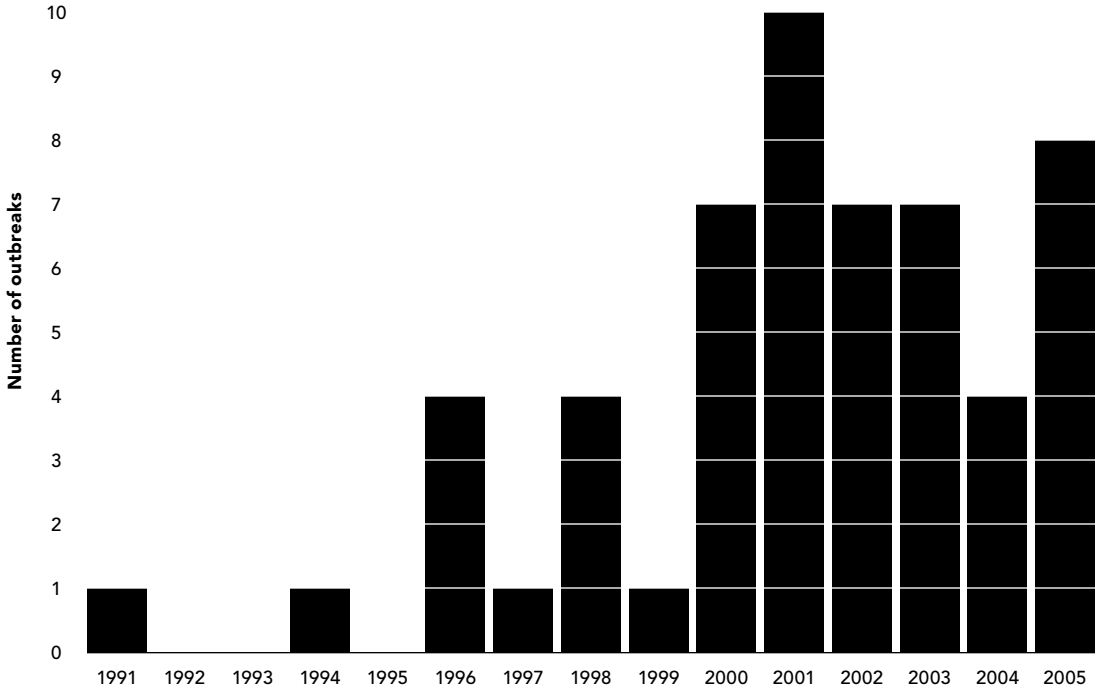
Evidence for nonfood exposures to AMR: farming communities, farmers, and farm workers

The issue of nonfood pathways of exposure has only recently received substantial attention. *This is a central matter in evaluating the effectiveness of current policies, such as HACCP, which are designed to reduce risks "from farm to fork," not including releases along the process to environmental pathways.* For this reason, this topic is discussed at length in this technical paper.

Most of the earlier studies have consisted of case reports, exemplified by the report by Fey et al. (Fey, Safranek et al. 2000), who carried out a case investigation of a child infected by ceftriaxone-resistant Salmonella acquired from living on a farm. Molecular methods (including DNA sequencing) were utilized to compare the salmonella isolate from the affected child with salmonella from the farm environment. Studies of farmers and farm workers have also reported that these groups are at high risk of exposure to AMR pathogens in and around animal houses, and they may transfer resistant infections to the general community. Two studies have examined exposures of farmers and farm workers to AMR pathogens in poultry houses. Van den Bogaard and Stobberingh et al. (van den Bogaard and Stobberingh 1999) reported that poultry farmers were at greatly increased risks of carrying drug-resistant Enterococci as compared to community referents, while Price et al. (Price, Graham et al. 2007) found that poultry house workers were 30 times more likely to carry gentamicin-resistant *E. coli* as compared to community referents. More recently, Huijsdens et al. (Huijsdens, van Dijke et al. 2006) reported on a case of methicillin-resistant *Staphylococcus aureus* infection in seven persons living or working at a large hog farm in the Netherlands; molecular methods were also used to confirm the clonality of the human and hog isolates. In a follow-up study, this group found a high prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in pigs sampled at slaughterhouses in the Netherlands (39% of 540 pigs) (de Neeling, van den Broek et al. 2007).

These exposures can translate into community risks as well, through person-to-person contacts (Smith, Dushoff et al. 2005). Smith et al. (Smith, Besser et al. 1999) carried out investigations of AMR *C. jejuni* in Minnesota, confirming elevated risks among communities in close contact with IFAP operations. As shown in Figure 7, an increasing number of outbreaks of enteric disease have been reported in association with animal contact, including farms as well as petting zoos and other events, to indicate the importance of ascertaining nonfood pathways of exposure (Steinmuller, Demma et al. 2006). Salmonella and *E. coli* 0157 were the most frequently reported pathogens in these outbreaks.

Figure 7. Number of reported outbreaks of enteric disease associated with animals in public settings in the US, by year, 1991-2005 (Steinmuller, Demma et al. 2006).



Environmental routes of release of AMR bacteria

Increasing attention is now being paid to nonfood routes of exposure, through environmental pathways of air, water, and dusts or soils. Exposures via these routes may contribute to the community burden, and they are also of importance because increased vigilance in terms of food safety and consumer initiatives (such as improved handling and cooking of meat products) will not diminish these nonfood risks. *Because of the failure of current regulations and practice to cover nonfood routes of exposure to AMR from IFAP, this issue is examined in further detail in this section.* AMR pathogens can be released into the general environment from animal houses through ventilation and waste disposal. Because confinement of thousands of animals requires controls to reduce heat and regulate humidity, poultry and swine houses are ventilated with high-volume fans that result in considerable movement of materials into the external environment. Tunnel ventilation systems that are increasingly used in the US industry generally consist of eight 1-meter-diameter fans positioned at one end of the building. These fans generate large quantities of aerosolized dust. Emissions of small particles (<10 m in size) from broiler house fans over a period of 24 hours can range from 25 to 40 grams per cubic meter, representing a million-fold increase of aerosolized dust near poultry house fans as compared to air sampled in a semi-rural area (Power 2004). AMR bacteria, originating in swine houses, have been detected in the environs of these houses as far as 30 meters (m) upwind and 150 m downwind (Gibbs, Green et al. 2006). Campylobacter strains with identical DNA fingerprints to those colonizing broilers have been measured in air up to 30 m downwind of broiler facilities. In addition, the antimicrobial drugs themselves have been found in dust from swine CAFOs (Hamscher, Pawelzick et al. 2003). There is evidence for the spread of resistant bacteria from animal houses by insects, rodents, and wild avians that may be particularly attracted to poultry Concentrated Animal Feeding Operations (CAFOs) where sources of food exist (e.g., spilled feed, animal manure, and poultry carcasses). For example, flies are found in significantly increased numbers in areas close to animal houses (Winpisinger, Ferketich et al. 2005). Houseflies have been found to play a major role in the epidemiology of Campylobacter infections in communities near CAFOs (Nichols 2005). Rodents can also transfer pathogens in and out of animal houses (Henzler and Opitz 1992). In a study of antibiotic resistance in *E. coli,* isolated from wild avians near CAFOs, the proportion of isolates resistant to antibiotics was significantly higher among isolates from birds in proximity to swine waste lagoons as compared to a reference set of samples (Cole, Drum et al. 2005). Additionally, the resistance patterns observed matched those most commonly reported by the National Antimicrobial Resistance Monitoring System for *Enterobacteriaceae* isolated from swine (Cole, Drum et al. 2005).

The major route of transfer of AMR *pathogens to the environment is via waste generation and disposal on land.* The magnitude of this transfer is more fully described in another technical paper. According to the US Department of Agriculture, confined food animals produce roughly 335 million tons (dry wt.) of waste per year (USDA National Program Annual Report—www.ars.usda.gov/research/programs/programs.htm?np_code=206&docid=13337), which is more than 40 times the mass of human biosolids generated by publicly owned treatment works (7.6 million tons in 2005). In contrast to human biosolids, no treatment-process control requirements or prescribed criteria for pathogens have been established for animal waste, although levels of pathogens, as well as antimicrobial-resistant bacteria, are often higher than levels found in human feces. For swine and cattle (i.e., beef feedlots and dairy cows), an estimated 95% to 99% of the waste produced is applied to land (USDA /APHIS 1995; Walton 2002), and for poultry litter (i.e., excreta, spilled feed, feathers, soil, and bedding material), over 90% is applied to land (Moore, Daniel et al. 1995).

Animal wastes carry a vast number of bacteria (Gerba and Smith 2005), and in cases where animals are exposed to AMS, these bacteria include resistant strains. A study of fecal samples from dairy cattle in Minnesota found significant increases in the prevalence of multidrug resistant *E. coli* from animals provided AMS in feed as compared to those from organic farms (Sato, Bartlett et al. 2005). Land disposal of animal wastes can have near and distant impacts. Tetracycline-resistant genes in pig waste are highly persistent in lagoons of hog waste and in soils amended with these wastes (Jensen, Agerso et al. 2002; Schmitt, Stoob et al. 2006). AMR *E. coli* from IFAP have been detected in surface waters and in groundwater sources for drinking water sampled near hog farms in Maryland (Sapkota, Curriero et al. 2007; Stine, Johnson et al. 2007), North Carolina (Anderson and Sobsey 2006), and Iowa (Chee-Sanford, Aminov et al. 2001), and in soils amended with hog wastes (Jensen, Agerso et al. 2002). In terms of public health significance, it should be noted that groundwater makes up roughly 40% of the water used for public water supplies and provides drinking water for more than 97% of rural US populations (Hutson et al. 2005). However, no studies have been done on population exposures via drinking water or water contact.

Contamination of surface waters from waste disposal can also impact food safety through irrigation (Stine 2005). Runoff from land amended with CAFO wastes has been implicated as a source of AMR pathogens recovered from food crops grown in soils amended by animal wastes or irrigated with contaminated water (Tauxe 2002; Islam, Doyle et al. 2004; Sivapalasingam, Friedman et al. 2004). These events can occur through water contamination from relatively distant sites of land disposal. This is the probable pathway for two recent outbreaks of *E. coli 0157: H7* in the US involving spinach and green onions used by fast food restaurants.

Health and Societal Impacts of AMR

The burden of food-borne disease in the US and other countries has been dealt with extensively (OECD 2003); this burden is increased in terms of direct and indirect health care costs when bacterial disease involves AMR organisms (see introduction; also review by (Barza and Travers 2002), among others). Thus, for example, in the case of Campylobacteriosis, one of the leading food-borne causes of gastroenteritis in the US, the additional costs of infections by AMR Campylobacteriosis in humans was considered by the FDA in evaluating regulatory interventions to remove fluoroquinolones from use in poultry production (Bartholomew, Vose et al. 2005).

Attributable risk of AM use in agriculture to AMR as a public health problem

An important element in policy making is estimating the proportion of the risk that can be attributed to a specific source or activity; this information permits estimation of the benefit (risk reduction) that may be attained by controlling this source or activity. *Attributable risk is the amount of proportion of the incidence of a disease or other adverse health impact in populations exposed to a specific risk factor that can be attributed to exposure to that factor* (Last 1995). It is an important concept in medicine and epidemiology, and it has real-world importance in evaluating options for controlling or reducing a risk. As noted in the introduction to this technical report, AMR is associated with all uses of AMs, including clinical, veterinary, and agricultural (nonveterinary). Both appropriate and inappropriate uses contribute to AMR as we have learned from studies of AMs in the laboratory as well as in practice. Moreover, from the microbial "point of view," all sources of selection pressure contribute to AMR, and its appearance (in a hospital or food-borne illness outbreak) may result from multiple sources. For this reason, it may not be possible or even appropriate to determine the attributable risk of AM use specific to agriculture or to the use of AMs as feed additives, in terms of the overall incidence of AMR in human infections given a community model of both risk and exposure.

Overall, there is a lack of critical data on human exposures to AMR from agricultural sources sufficient to support a rigorous analysis of the attributable risks of agricultural AM use. The existing monitoring and surveillance programs are passive systems, and the investigations following detection of AMR usually focus on nosocomial (hospital or healthcare or food sources of exposure and infection. For example, waterborne infections are not usually traced back to agricultural inputs (for example, Lee, Levy et al. 2002).

Moreover, the surveillance network (FoodNet) does not provide coverage of those regions in the US where most IFAP are located. Thus, our ability to evaluate these impacts is significantly limited by the data available for source attribution (Sivapalasingam, Friedman et al. 2004). It is both methodologically difficult and scientifically inappropriate to attempt an apportionment of the burden of these impacts to agricultural AM use and other uses given the flow of resistance among bacterial species and human populations. That is, in attempting to calculate attributable risks on the basis of data related to infections by specific pathogens with specific resistance traits, it is imperative to incorporate the concepts of resistance reservoirs, movement of resistance cassettes, and gene flow among commensals and pathogens, as discussed previously. Moreover, a simple concept of antimicrobial pressure in terms of mass action supports the conclusion that the preponderant use of antimicrobials—which is in food animal production—must be a significant source of antimicrobial resistance.

Some of the research discussed earlier, in terms of time trend studies, can be related to the question of attributable risk. As discussed above, there are data to indicate that substantial increases in AMR in bacterial isolates from human populations have followed on the registration of AMs for application in drinking water for animals or use in animal feeds. These data are reviewed here to emphasize their relevance to discussions of attributable risk. In Spain, a striking increase was observed starting in 1990 in the prevalence of fluoroquinolone resistance in *C. jejuni* isolates from hospitalized patients in Spain. In 1990, the Spanish government authorized the use of fluoroquinolones in poultry production; otherwise, no dramatic changes occurred in the volume of clinical use of this antimicrobial. In a study by the CDC on trends in resistant *Campylobacter*, no isolates from US hospital patients were found to be resistant to fluoroquinolones prior to 1991, at which point this family of compounds was permitted in poultry production by the FDA; after this time, there has been a steady increase in the prevalence of resistance, as shown below (Gupta, Nelson et al. 2004) comment by (Collignon 2005)). While these studies did not trace the origin of resistant isolates in the population

sampled, the trend is consistent with an impact associated with governmental registration.

The intervention studies conducted by European researchers following up on AMR in animals, food products, and clinical isolates subsequent to the ban on avoparcin in agriculture are also relevant. As discussed previously, monitoring of food animals in Denmark indicates a significant decline within five years in the prevalence of vancomycin-resistant isolates collected from pigs and poultry, as well as in the prevalence of vancomycin resistance in human isolates. These data are not conclusive, but they are also consistent with a role for animal agriculture use of antimicrobial resistance in that resistance prevalence appears to rise and fall with regulatory decisions and practice concerning agricultural use.

While these studies provide some measure of the likely contribution of agricultural AM use to the incidence and prevalence of vancomycin-resistant enterococci in human isolates, the incompleteness of these data must be recognized (Bywater 2004). More importantly, AMR may be "silent" in the reservoir of microbial communities or within asymptomatic persons. Its impact—expressed as incidence of an AMR infection—will appear only when a person enters medical treatment and treatment failure is recognized.

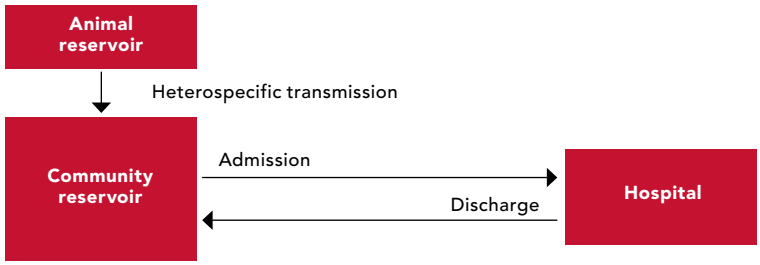
These data are also of special interest since they indicate that interventions to reduce agricultural AM use can have a significant public health benefit in the relatively short term.

There may be more fundamental challenges to estimating attributable risk in terms of any specific use, such as agricultural vs. clinical AM uses, given the flow of resistance among bacteria and human populations (Summers 2006; Wright 2007). In terms of human disease risk, there is a similar and increasing realization of the role of *community* infections as sources of nosocomial (hospital) infections, in contrast with assumptions that AMR infections in hospitals were largely associated with hospital use of AMs (Smith, Yago et al. 2005). While hospital use of AMs has generally been assumed to generate the highest risk of AMR and transmission of AMR infection, this conclusion may be biased by the fact that most resistant infections are identified in hospitals. From an ecological perspective, the greater selection pressure for resistance generated by agricultural uses may result in carriage of AMR bacteria, both pathogenic and commensal, by persons in the nonhospitalized population. When these people enter hospital, they may be a major source of transmitted infections in the hospital environment. The community basis of hospital infections is increasingly recognized (Pop-Vicas and D'Agata 2005; de Neeling, van den Broek et al. 2007). Although hospital use of AMs may generate the highest risk of transmission of resistant infection (due to opportunities for contact among large populations of susceptible populations, similar to poultry houses), agricultural uses may result in a larger reservoir of antimicrobial resistance outside the hospital, in the form of pathogenic and nonpathogenic bacteria, as well as transposable genetic elements. As these people enter hospital, they may be a major source of resistant infections to the hospital environment. Because conditions in the hospital enhance the likelihood of person-to-person transmission, the risks of becoming infected by a resistant pathogen are higher in hospitals, but the source of resistance from outside the hospital is largely determined by this larger community reservoir of resistance (which, for many reasons discussed in this paper, is driven in large part by the magnitude of agricultural uses and affects environmental and dietary pathways of exposure through drinking water and consumer meat and poultry products). As Smith et al. (Smith, Yago et al. 2005) conclude, a large number of people exposed to a low risk may generate more cases than a small number of people exposed to a high risk. This is shown visually in Figure 8.

Valuation of impacts

The same limitations on attributing risk also impede our ability to value the impacts of AMR on human health, in monetized and other metrics. The economic burden of AMR on medical care systems has been evaluated in studies carried out in specific hospitals (Kim, Oh et al. 2001; Capitano, Leshem et al. 2003) and more generally (Okeke, Laxminarayan et al. 2005; Smith, Yago et al. 2005) as well as by governmental and international organizations (OECD, CDC) as well as Non-Governmental Organizations (NGOs) (APUA). The FDA also conducted an impact analysis in connection with its regulatory assessment for the ban on fluoroquinolones in poultry production. This analysis was challenged by industry.

Figure 8. How large is the impact of antibiotic use in agriculture? The community reservoir is driven by the animal reservoir, which then largely determines the entry of resistance into the hospital (From Smith et al. (2005).



Risk Assessments of AMR

Because of the importance of risk assessment as a formal method in policy making in the US, we review risk assessments and scientific issues relevant to IFAP.

The principles of risk assessment have been adopted by international organizations and national agencies, including the US FDA, in activities to evaluate agricultural antimicrobial use (Doyran 2004; Helmuth and Hensel 2004; Maudoux, Saegerman et al. 2006). While there is an extensive literature and research base on risk assessment methods with respect to chemicals and agents such as ionizing radiation, the methodologies and critical evaluations are more limited with respect to microbial risk assessment *(see AMR annotated bibliography)*. These methods are not as sophisticated as those that have been developed for chemical regulation, particularly with respect to the incorporation of biological and mechanistic principles such as growth rates, evolutionary rates, and gene flow.

For these reasons, there are substantial limits on current methods of risk assessment (Barza and Travers 2002). Most risk assessments continue to focus on specific resistance traits in specific bacteria, with an emphasis on resistance to clinically important antimicrobials in clinically significant pathogens (e.g., NRC 1999). As discussed above, this approach does not reflect current understanding of the role of resistance reservoirs and the multiple opportunities for exposures to AMR pathogens. There is moreover a lack of attention to the importance of bacteria as *living organisms*—which are fundamentally different from chemicals—since living organisms are capable of expanding in number and potential risk. This complicates the notion of "threshold of resistance," which is utilized by the EPA in its microbial risk assessments.

US Government Risk Assessments

The risks of consumer exposure to AMR pathogens via food consumption have stimulated considerable regulatory and voluntary risk reduction activity. The nature of the hazard—AMR in food-borne pathogens—is recognized in the HACCP principles, which cover *from* farm to fork (emphasis added) and not *within* the farm. Thus, HACCP accepts the fact that, under current practices, animals will be contaminated with pathogens and AMR pathogens during their raising; controls are instituted to contain this problem *after* the animals leave the farms. *Whether this is an effective or reliable policy approach is an issue for the PCIFAP to consider.* The focus of HACCP is to reduce, insofar as possible, the presence of all pathogenic bacteria, whether or not they are resistant, through ensuring a high standard of operations at the processing plant, including slaughter, processing, packaging, storage, and shipment. Additional guidance is provided to wholesale and retail sales outlets, restaurants and food service organizations, as well as to consumers. From the perspective of a fully implemented HACCP system, there is no added burden on the management of all aspects of food animal production to contain risks of AMR bacteria as compared to susceptible bacteria. HACCP does not consider the potential for health risks associated with nonfood pathways of release and exposure, as discussed above.

In the process of reviewing and eventually revoking the registration for fluoroquinolones in poultry production, the FDA has recently developed approaches to the risk assessment of AMS as feed additives (Bartholomew, Vose et al. 2005). This approach utilizes a linear model for estimating risk that is consistent with a conservative approach utilized in chemical risk assessment (NRC 1983; NRC 1990). This approach has been criticized by industrial consultants (Phillips, Casewell et al. 2004; Cox 2005 but see many commentaries on this article), but constitute US policy at the present time. In the context of recent proposals to register a fourth-generation cephalosporin (cefquinome) for use in confined food animals, some limitations on the scope of the FDA risk assessment guidelines as proposed have emerged. These concern the barriers to assessing risks of a novel antimicrobial for which the first use will be in agriculture as well as the lack of a comprehensive risk assessment that incorporates both-food borne risks as well as contributions to the AMR reservoir.

Definitions and methodologies (US):
Risk assessment is the process of assembling, evaluating, and integrating information related to hazard, dose-response, and exposure in order to inform appropriate management and protection of health.

World Health Organization (WHO)/ Food and Agricultural Organization (FAO)/CODEX Alimentarius (CA) Risk Assessments

These three organizations coordinate many international activities related to food safety, and they have explicitly coordinated their consultations and policies on the subject of antimicrobial resistance (see above). In addition, these organizations are now reference organizations under the World Trade Organization (WTO) with respect to resolution of national differences on risk assessment and other policies related to international trade in animals, animal products, and other foods (Luetzow et al. 2003). Thus, if there were trade issues arising from different policies on agricultural antimicrobial use (for example, between the US and the EU), the risk assessment methods of the FAO and CA would be dispositive in any adjudicative process, as they were in the US/EU dispute over hormonal additives for cattle production (EEA 2001).

The FAO/WHO/CODEX adopted principles for risk assessment of microbiological risks (sometimes referred to as "risk analysis" in Europe) in 1999.

The elements of risk assessment are similar to those first explicated in the US (NRC 1983), that is, consisting

of hazard identification (nature of the toxicity or health impact associated with the entity being assessed), dose/response evaluation, quantitation of the magnitude (severity or likelihood) associated with the amount or duration of exposure, and exposure assessment (evaluation of the range of likely exposures to be encountered by human populations). A report on recent assessments by FAO, WHO, and OIE on agricultural antimicrobial use and AMR is available in a set of papers published in the *Journal of Veterinary Medicine Series B*, Volume 51 (2004).

Conclusions

One of the most significant public health issues associated with IFAP is its contribution to the increasing crisis of antimicrobial resistant infections worldwide. All uses of antimicrobials contribute to the selection of resistance among commensal and pathogenic bacteria, and for that reason, controls over inappropriate use are of high priority internationally. There is considerable evidence associating antimicrobial use in agriculture with resistant pathogens in the food supply, on the farm, and in the environment. Temporal studies following both the introduction and the removal of antimicrobials from feeds and water have demonstrated strong associations between these uses and the prevalence of antimicrobial resistance in animal wastes, human food, and isolates from human populations. Because of opportunities for dispersal from farms into the environment, agricultural antimicrobial use is a significant contributor to the expanding reservoir of resistance within microbial communities. It is increasingly recognized that the reservoir of resistance is the source of resistance genes in pathogens that may be recognized in hospitals.

Finally, the use of antimicrobials for nontherapeutic purposes (growth promotion) in agriculture is not justified for economic reasons in the modern food animal production setting. Several large-scale studies conducted in poultry and swine operations have demonstrated that the cost of antimicrobials as feed additives outweighs any marginal increase in profits, and that improvements in growth and disease prevention can be accomplished by increasing the hygienic conditions in which animals are held. As the industrial model of food animal production is adopted worldwide for poultry, swine, beef, and aquatic organisms, there is an urgent need to institute guidelines for prudent use of drugs in food animal production and for excluding the use of the drug as growth promoters.

References

Aarestrup, FM, Y Agerso, et al. (2000). "Comparison of antimicrobial resistance phenotypes and resistance genes in Enterococcus faecalis and Enterococcus faecium from humans in the community, broilers, and pigs in Denmark." Diagn Microbiol Infect Dis 37(2): 127-37.

Aarestrup, FM, AM Seyfarth, et al. (2001). "Effect of abolishment of the use of antimicrobial agents for growth promotion on occurrence of antimicrobial resistance in fecal enterococci from food animals in Denmark." Antimicrob Agents Chemother 45(7): 2054-9.

Alekshun, MN and SB Levy (2006). "Commensals upon us." Biochem Pharmacol 71(7): 893-900.

Anderson, ME and MD Sobsey (2006). "Detection and occurrence of antimicrobially resistant E. coli in groundwater on or near swine farms in eastern North Carolina." Water Sci Technol 54(3): 211-8.

Barber, M, FG Hayhoe, et al. (1949). "Penicillin-resistant staphylococcal infection in a maternity hospital." Lancet 2(25): 1120-5.

Bartholomew, MJ, DJ Vose, et al. (2005). "A linear model for managing the risk of antimicrobial resistance originating in food animals." Risk Anal 25(1): 99-108.

Barza, M. and K. Travers (2002). "Excess infections due to antimicrobial resistance: the 'Attributable Fraction'." Clin Infect Dis 34 Suppl 3: S126-30.

Bengis, RG, FA Leighton, et al. (2004). "The role of wildlife in emerging and re-emerging zoonoses." Rev Sci Tech 23(2): 497-511.

Berge, AC, DA Moore, et al. (2006). "Prevalence and antimicrobial resistance patterns of Salmonella enterica in preweaned calves from dairies and calf ranches." *Am J Vet Res* 67(9): 1580-8.

Billy, TJ and IK Wachsmuth (1997). "Hazard analysis and critical control point systems in the United States Department of Agriculture regulatory policy." Rev Sci Tech 16(2): 342-8.

Boerlin, P, R Travis, et al. (2005). "Antimicrobial resistance and virulence genes of Escherichia coli isolates from swine in Ontario." Appl Environ Microbiol 71(11): 6753-61.

Bywater, RJ (2004). "Veterinary use of antimicrobials and emergence of resistance in zoonotic and sentinel bacteria in the EU." *J Vet Med B Infect Dis Vet Public Health* 51(8-9): 361-3.

Capitano, B, OA Leshem, et al. (2003). "Cost effect of managing methicillin-resistant Staphylococcus aureus in a long-term care facility." *J Am Geriatr Soc* 51(1): 10-6.

Chapin, A, A Rule, et al. (2005). "Airborne multidrug-resistant bacteria isolated from a concentrated swine feeding operation." Environ Health Perspect 113(2): 137-42.

Chapman, HD and ZB Johnson (2002). "Use of antibiotics and roxarsone in broiler chickens in the USA: analysis for the years 1995 to 2000." Poult Sci 81(3): 356-64.

Chee-Sanford, JC, RI Aminov, et al. (2001). "Occurrence and diversity of tetracycline resistance genes in lagoons and groundwater underlying two swine production facilities." Appl Environ Microbiol 67(4): 1494-502.

Cole, D, DJV Drum, et al. (2005). "Free-living Canada geese and antimicrobial resistance." Emerg Infect Dis 11(6): 935-938.

Collignon, P (2005). "Fluoroquinolone use in food animals." Emerg Infect Dis 11(11): 1789-90; author reply 1790-2.

Cox, LA, Jr. (2005). "Some limitations of a proposed linear model for antimicrobial risk management." Risk Anal 25(6): 1327-32.

DANMAP (2000). "DANMAP 99—Consumption of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark." Danish Veterinary Laboratory: 1-52.

de Neeling, AJ, MJ van den Broek, et al. (2007). "High prevalence of methicillin resistant Staphylococcus aureus in pigs." Vet Microbiol 122(3-4): 366-72.

Donabedian, SM, MB Perri, et al. (2006). "Quinupristin-dalfopristin resistance in Enterococcus faecium isolates from humans, farm animals, and grocery store meat in the United States." *J Clin Microbiol* 44(9): 3361-5.

Donaldson, SC, BA Straley, et al. (2006). "Molecular epidemiology of ceftiofur-resistant Escherichia coli isolates from dairy calves." Appl Environ Microbiol 72(6): 3940-8.

Doyran, SH (2004). "Risk Analysis of Antibiotic Resistance, Berlin, BfR, 10-12 November 2003: activities of the Codex Alimentarius Commission related to antibiotic resistance." *J Vet Med B Infect Dis Vet Public Health* 51(8-9): 408-10.

EEA (2001). Late Lessons From Early Warnings: the Precautionary Principle 1896-2000. Luxemborg, Office for Official Publications of the European Communities.

Emborg, HD, AK Ersboll, et al. (2001). "The effect of discontinuing the use of antimicrobial growth promoters on the productivity in the Danish broiler production." Prev Vet Med 50(1-2): 53-70.

Emborg, HD, JS Andersen, et al. (2003). "Relations between the occurrence of resistance to antimicrobial growth promoters among Enterococcus faecium isolated from broilers and broiler meat." *Int J Food Microbiol* 84(3): 273-84.

Endtz, HP, GJ Ruijs, et al. (1991). "Quinolone resistance in campylobacter isolated from man and poultry following the introduction of fluoroquinolones in veterinary medicine." *J Antimicrob Chemother* 27(2): 199-208.

Engster, HM, D Marvil, et al. (2002). "The effect of withdrawing growth promoting antibiotics from broiler chickens: a long-term commercial industry study." *J App Poult Res*(11): 431-6.

Erb, A, T Sturmer, et al. (2007). "Prevalence of antibiotic resistance in Escherichia coli: overview of geographical, temporal, and methodological variations." *Eur J Clin Microbiol Infect Dis* 26(2): 83-90.

Falagas, ME and IA Bliziotis (2007). "Pandrug-resistant Gram-negative bacteria: the dawn of the post-antibiotic era?" *Int J Antimicrob Agents* 29(6): 630-6.

Fevre, EM, BM Bronsvoort, et al. (2006). "Animal movements and the spread of infectious diseases." Trends Microbiol 14(3): 125-31.

Fey, PD, TJ Safranek, et al. (2000). "Ceftriaxone-resistant salmonella infection acquired by a child from cattle." *N Engl J Med* 342(17): 1242-9.

Garau, J, M Xercavins, et al. (1999). "Emergence and dissemination of quinolone-resistant Escherichia coli in the community." Antimicrob Agents Chemother 43(11): 2736-41.

Gebreyes, WA and S Thakur (2005). "Multidrug-resistant Salmonella enterica serovar Muenchen from pigs and humans and potential interserovar transfer of antimicrobial resistance." Antimicrob Agents Chemother 49(2): 503-11.

Gerba, CP and JE Smith, Jr. (2005). "Sources of pathogenic microorganisms and their fate during land application of wastes." *J Environ Qual* 34(1): 42-8.

Gibbs, SG, CF Green, et al. (2006). "Isolation of antibiotic-resistant bacteria from the air plume downwind of a swine confined or concentrated animal feeding operation." Environ Health Perspect 114(7): 1032-7.

Ginocchio, CC (2002). "Role of NCCLS in antimicrobial susceptibility testing and monitoring." *Am J Health Syst Pharm* 59(8 Suppl 3): S7-11.

Graham, JP, JJ Boland, et al. (2007). "Growth promoting antibiotics in food animal production: an economic analysis." Public Health Rep 122(1): 79-87.

Gupta, A, JM Nelson, et al. (2004). "Antimicrobial resistance among Campylobacter strains, United States, 1997-2001." Emerg Infect Dis 10(6): 1102-9.

Halbert, LW, JB Kaneene, et al. (2006). "Evaluation of antimicrobial susceptibility patterns in Campylobacter spp isolated from dairy cattle and farms managed organically and conventionally in the midwestern and northeastern United States." *J Am Vet Med Assoc* 228(7): 1074-81.

Hamscher, G, HT Pawelzick, et al. (2003). "Antibiotics in dust originating from a pig-fattening farm: a new source of health hazard for farmers?" Environ Health Perspect 111(13): 1590-4.

Hayes, JR, LL English, et al. (2004). "Multiple-antibiotic resistance of Enterococcus spp. isolated from commercial poultry production environments." Appl Environ Microbiol 70(10): 6005-11.

Hayes, JR, LL English, et al. (2003). "Prevalence and antimicrobial resistance of enterococcus species isolated from retail meats." Appl Environ Microbiol 69(12): 7153-60.

Helmuth, R and A Hensel (2004). "Towards the rational use of antibiotics: results of the first International Symposium on the Risk Analysis of Antibiotic Resistance." *J Vet Med B Infect Dis Vet Public Health* 51(8-9): 357-60.

Henzler, DJ and HM Opitz (1992). "The role of mice in the epizootiology of Salmonella enteritidis infection on chicken layer farms." Avian Dis 36(3): 625-31.

Heuer, OE, AM Hammerum, et al. (2006). "Human health hazard from antimicrobial-resistant enterococci in animals and food." Clin Infect Dis 43(7): 911-6.

Huijsdens, XW, BJ van Dijke, et al. (2006). "Community-acquired MRSA and pig-farming." Ann Clin Microbiol Antimicrob 5: 26.

Hutson, SS, Barber, NL, Kenny, JF, Linsey, KS, Lumia, DS, Maupin, MA (2005). Estimated Use of Water in the United States in 2000. USG. Survey, USGS. Circular 1268.

Islam, M, MP Doyle, et al. (2004). "Persistence of enterohemorrhagic Escherichia coli O157:H7 in soil and on leaf lettuce and parsley grown in fields treated with contaminated manure composts or irrigation water." *J Food Prot* 67(7): 1365-70.

Jensen, LB, Y Agerso, et al. (2002). "Presence of erm genes among macrolide-resistant Gram-positive bacteria isolated from Danish farm soil." Environ Int 28(6): 487-91.

Jensen, VF, L Jakobsen, et al. (2006). "Correlation between apramycin and gentamicin use in pigs and an increasing reservoir of gentamicin-resistant Escherichia coli." *J Antimicrob Chemother* 58(1): 101-7.

Johnson, JR, MA Kuskowski, et al. (2005). "Antimicrobial-resistant and extraintestinal pathogenic Escherichia coli in retail foods." *J Infect Dis* 191(7): 1040-9.

Joseph, SW, JR Hayes, et al. (2001). "Implications of multiple antimicrobial-resistant enterococci associated with the poultry environment." Food Addit Contam 18(12): 1118-23.

Jukes, TH (1979). "Antibacterial agents in animal feeds." Clin Toxicol 14(3): 319-22.

Kieke, AL, MA Borchardt, et al. (2006). "Use of streptogramin growth promoters in poultry and isolation of streptogramin-resistant Enterococcus faecium from humans." *J Infect Dis* 194(9): 1200-8.

Kim, T, PI Oh, et al. (2001). "The economic impact of methicillin-resistant Staphylococcus aureus in Canadian hospitals." Infect Control Hosp Epidemiol 22(2): 99-104.

Klare, I, D Badstubner, et al. (1999). "Decreased incidence of VanA-type vancomycin-resistant enterococci isolated from poultry meat and from fecal samples of humans in the community after discontinuation of avoparcin usage in animal husbandry." Microb Drug Resist 5(1): 45-52.

Last, JM (1995). A Dictionary of Epidemiology. New York, Oxford University Press.

Lauderdale, TL, YR Shiau, et al. (2007). "Effect of banning vancomycin analogue avoparcin on vancomycin-resistant enterococci in chicken farms in Taiwan." Environ Microbiol 9(3): 819-23.

Lautenbach, E, BL Strom, et al. (2004). "Longitudinal trends in fluoroquinolone resistance among Enterobacteriaceae isolates from inpatients and outpatients, 1989-2000: differences in the emergence and epidemiology of resistance across organisms." Clin Infect Dis 38(5): 655-62.

Lautenbach, E, P Tolomeo, et al. (2006). "Duration of outpatient fecal colonization due to Escherichia coli Isolates with decreased susceptibility to fluoroquinolones: longitudinal study of patients recently discharged from the hospital." Antimicrob Agents Chemother 50(11): 3939-43.

Laxminarayan, R (2007). Extending the cure: policy responses to the growing threat of antibiotic resistance. Washington, DC, Resources for the Future.

Lee, SH, DA Levy, et al. (2002). "Surveillance for waterborne-disease outbreaks—United States, 1999-2000." MMWR Surveill Summ 51(8): 1-47.

Levin, BR, V Perrot, et al. (2000). "Compensatory mutations, antibiotic resistance and the population genetics of adaptive evolution in bacteria." Genetics 154(3): 985-97.

Levy, SB (1998). "The challenge of antibiotic resistance." Sci Am 278(3): 46-53.

Levy, SB and B Marshall (2004). "Antibacterial resistance worldwide: causes, challenges and responses." Nat Med 10(12 Suppl): S122-9.

Levy S, Miller R (1989). Gene transfer in the environment. McGraw Hill.

Luangtongkum, T, TY Morishita, et al. (2006). "Effect of conventional and organic production practices on the prevalence and antimicrobial resistance of Campylobacter spp. in poultry." Appl Environ Microbiol 72(5): 3600-7.

MARAN (2002). Monitoring of antimicrobial resistance and antimicrobial usage in animals in the Netherlands in 2002. The Netherlands, CIDC Lelystad.

Martinez, S (2002). Vertical Coordination of Marketing Systems: Lessons from the Poultry, Egg, and Pork Industries [cited 2006 Jun 21]. Available from http://www.ers.usda.gov/publications/aer807fm.pdf. Washington, DC, United States Department of Agriculture, Economic Research Service.

Mathew, AG, WG Upchurch, et al. (1998). "Incidence of antibiotic resistance in fecal Escherichia coli isolated from commercial swine farms." *J Anim Sci* 76(2): 429-34.

Maudoux, JP, C Saegerman, et al. (2006). "Food safety surveillance through a risk based control programme: approach employed by the Belgian Federal Agency for the Safety of the Food Chain." Vet Q 28(4): 140-54.

Mellon, M, C Benbrook, et al. (2001). Hogging it: Estimates of antimicrobial abuse in livestock. Cambridge, MA, Union of Concerned Scientists Publications.

Miller, GY, KA Algozin, et al. (2003). "Productivity and economic effects of antibiotics use for growth promotion in US pork production." *Journal of Agricultural and Applied Economics* 35(3): 469-482.

Moore, PA, TC Daniel, et al. (1995). "Poultry manure management: Environmentally sound options." *Journal of Soil and Water Conservation* 50(3): 321-327.

Mora, A, JE Blanco, et al. (2005). "Antimicrobial resistance of Shiga toxin (verotoxin)-producing Escherichia coli O157:H7 and non-O157 strains isolated from humans, cattle, sheep and food in Spain." Res Microbiol 156(7): 793-806.

Morris, JG, Jr (2003). "The color of hamburger: slow steps toward the development of a science-based food safety system in the United States." Trans Am Clin Climatol Assoc 114: 191-201; discussion 201-2.

Nachamkin, I (2000). Campylobacter. Washington, DC, ASM Press.

Naimi, TS, JH Wicklund, et al. (2003). "Concurrent outbreaks of Shigella sonnei and enterotoxigenic Escherichia coli infections associated with parsley: implications for surveillance and control of foodborne illness." *J Food Prot* 66(4): 535-41.

Nandi, S, JJ Maurer, et al. (2004). "Gram-positive bacteria are a major reservoir of Class 1 antibiotic resistance integrons in poultry litter." Proc Natl Acad Sci USA 101(18): 7118-22.

NCCLS (2006). Methods for dilution antimicrobial susceptibility tests. Wayne, PA, CLSI.

Nichols, GL (2005). "Fly transmission of Campylobacter." Emerg Infect Dis 11(3): 361-4.

Norstrom, M, M Hofshagen, et al. (2006). "Antimicrobial resistance in Campylobacter jejuni from humans and broilers in Norway." Epidemiol Infect 134(1): 127-30.

NRC (1983). National Research Council. Risk Assessment in the Federal Government: Managing the Practice. Washington DC, NAS Press.

NRC (1990). National Research Council. Valuing Health Risks, Costs, and Benefits for Environmental Decision Making. Washington, DC, National Academy Press.

NRC (1999). National Research Council. The use of drugs in food animals: benefits and risks. Washington DC, National Academy Press.

Nwosu, VC (2001). "Antibiotic resistance with particular reference to soil microorganisms." Res Microbiol 152(5): 421-30.

OECD (2003). Foodborne Disease in OECD Countries: Present State and Economic Costs. Paris, OECD Publications.

Ohlsen, K, W Ziebuhr, et al. (1998). "Effects of subinhibitory concentrations of antibiotics on alpha-toxin (hla) gene expression of methicillin-sensitive and methicillin-resistant Staphylococcus aureus isolates." Antimicrob Agents Chemother 42(11): 2817-23.

Okeke, IN, R Laxminarayan, et al. (2005). "Antimicrobial resistance in developing countries. Part 1: recent trends and current status." Lancet Infect Dis 5(8): 481-93.

Orriss, GD (1997). "Animal diseases of public health importance." Emerg Infect Dis 3(4): 497-502.

Phillips, I, M Casewell, et al. (2004). "Does the use of antibiotics in food animals pose a risk to human health? A critical review of published data." *J Antimicrob Chemother* 53(1): 28-52.

Pop-Vicas, AE and EM D'Agata (2005). "The rising influx of multidrug-resistant gram-negative bacilli into a tertiary care hospital." Clin Infect Dis 40(12): 1792-8.

Power, C (2004). The source and means of spread of avian influenza virus in the Lower Fraser Valley of British Columbia during an outbreak in the winter of 2004, Canadian Food Inspection Agency: Animal Disease Surveillance Unit.

Price, LB, JP Graham, et al. (2007). "Elevated risks of carrying gentamycin-resistant E coli among US poultry workers." Envir Hlth Persp (In Press).

Price, LB, E Johnson, et al. (2005). "Fluoroquinolone-resistant Campylobacter isolates from conventional and antibiotic-free chicken products." Envir Hlth Persp 113(5): 557-60.

Price, LB, LG Lackey, et al. (2007). "The persistence of fluoroquinolone-resistant Campylobacter in poultry production." Envir Hlth Persp 115(7): 1035-9.

Radostits, OM (2004). "Fluoroquinolone resistance trends and animal drug use: a retrospective analysis." *Int J Infect Dis* 8(3): 187-9; author reply 190-2.

Ray, KA, LD Warnick, et al. (2006). "Antimicrobial susceptibility of Salmonella from organic and conventional dairy farms." *J Dairy Sci* 89(6): 2038-50.

Saenz, RA, HW Hethcote, et al. (2006). "Confined animal feeding operations as amplifiers of influenza." Vector Borne Zoonotic Dis 6(4): 338-46.

Saenz, Y, M Zarazaga, et al. (2001). "Antibiotic resistance in Escherichia coli isolates obtained from animals, foods and humans in Spain." *Int J Antimicrob Agents* 18(4): 353-8.

Salyers, A and NB Shoemaker (2006). "Reservoirs of antibiotic resistance genes." Anim Biotechnol 17(2): 137-46.

Salyers, AA and CF Amabile-Cuevas (1997). "Why are antibiotic resistance genes so resistant to elimination?" Antimicrob Agents Chemother 41(11): 2321-5.

Sapkota, AR, FC Curriero, et al. (2007). "Antibiotic-resistant enterococci and fecal indicators in surface water and groundwater impacted by a concentrated swine feeding operation." Environ Health Perspect 115(7): 1040-5.

Sarmah, AK, MT Meyer, et al. (2006). "A global perspective on the use, sales, exposure pathways, occurrence, fate and effects of veterinary antibiotics (VAs) in the environment." Chemosphere 65(5): 725-59.

Sato, K, PC Bartlett, et al. (2005). "Antimicrobial susceptibility of Escherichia coli isolates from dairy farms using organic versus conventional production methods." *J Am Vet Med Assoc* 226(4): 589-94.

Schmitt, H, K Stoob, et al. (2006). "Tetracyclines and tetracycline resistance in agricultural soils: microcosm and field studies." Microb Ecol 51(3): 267-76.

Seybold, U, EV Kourbatova, et al. (2006). "Emergence of community-associated methicillin-resistant Staphylococcus aureus USA 300 genotype as a major cause of health care-associated blood stream infections." Clin Infect Dis 42(5): 647-56.

Simjee, S, DG White, et al. (2002). "Prevalence of streptogramin resistance genes among Enterococcus isolates recovered from retail meats in the Greater Washington DC area." *J Antimicrob Chemother* 50(6): 877-82.

Sivapalasingam, S, CR Friedman, et al. (2004). "Fresh produce: a growing cause of outbreaks of foodborne illness in the United States, 1973 through 1997." *J Food Prot* 67(10): 2342-53.

Smith, DL, J Dushoff, et al. (2005). "Agricultural antibiotics and human health." PLoS Med 2(8): e232.

Smith, DL, AD Harris, et al. (2002). "Animal antibiotic use has an early but important impact on the emergence of antibiotic resistance in human commensal bacteria." Proc Natl Acad Sci USA 99(9): 6434-9.

Smith, KE, JM Besser, et al. (1999). "Quinolone-resistant Campylobacter jejuni infections in Minnesota, 1992-1998. Investigation Team." *N Engl J Med* 340(20): 1525-32.

Smith, RD, M Yago, et al. (2005). "Assessing the macroeconomic impact of a healthcare problem: the application of computable general equilibrium analysis to antimicrobial resistance." *J Health Econ* 24(6): 1055-75.

Sorum, M, PJ Johnsen, et al. (2006). "Prevalence, persistence, and molecular characterization of glycopeptide-resistant enterococci in Norwegian poultry and poultry farmers 3 to 8 years after the ban on avoparcin." Appl Environ Microbiol 72(1): 516-21.

Steinmuller, N, L Demma, et al. (2006). "Outbreaks of enteric disease associated with animal contact: not just a foodborne problem anymore." Clin Infect Dis 43(12): 1596-602.

Stevens, DL, Y Ma, et al. (2007). "Impact of antibiotics on expression of virulence-associated exotoxin genes in methicillin-sensitive and methicillin-resistant Staphylococcus aureus." *J Infect Dis* 195(2): 202-11.

Stine, OC, JA Johnson, et al. (2007). "Widespread distribution of tetracycline resistance genes in a confined animal feeding facility." *Int J Antimicrob Agents* 29(3): 348-52.

Stine, SW (2005). "Application of microbial risk assessment to the development of standards for enteric pathogens in water used to irrigate fresh produce." *J Food Prot* 58(5): 913-8.

Stokstad, ELR and TH Jukes (1958-1959). "Studies of the growth-promoting effect of antibiotics in chicks on a purified diet." Antibiotics Annual: 998-1002.

Summers, AO (2002). "Generally overlooked fundamentals of bacterial genetics and ecology." Clin Infect Dis 34 Suppl 3: S85-92.

Summers, AO (2006). "Genetic linkage and horizontal gene transfer, the roots of the antibiotic multi-resistance problem." Anim Biotechnol 17(2): 125-35.

Sunde, M and M Norstrom (2006). "The prevalence of, associations between and conjugal transfer of antibiotic resistance genes in Escherichia coli isolated from Norwegian meat and meat products." *J Antimicrob Chemother* 58(4): 741-7.

Tauxe, RV (2002). "Emerging foodborne pathogens." *Int J Food Microbiol* 78(1-2): 31-41.

Tenover, FC (2006). "Mechanisms of antimicrobial resistance in bacteria." *Am J Med* 119(6 Suppl 1): S3-10; discussion S62-70.

Teuber, M (2001). "Veterinary use and antibiotic resistance." Curr Opin Microbiol 4(5): 493-9.

Travers, K and M Barza (2002). "Morbidity of infections caused by antimicrobial-resistant bacteria." Clin Infect Dis 34 Suppl 3: S131-4.

Unicomb, LE, J Ferguson, et al. (2006). "Low-level fluoroquinolone resistance among Campylobacter jejuni isolates in Australia." Clin Infect Dis 42(10): 1368-74.

USDA /APHIS (1995). Part I: Feedlot Management Practices. NHMS United States Department of Agriculture.

USDA /APHIS (2003). Antibiotic Use in US Livestock Production.

van den Bogaard, AE and EE Stobberingh (1999). "Antibiotic usage in animals: impact on bacterial resistance and public health." Drugs 58(4): 589-607.

van den Bogaard AE, Mertens P, London NH, Stobberingh EE (1997). High prevalence of colonization with vancomycin- and pristinamycin-resistant enterococci in healthy humans and pigs in The Netherlands: is the addition of antibiotics to animal feeds to blame? *J Antimicrob Chemother* 40: 454-6.

Velge, P, A Cloeckaert, et al. (2005). "Emergence of Salmonella epidemics: the problems related to Salmonella enterica serotype Enteritidis and multiple antibiotic resistance in other major serotypes." Vet Res 36(3): 267-88.

Walton, TE (2002). Swine 2000—Part III: Reference of Swine Health & Environmental Management in the United States. APHIS United States Department of Agriculture, National Health Monitoring System.

Wegener, HC (2003). "Antibiotics in animal feed and their role in resistance development." Curr Opin Microbiol 6(5): 439-45.

White, DG, S Zhao, et al. (2001). "The isolation of antibiotic-resistant salmonella from retail ground meats." *N Engl J Med* 345(16): 1147-54.

Winpisinger, KA, AK Ferketich, et al. (2005). "Spread of Musca domestica (Diptera: muscidae), from two caged layer facilities to neighboring residences in rural Ohio." *J Med Entomol* 42(5): 732-8.

Wright, GD (2007). "The antibiotic resistome: the nexus of chemical and genetic diversity." Nat Rev Microbiol 5(3): 175-86.

Zhang, Q, J Lin, et al. (2003). "Fluoroquinolone-resistant Campylobacter in animal reservoirs: dynamics of development, resistance mechanisms and ecological fitness." Anim Health Res Rev 4(2): 63-71.

Zhang, Q, O Sahin, et al. (2006). "Fitness of antimicrobial-resistant Campylobacter and Salmonella." Microbes Infect 8(7): 1972-8.

Antibiotic (classic definition): A substance produced by a microorganism that has the ability to kill or inhibit the growth of other microorganisms. Synthetic antibiotics, usually chemically related to natural antibiotics, can now be produced.

Antibiotic (popular usage): A drug used to treat infections caused by bacteria. Most antibiotics in use are specific to bacteria because they act on aspects of bacterial growth, development, and/or structure that are specific to bacteria and are not part of the growth, development, or structure of the host organism. Thus, the bacterium is harmed, but not its host.

Antibiotic Resistance: The ability of microorganisms to withstand the effects of one or multiple antibiotics (can be innate or acquired). Resistance to multiple drugs is known as multidrug resistance. Some bacteria are naturally resistant to multiple drugs; all can acquire resistance genes. Selective pressure from exposure to antibiotics is among the most potent forces that drive antibiotic resistance.

Antibiotic Resistance (modified from WHO): Resistance to antimicrobials is a natural biological phenomenon that can be amplified or accelerated by a variety of factors, including exposure to antibiotics. Use of antimicrobials (whether for treatment or prophylaxis) forces microbes to adapt or die. Those that survive carry genes for resistance that can be passed on.

Antimicrobials: Substances that kill or inhibit the growth of microorganisms. The terms "antibiotics" and "antimicrobials" are often used interchangeably, although "antimicrobial" actually covers a wider range of substances.

Category 1 Drugs: Drugs that do not require a withdrawal period prior to slaughter. A withdrawal period is a period of time before the animal is slaughtered (for human consumption) during which the drug may not be administered to the animal. If the category 1 drug is being administered at doses above the approved dose for the particular purpose, a withdrawal period may still be necessary.

Category 2 Drugs: Drugs that require a withdrawal period prior to slaughter, regardless of the dose. It must be shown that no drug residues are found in the slaughtered animal.

Commensal Bacteria: Bacteria that share a symbiotic relationship with their host are termed commensal. That is, both the bacteria and their host benefit from the bacteria living within the host. In humans, and all other animals, the largest example is the bacteria that populate the gut. Those bacteria perform a wide range of tasks, from metabolism to defense, which benefit the host. The bacteria benefit by being provided room and board. However, when commensal bacteria replicate to levels higher than their normal population, they can be harmful to the host.

Concentrated Animal Feeding Operations (CAFOs): For regulatory purposes, the EPA defines CAFOs as: "New and existing operations which stable or confine and feed or maintain for a total of 45 days or more in any 12-month period more than 1,000 animal units from a combination of slaughter steers and heifers, mature dairy cattle, swine over 55 pounds and sheep; OR new and existing operations which discharge pollutants into navigable waters either through a man-made ditch, flushing system, or other similar man-made device, or directly into waters of the United States, and which stable or confine and feed or maintain for a total of 45 days or more in any 12-month period more than 300 animal units (from a combination of slaughter steers and heifers, mature dairy cattle, swine over 55 pounds and sheep). Provided, however, that no animal feeding operation is a concentrated animal feeding operation as defined above if such animal feeding operation discharges only in the event of a 25-year, 24-hour storm event." The EPA is currently in the process of reviewing this definition. In general, the term CAFO is popularly used to refer to animal production in confined, high-density conditions.

Confinement Agriculture/Systems: This refers to types of agriculture in which the movement of animals is confined and they are raised in high density, usually with stimulated feeding, and weight gain optimized so as to decrease time to mature weight.

Control: In terms of antibiotic use, this refers to the administration of antibiotics when morbidity (instances of disease) or mortality (instances of death) is elevated above normal levels. These antibiotics are usually administered at the herd or flock level.

Dosage: The amount of antibiotic administered to the animal(s), often in weight of antibiotic per weight of feed (i.e., X grams of antibiotic per ton of feed).

Federal Food, Drug, and Cosmetic Act: A regulatory act in the United States that, since 1938, has regulated all use of antibiotics in the United States. The Food Additives Amendment of 1958 pertains to the use of antibiotics in feed for animals and products for direct human consumption. The Animal Drug Amendments of 1968 added new drugs and antimicrobials used in animals to this regulation.

Feed Efficiency: This term refers to the efficiency by which an individual converts food into weight. For example, chickens have very high feed efficiency, on average converting two pounds of food into one pound of weight at slaughter. Other larger and longer-lived animals, such as cattle, are less efficient, needing ten or more pounds of food to create one pound of animal weight at slaughter. Increasing feed efficiency decreases costs of production and generally decreases the amount of time needed to produce a mature (in terms of weight) individual.

Growth Promoter: Compounds used as additives to animal feed which are intended to increase the rate of growth or maximal size and/or weight of the individual.

Ionophore: A lipid-soluble molecule made by microorganisms such as bacteria to transport ions into and out of the cell is called an ionophore. They are carriers for ions which otherwise would not be able to move into or out of the cell.

Medically Important Antibiotics: This term is used to describe antibiotics used in treatment of human disease and designated by the FDA as highly or critically important for the treatment of disease in humans.

Medicated Feeds: Animal feeds sold with antibiotics or other drugs in the feed mixture may be called medicated feeds. The majority of these are sold over the counter, with the exception of a very few which require a Veterinary Feed Directive (akin to a prescription in human medicine) for sale.

Metaphylaxis: This term may refer to the use of high doses of antibiotics over short periods of time to control the spread of bacterial infection from animal to animal. It is meant to treat disease in one individual while preventing disease in other individuals.

Microbiological Safety: This is terminology used by the FDA in determining the safety of antibiotics, for example the probability that use in animal feed will result in the creation of resistance in bacterial populations.

Natural Growth Promoters: Agents added to animal feed intended to increase the rate of growth or the size of the individual that do not contain antibiotics, are often called "natural growth promoters." Common classes of natural growth promoters include: acidifiers, probiotics, prebiotics, synbiotics, phytogenics, feed enzymes, and immune stimulants.

New Animal Drug Application: This is the current regulatory procedure for approval of antibiotics and other drugs for use in animals, either intended for veterinary or agricultural use.

Nontherapeutic: The use of antimicrobials in food animals in the absence of microbial disease or known (documented) microbial disease exposure; i.e., any use of the drug as an additive for growth promotion, feed efficiency, weight gain, routine disease prevention in the absence of documented exposure, or other routine purpose is considered nontherapeutic.

Prophylactic: The use of antimicrobials in healthy animals in advance of an expected exposure to an infectious agent or following such an exposure but before onset of laboratory-confirmed clinical disease as determined by a licensed professional. Prophylactic use of antibiotics is usually employed in situations where there is a high risk of developing disease or illness. In human medicine, this usually involves situations of high-density cohabitation where a disease has been detected (i.e., meningitis diagnosis of one student may result in treatment of an entire dorm). In food animals, the term has also been used to describe situations where a drug is used due to the high probability of the development of a disease, without actual diagnosis.

Subtherapeutic: The use of antibiotics at doses or concentrations below those known to effectively harm or kill bacteria so as to prevent or cure disease is called subtherapeutic use.

Therapeutic: This term refers to the use of antimicrobials in food animals with diagnosed microbial disease.

Veterinary Feed Directive: A prescription for a medicated feed or antibiotic to be added to animal feed is called a Veterinary Feed Directive.

The PCIFAP is a two-year study funded by The Pew Charitable Trusts through a grant to Johns Hopkins Bloomberg School of Public Health. This report was commissioned to examine the specific aspects of IFAP contained herein. It does not reflect the position of the Commission. The positions and recommendations of the PCIFAP are contained in its final report.

PCIFAP Commissioners

John Carlin, Chair
Executive-in-residence
Kansas State University

Michael Blackwell, DVM, MPH, Vice Chair
Assistant Surgeon General, USPHS (ret.)
President and CEO
Blackwell Consulting, LLC

Brother David Andrews, CSC, JD
Former Executive Director
National Catholic Rural Life Conference

Fedele Bauccio, MBA
Co-founder and CEO
Bon Appétit Management Company

Tom Dempster
State Senator, South Dakota

Dan Glickman, JD
Former US Secretary of Agriculture
Chairman and CEO
Motion Picture Association of America

Alan M. Goldberg, PhD
Professor
Johns Hopkins Bloomberg School of Public Health

John Hatch, DrPH
Kenan Professor Emeritus
University of North Carolina at Chapel Hill
School of Public Health

Dan Jackson
Cattle Rancher

Frederick Kirschenmann, PhD
Distinguished Fellow
Leopold Center for Sustainable Agriculture
Iowa State University

James Merchant, MD, DrPH
Dean
University of Iowa College of Public Health

Marion Nestle, PhD, MPH
Paulette Goddard Professor
Department of Nutrition, Food Studies,
and Public Health
New York University

Bill Niman
Cattle Rancher and Founder of Niman Ranch, Inc.

Bernard Rollin, PhD
Distinguished Professor of Philosophy
Colorado State University

Mary Wilson, MD
Associate Professor
Harvard School of Public Health
Associate Clinical Professor of Medicine
Harvard Medical School

Acknowledgments: This report is supported by a grant from The Pew Charitable Trusts. The opinions expressed are those of the author(s) and do not necessarily reflect the views of The Pew Charitable Trusts.

PCIFAP Staff

Robert P. Martin
Executive Director

Ralph Loglisci
Communications Director

Paul Wolfe
Policy Analyst

Emily A. McVey, PhD
Science Director

Lisa Bertelson
Research Associate

The Commission gratefully acknowledges the contribution of Dr. Amira Roess during her tenure with the Commission

Report Authors

Ellen Silbergeld, PhD
Professor
Environmental Health Sciences
Johns Hopkins Bloomberg School of Public Health
Baltimore, MD

Jay Graham, PhD
Johns Hopkins Bloomberg School of Public Health
Baltimore, MD

Lance B. Price, PhD
Johns Hopkins Bloomberg School of Public Health
Baltimore, MD

Contributors

Emily A. McVey, PhD
Pew Commission on Industrial Farm Animal Production

Leila Grace Lackey, MHS
Johns Hopkins Bloomberg School of Public Health

Peer Reviewers

The PCIFAP thanks the reviewers for their time, expertise, and insights. The opinions expressed in this report do not necessarily represent the views of these individuals or their organizations.

Fred Angulo, DVM, PhD
Deputy Branch Chief
Enteric Diseases Epidemiology Branch
Division of Foodborne, Bacterial and Mycotic Diseases
National Center for Zoonotic, Vectorborne, and Enteric Diseases
Centers for Disease Control and Prevention

Paula J. Fedorka-Cray, PhD
Research Leader, Microbiologist
Bacterial Epidemiology and Antimicrobial Resistance
United States Department of Agriculture
Athens, Georgia

Frank M. Aarestrup
Professor
National Food Institute
Technical University of Denmark
Copenhagen V, Denmark

Abigail Salyers, PhD
Professor of Microbiology
University of Illinois at Urbana-Champaign
Urbana, Illinois

Anonymous

PEW COMMISSION ON
INDUSTRIAL FARM
ANIMAL PRODUCTION

FMI Backgrounder

Low-Level Use of Antibiotics In Livestock and Poultry

Executive Summary

Antibiotics have long been used to treat illnesses in humans and farm animals. About 50 years ago, the U.S. Food and Drug Administration (FDA) approved their use in feed in subtherapeutic or low doses to help animals grow faster, produce more meat and avoid illness.

As antibiotic use increased in both animals and humans, bacteria emerged that are resistant to the same drugs given to both. There is also evidence that resistance may develop in chemically similar bacteria.

As antibiotic use has increased in both animals and humans, bacteria have emerged that are resistant to the same drugs given to both.

Scientists agree that the widespread use — and overuse — of antibiotics to treat disease in humans is the primary cause for the increase in resistant bacteria. A growing body of science suggests a link between the low-level use of antibiotics in farm animals and the increase in bacteria resistant to the same or similar antibiotics administered to humans. The leading health agencies in the U.S. and European Union (EU) and World Health Organization (WHO) agree that the link is serious enough to ban the subtherapeutic use of at least some antibiotics in farm animals. In 2001, the American Medical Association (AMA) approved a resolution to ban all low-level use. The FDA, EU and WHO are selectively banning such use, blocking the drugs that are used in both animals and humans. Consumer advocacy groups strongly support these actions and are calling for more widespread bans. Animal health groups disagree, saying that a small percentage of antibiotics are put to nonmedical uses, minimizing this application in promoting drug resistance.

The U.S. Department of Agriculture (USDA) and animal health organizations have developed guidelines to limit low-level use. Major private buyers of livestock products such as the McDonald's Corporation are requiring suppliers to stop using antibiotics as growth-promoters that are also given to humans. To be certified organic, U.S. meat must come from animals raised without antibiotics.

At issue is whether low-level use of antibiotics in animal feed should be more widely banned.

At issue is whether low-level use of antibiotics in animal feed should be more widely banned.

1. Why are antibiotics routinely fed to livestock and poultry?

There are three major reasons, according to the CDC:[1]

- Treat sick animals.

[1] CDC National Anti-microbial Resistance Monitoring Systems (NARMS) "FAQ: Antibiotic Resistance and Foodborne Illness" (www.cdc.gov/narms/faq.htm).

The Food Marketing Institute (FMI) is a nonprofit association conducting programs in research, education, industry relations and public affairs on behalf of its 2,300 members including their subsidiaries — food retailers and wholesalers — in the United States and around the world. FMI's U.S. members operate approximately 26,000 retail food stores with a combined annual sales volume of $340 billion — three-quarters of all food retail store sales in the United States. FMI's retail membership is composed of large multi-store chains, small regional firms and independent supermarkets. Its international membership includes 200 members from 60 countries.

FOOD MARKETING INSTITUTE

655 15th Street, N.W., Washington, DC 20005
202.452.8444 fax: 202.429.4519
fmi@fmi.org ■ http://www.fmi.org

- Prevent disease among animals susceptible to infections. This use affects a larger number of animals, because it usually involves treating a whole herd or flock, which increases the likelihood of genetic selecting for organisms that are resistant to the antibiotic.
- Promote the growth of cattle, poultry and swine when they are fed low doses for long periods. As a growth-promoter, antibiotics in feed help animals gain weight more efficiently by controlling the bacteria that can interfere with their ability to absorb nutrients. Animals become healthier, grow faster and stronger, and fewer die from disease.

As a growth promoter, antibiotics in feed help animals gain weight more efficiently by controlling the bacteria that can interfere with their ability to absorb nutrients.

2. Are drug residues in food the issue?

No. USDA routinely inspects meat, poultry and egg products for residues that exceed tolerance levels. The inspectors seldom find residues that exceed safe levels. The issue here involves antibiotic *resistance* of bacteria, not antibiotic residues.

It is also important to understand that resistance has nothing to do with potency. The resistant bacteria are not stronger; they simply cannot be treated with antibiotics that are currently available.

The issue here involves antibiotic resistance of bacteria, not antibiotic residues.

3. Why has antibiotic resistance increased in humans?

It is widely accepted that the primary cause is overuse and misuse of antibiotics. In some cases, doctors prescribe or patients demand the drugs too frequently or inappropriately, such as for illnesses that are not caused by bacteria and do not respond to antibiotics. In other cases, patients fail to complete the prescribed course of an antibiotic treatment, making it more likely that surviving bacteria will develop resistance to the drug.

There is also evidence that antibiotic use in food-producing animals contributes to human drug resistance, although to a far lesser degree than human use does. The controversy centers over how significant this contribution is, how much of the problem stems from subtherapeutic use and how to respond.

4. What triggered the controversy?

The issue emerged in 1984 when a CDC study linked antibiotics in livestock and poultry feed to resistant bacteria in humans.[2] The issue resurfaced in the 1990s with reports about the emergence of antibiotic-resistant strains of *Salmonella*, *Campylobacter* and *E. coli* O157:H7. CDC reported an increase in resistance in laboratory samples from 0.6 percent in 1979 to 34 percent in 1996.[3] The study noted that a serotype of *Salmonella* known as DT104 is resistant to five antibiotics and has become a major cause of illness in humans and animals in Europe, especially in the United Kingdom.

The issue emerged in 1984 when a CDC study linked antibiotics in livestock and poultry feed to resistant bacteria in humans.

A Minnesota study linked an increase in quinolone-resistant *Campylobacter jejuni* infections from 1992 through 1998 to the licensing

[2] "Drug-Resistant Salmonella From Animals Fed Antimicrobials," *New England Journal of Medicine*, September 6, 1984.

[3] "Emergence of Multidrug-Resistant *Salmonella enterica* Serotype Typhimurium DT104 Infections in the United States," *New England Journal of Medicine*, May 7, 1998.

of fluoroquinolones for use in livestock and poultry.[4] FDA approved these drugs in 1995 to prevent bacterial diseases in poultry. The report cited Minnesota Health Department data showing that *Campylobacter* became increasingly resistant to a fluoroquinolone. The resistant bacteria were found in samples from people suffering from foodborne illness.

A 2001 study cited the appearance of bacteria resistant to the drug Synercid (quinupristin/dalfopristin) in patients who had never been exposed to it, suggesting a nonhuman source.[5] Synercid is an antimicrobial used as a last-resort treatment against antibiotic-resistant bacteria. FDA was assessing the possible link between human resistance to quinupristin/dalfopristin and the use of a structurally related growth-promoter in animals.

5. What is the position of the scientific community?

There is considerable debate over the use of antibiotics to promote growth in farm animals. Among the strongest opponents is the World Health Organization (WHO), which in August 2003 recommended that nations stop using antibiotics for growth promotion. WHO asserts that "the largest quantities" of antimicrobials given at low doses to food-producing animals "are used as regular supplements for . . . growth promotion, thus exposing a large number of animals, irrespective of their health status . . . ."[6] Its recommendation was based on a Denmark study of food-producing animals that have not consumed antibiotic growth promoters since the end of 1999. The Danish ban led to significant declines in resistant bacteria in pork and chicken: 60-80 percent had bacteria resistant to three widely used antibiotics before the ban, compared with 5-35 percent afterwards.

There is considerable debate over the use of antibiotics to promote growth in farm animals.

In June 2001, the American Medical Association adopted a resolution opposing all subtherapeutic use of antibiotics in farm animals.[7]

In June 2001, the American Medical Association adopted a resolution opposing all subtherapeutic use of antibiotics in animals.

Others say such action is unnecessary. In September 2003, scientists at the Interscience Conference on Antimicrobial Agents and Chemotherapy released a study of two macrolide antibiotics, tylosin and tilmicosin. They found that the risk of humans acquiring resistant bacteria by eating meat or poultry from animals treated with the drugs is less than one in 10 million per year for resistant *Campylobacter* and less than one in three billion for *E. faecium*. "People would be more likely to die from a bee sting than for their antibiotic treatment to fail because of macrolide-resistant bacteria in meat or poultry," said Stephanie Doores, Ph.D., of Pennsylvania State University.[8]

---

[4] "The Consequences for Food Safety of the Use of Fluoroquinolones in Food Animals," *New England Journal of Medicine*, May 20, 1999.

[5] Nawaz, Mohammed S., et al. "Human Health Impact and Regulatory Issues Involving Antimicrobial Resistance in the Food Animal Production Environment." *Regulatory Research Perspectives*, July 2001.

[6] Communicable Diseases Cluster, *WHO Global Strategy for Containment of Antimicrobial Resistance*.

[7] Res. 508, A-01, H-440.895, Antimicrobial Use and Resistance.

[8] AVMA press release, "New Antibiotic Risk Assessment Concludes Macrolides Can Be Safely Used in Food Animal Production," September 16, 2003.

FDA, CDC and USDA all agree that antibiotics are as critical in treating bacterial infections in animals as in humans. Government scientists also acknowledge the relationship between the use of antibiotics in food-producing animals and the emergence of drug-resistant bacteria that can infect people.

FDA, CDC and USDA all agree that antibiotics are critical in treating bacterial infections in animals as well as humans.

6. Where do animal health experts stand on this issue?

Antibiotic resistance is a major concern among drug manufacturers and veterinarians. The Animal Veterinary Medical Association (AVMA) notes that "evidence is accumulating to support the hypothesis that antimicrobial resistance in animals can result in the transfer of resistant bacteria . . . or genetic determinants to humans through the food supply by direct animal-to-human contact or indirectly through the environment."[9] In May 2003, AVMA issued a position statement reading, in part, "The AVMA supports a national, coordinated, and appropriate response to the issue of antimicrobial resistance in bacteria that includes an open or public FDA approval process that is rigorous and that includes an assessment of food safety to approve animal health products for use in animals." AVMA, the Animal Health Institute (AHI) and other groups are now developing guidelines for the prudent use of antibiotics in farm animals.

At the same time, some animal health experts argue that most of the antibiotics given to farm animals are to prevent or treat illnesses, and that relatively little is administered to promote growth. AHI says each ton of animal feed contains just four to 25 grams of antibiotics, with only 13 percent of all antibiotics in animal feed used for growth promotion. AHI also cites declines in the incidence of drug-resistant *Salmonella* and *Campylobacter* in humans since 1996, pointing to data from CDC's National Antimicrobial Resistance Monitoring Systems (NARMS).[10]

'Each ton of animal feed contains just four to 25 grams of antibiotics, with only 13 percent of all antibiotics in animal feed used for growth promotion.' — Animal Health Institute

In 2001, a study by the European Federation of Animal Health concluded that humans consumed 65 percent of all antibiotics administered in the European Union in 1999, versus 35 percent for animals. The study found that only 6 percent of all antibiotics took the form of growth promoters in animal feed. It also claimed that this use of antibiotics fell by 50 percent between 1997 and 1999. Reacting to these findings, the Animal and Plant Health Association (APHA) asserted that the use of antibiotics in farm animals is, at most, only a "very small contributing factor to the problem of antimicrobial resistance," according to Declan O'Brien, the group's director.[11]

7. What is the position of consumer advocates?

The Union of Concerned Scientists (UCS) supports reducing the use of antibiotics in food animals, saying the drugs produce benefits that "are

[9] AVMA, "Judicious Therapeutic Use of Antimicrobials" (www.avma.org/scienact/jtua/default.asp).

[10] See footnote 8.

[11] APHA press release, "Antibiotic Use in Farm Animals Does Not Threaten Human Health, a New Study Suggests," June 13, 2001.

economic, not therapeutic." In a January 2001 report titled "Hogging It!: Estimates of Antimicrobial Abuse in Livestock," the advocacy group estimated that U.S. livestock producers use 24.6 million pounds of antimicrobials for subtherapeutic purposes each year, including tetracycline, penicillin, erythromycin and other drugs that are important for human use. The group argues that banning or curtailing this use "would have the added benefit of pushing livestock management in the direction of more sustainable practices."

The FDA Center for Veterinary Medicine must approve every drug used in animals, looking at how drugs may harm animals and humans who consume the meat.

In 1998, UCS joined the Center for Science in the Public Interest (CSPI) and other advocacy groups in petitioning FDA to withdraw approval of farm uses of antibiotics that threaten human health. "Specifically, the FDA should not allow an antibiotic to be used as a livestock feed additive if that antibiotic is used (or related to one used in) human medicine," according to CSPI.[12]

CSPI reasserted this appeal in 1999 after a study in the *New England Journal of Medicine* showed that humans with fluoroquinolone-resistant *Campylobacter* most likely acquired the infection by eating poultry that had been given these antibiotics.

The following year, FDA's Center for Veterinary Medicine banned subtherapeutic use of fluoroquinolones in poultry. In March 2004, and FDA administrative law judge upheld the ban.

8. How has the federal government responded?

HHS is coordinating a public health plan to address antimicrobial resistance. A key player is USDA, which approves all antibiotics used for food-producing animals. In recent years, the agency has acknowledged a proven — though unquantifiable — link between the use of antibiotics in animals and drug resistance in humans.

Since 1996, USDA has engaged in programs to better understand, track and reduce antimicrobial resistance in humans. These efforts include supporting improved nutrition for farm animals, biosecurity to minimize infections on farms and prudent use of antibiotics. USDA now undertakes three activities related to antimicrobial resistance: surveillance, research, and prevention and control.

Since 1996, USDA has engaged in programs to better understand, track and reduce antimicrobial resistance in humans.

In 1996, the agency's Food Safety and Inspection Service (FSIS) joined with CDC, FDA and 28 state and local health departments to establish the NARMS Enteric Bacteria program to test for antimicrobial resistance in agriculture. The program collects and analyzes *Salmonella*, *Campylobacter*, *E. coli* and *Enterococcus* samples from animals and humans. Among other monitoring projects, the NARMS initiative also investigates outbreaks caused by particular bacteria,

The FDA Center for Veterinary Medicine (CVM) investigates antibiotic resistance. It must approve every drug used in animals, looking at how drugs may harm animals and humans who consume the meat. It works with USDA to inspect food products, such as sampling body

[12] CSPI Petition to the U.S. Food and Drug Administration to Ban the Use of Certain Antibiotics in Livestock Feed (www.cspinet.org/reports/petition_antibiotic.htm).

tissues from slaughtered animals. CVM has also taken steps to enable the animal-drug approval system to make adjustments when antimicrobial resistance becomes a concern, either for human or animal treatment. The adjustments are incorporated into a framework that calls for drugs with the highest risk of creating problems for human therapy to be the least likely to be approved for animal uses.

Other government responses:

- USDA National Organic Program, which took effect in 2002, permits neither subtherapeutic nor therapeutic antibiotics in organic livestock.
- Bipartisan legislation introduced in July 2003 would phase out the use of subtherapeutic drugs in livestock that are used to treat or prevent infection in humans. The drugs would still be used to treat sick animals; they also would retain approval for subtherapeutic use if their manufacturers prove that such use poses no risk to human health.[13]

USDA National Organic Program permits neither subtherapeutic nor therapeutic antibiotics in organic livestock.

9. How has the industry responded?

Many companies that make medicines for animals, together with veterinarians, food producers and others, have expressed interest in working with U.S. and global authorities to enhance monitoring and surveillance programs. Some companies have also altered their practices.

Groups such as AHI and AVMA are developing guidelines for the prudent use of antibiotics in farm animals. These include guidelines for "judicious therapeutic use of antimicrobials" in pork and poultry production, as well as for the veterinarians of beef cattle, dairy cows, swine and poultry.

Groups such as AHI and AVMA are developing guidelines for the prudent use of antibiotics in farm animals.

In 2001, AVMA and the American Association of Veterinary Laboratory Diagnosticians initiated a pilot project to develop a monitoring program for animal pathogen resistance.

In June 2003, the McDonald's Corporation announced a policy giving direct suppliers until the end of 2004 to stop using 24 growth-promoting antibiotics that are also used in human medicine. The fast-food giant's producers supply more than 2.5 billion pounds of chicken, beef and pork annually, prompting speculation that the policy could set the stage for others to take similar steps. The Coalition for Animal Health — consisting of AHI, AVMA and other industry groups — condemned the policy as not being grounded in science, noting that the banned products have received FDA approval.[14]

[13] American Veterinary Medical Association, "Lawmakers seek to curb antimicrobial use in livestock," *JAVMA News*, September 15, 2003 (www.avma.org/onlnews/javma/sep03/030915q.asp).

[14] *AgriNews Online*, "Industry coalition questions WHO recommendation on antibiotics," September 9, 2003 (www.agrinewspubs.com).

10. What are the economic implications of restricting or banning subtherapeutic use of antibiotics?

This, too, is subject to debate. According to a 2003 Iowa State University study, a U.S. ban on growth-promoting antibiotics in hog feed would increase disease-treatment costs by $4.50 per pig per year ($700 million over 10 years).[15] Funded in part by the National Pork Board, this study was based on Denmark's suspension of antibiotics used for subtherapeutic purposes. It found that most of the costs were incurred when the ban was imposed at the weaning stage, when piglets "encountered severe health problems and incurred large costs" by requiring more antibiotics as therapeutic medications.

A U.S. ban on growth-promoting antibiotics in hog feed would increase disease-treatment costs by $4.50 per pig per year ($700 million over 10 years).
— 2003 Iowa State University study

In its own review of Denmark's experience, the World Health Organization (WHO) said the ban increased the cost of producing pigs by just over 1 percent. The WHO report noted that this figure excluded some costs, including some "associated with modifications of the production systems," but added that additional production costs "may be at least partially offset by the benefits of increased consumer confidence in, and demand for, Danish pig and poultry meat produced without antimicrobial growth promoters."[16]

11. How significant an issue is the use of antibiotics in animal feed outside the United States?

The United Kingdom (UK) banned the use of penicillin and tetracycline for growth promotion in the early 1970s; Sweden banned the use of all antibiotics for growth promotion in 1986; and Denmark banned the use of the antibiotic virginiamycin in animal feed in 1998. Virtually no antimicrobial growth-promoters have been used in Denmark since the end of 1999.

Recent actions taken by the European Union (EU) may stem from the outbreak of mad cow disease in Britain in the 1990s. In July 1999, the EU banned four widely used antibiotics in animal feed that are similar to drugs used in human medicine after banning 15 antibiotics for this use in the past. The ban does not apply the using antibiotics to treat animal diseases — only to their routine use in feeds. It was triggered by concerns over laboratory tests showing that a Dutch poultry farmer had become infected with the same antibiotic-resistant bacteria found in his chickens.

Recent actions taken by the 15-nation European Union may stem from the outbreak of mad cow disease in Britain in the 1990s.

Canada's health department has called for a voluntary reduction in the amount of antibiotics used in agriculture, but is considered unlikely to ban their use. Instead, experts there say they would prefer to evaluate each drug individually to see if the benefits outweigh the risks.

---

[15] Dermot J. Hayes and Helen H. Jenson. "Lessons from the Danish Ban on Feed-Grade Antibiotics," Briefing Paper 03-BP 41, June 2003, Center for Agricultural and Rural Development, Iowa State University (www.card.iastate.edu).

[16] WHO, Executive Summary to *Impacts of antimicrobial growth promoter termination in Denmark*.

Sources of Additional Information

American Veterinary Medical Association
1931 North Meacham Road, Suite 100
Schaumburg, IL 60173
847-925-8070
www.avma.org

Animal Health Institute
1325 G Street N.W.
Washington, DC 20005
202-637-2440
www.ahi.org

Centers for Disease Control and Prevention
Food Safety Office
404-639-2213
www.cdc.gov/foodsafety

FDA Center for Food Safety and Applied Nutrition
5100 Paint Branch Parkway
College Park, MD 20740-3835
Information line: 1-888-SAFEFOOD
http://vm.cfsan.fda.gov

FDA Center for Veterinary Medicine
7519 Standish Place, HFV-12
Rockville, MD 20855
301-827-3800
www.fda.gof/cvm

National Antimicrobial Resistance Monitoring System
www.cdc.gov/narms

USDA Food Safety and Inspection Service
Food Safety Education Staff
5601 Sunnyside Avenue
Beltsville, MD 20705
301-504-9605
www.fsis.usda.gov

POLICY & ACTION FROM CONSUMER REPORTS

The Overuse of Antibiotics in Food Animals Threatens Public Health

Research

The Overuse of Antibiotics in Food Animals Threatens Public Health

The Overuse of Antibiotics in Food Animals Threatens Public Health

Antibiotics have been used since the 1940s and have led to a dramatic reduction in illness and death from infectious diseases. But according to the federal Interagency Task Force on Antimicrobial Resistance, "[t]he extensive use of antimicrobial drugs has resulted in drug resistance that threatens to reverse the medical advances of the last seventy years."1 Since antibiotics have been used so widely and for so long, antibiotic resistance has become a major public health threat.

In response, there has been a concerted effort by the Centers for Disease Control and Prevention (CDC) and others to encourage doctors and patients to use antibiotics more wisely. Unfortunately, little progress has been made to reduce the use of antibiotics on farms, where most of these drugs are administered.

Approximately 80 percent of the antibiotics sold in the United States are used in meat and poultry production.2 The vast majority is used on healthy animals to promote growth, or prevent disease in crowded or unsanitary conditions. The meat and poultry production industry argues, however, that that there is no harm in this. They say for example that "animal use contributes little, if anything, to the burden of human antibiotic resistance..."3 .

A key question is, can antibiotic use in animals promote the development of hard-to-treat antibiotic-resistant superbugs that make people sick? And if it can, are the illnesses rare occurrences, and the risks theoretical, or could current usage in animals pose a serious threat to human health.

But Consumers Union has concluded that the threat to public health from the overuse of antibiotics in food animals is real and growing. Humans are at risk both due to potential presence of superbugs in meat and poultry, and to the general migration of superbugs into the environment, where they can transmit their genetic immunity to antibiotics to other bacteria, including bacteria that make people sick.

Numerous health organizations, including the American Medical Association, American Public Health Association, Infectious Disease Society of America, and the World Health Organization, agree and have called for significant reductions in the use of antibiotics for animal food production.

History of Expert Opinion

Scientific expert bodies for more than two decades have concluded that there is

a connection between antibiotic use in animals and the loss of effectiveness of these drugs in human medicine. In 1988, the Institute of Medicine (part of the National Academy of Sciences) concluded that "the committee believes that important, although as yet sparse, data show the flow of distinct salmonella clones from farm animals medicated with antibiotics in subtherapeutic concentrations, through food products, to humans, who thus acquire clinical salmonellosis."4

Ten years later, the National Research Council (part of the National Academy of Sciences) concluded that "a link can be demonstrated between the use of antibiotics in food animals, the development of resistant microorganisms in those animals, and the zoonotic spread of pathogens to humans."5

In 2003, an Expert Workshop co-sponsored by the World Health Organization, Food and Agricultural Organization (FDA), and World Animal Health Organization (OIE) concluded "that there is clear evidence of adverse human health consequences due to resistant organisms resulting from non-human usage of antimicrobials. These consequences include infections that would not have otherwise occurred, increased frequency of treatment failures (in some cases death) and increased severity of infections"6 .

In 2010, the U.S. Food and Drug Administration, U.S. Department of Agriculture, and the CDC all testified before Congress that there is a connection between the routine use of antibiotics for meat production and the declining effectiveness of antibiotics for people.7 Dr. Thomas R. Frieden, Director of the CDC, noted that "there is strong scientific evidence of a link between antibiotic use in food animals and antibiotic resistance in humans."8

Most recently in 2012, the FDA stated "Misuse and overuse of antimicrobial drugs creates selective evolutionary pressure that enables antimicrobial resistant bacteria to increase in numbers more rapidly than antimicrobial susceptible bacteria and thus increases the opportunity for individuals to become infected by resistant bacteria."9 Also in 2012, the FDA, in its final rule banning certain extralabel uses of cephalosporin antimicrobial drugs in certain food producing animals, stated "In regard to antimicrobial drug use in animals, the Agency considers the most significant risk to the public health associated with antimicrobial resistance to be human exposure to food containing antimicrobial-resistant bacteria resulting from the exposure of food-producing animals to antimicrobials."10

Nevertheless, the livestock industry continues to argue that while antibiotic use may have something to do with antibiotic resistance in bacteria on the farm, it is not an important human health issue, and little change in current practices are needed.

What Happens on the Farm

Numerous studies have demonstrated that routine use of antibiotics on the farm promotes drug-resistant superbugs in those facilities. Some of the most dramatic evidence came as a result of FDA approval of flouroquinolones–a class of antibiotics that includes Cipro (ciprofloxacin), which has been used in poultry production since 1995. By 1999 nearly 20 percent chicken breasts sampled contained ciprofloxacin-resistant *Camplobacter*, a disease-causing bacteria.11 After a long fight in the courts, FDA finally banned use of the drug in 2005, at which point nearly 30 percent of *C. coli* found in chicken breasts were ciprofloxacin resistant; by 2010, resistance to ciprofloxacin had declined to 13.5 percent.12

The reason for this is that when you feed antibiotics to animals, the bacteria in and around the animals are exposed to the drug, and many of them die. But there are always some that the drug can't kill, and those survive and proliferate. Voila, superbugs.

While not disputing these facts, the industry argues essentially that what happens on the farm stays on the farm. There may be some superbugs there, but they don't affect people. There are two main routes, however, by which superbugs can leave the farm and infect humans. One is a direct route, in meat and poultry products, and the other is an indirect route through the environment.

Superbugs Move From Farm to Kitchen

Once they appear on the farm, superbugs most definitely move from the farm to the kitchen, via uncooked meat and poultry. *Consumer Reports* tests of chicken in both 200613 and 2010 14 revealed widespread presence of antibiotic-resistant pathogens in retail poultry products. In both years, more than two thirds of chicken samples were contaminated with *Salmonella* and/or *Campylobacter*, and more than 60 percent of those bacteria were resistant to one or more antibiotics.

The industry argues that even this is not a concern because people know to cook poultry thoroughly. Indeed they do, but packages can drip in the refrigerator, or cutting boards can become contaminated, as well as other problems. There aren't good data on how frequently this causes illness, especially difficult-to-treat illness, because most people just ride out an infection and it fades into the background of the estimated 48 million cases of food borne illness we have annually in the US.

But occasionally a superbug outbreak is serious enough to command the attention of the Center for Disease Control. One such case occurred in 2011, in which ground turkey was linked to 136 illnesses and one death, all caused by a strain of *Salmonella* resistant to four different antibiotics, ampicillin, streptomycin, tetracycline and gentamicin.15 Some 36 million pounds of ground turkey were recalled.

Another case was ground beef from the Hannaford grocery store chain in New England linked in 2011 to 19 infections and at least seven hospitalizations, all caused by a strain of *Salmonella* resistant to multiple antibiotics, including amoxicillin/clavulanic acid, ampicillin, ceftriaxone, cefoxitin, kanamycin, streptomycin, and sulfisoxazole.16

Superbugs Move From Farm to the Environment

Superbugs can also spread beyond the farm and threaten public health through environmental transmission. This can happen in various ways, particularly via workers, or farm runoff. Once farm-raised superbugs make it off the farm, they can exchange genetic material and give their resistance to other bacteria, even of other genera and species, that have never been anywhere antibiotics. This can happen in lakes, in wild animals, and even in the human digestive tract.

Workers are particularly likely to pick up resistant bacteria from animals and take them elsewhere. A study of poultry workers in the Delmarva peninsula found they were 32 times more likely to carry gentamicin-resistant *Escherichia coli*, and more than five times more likely to carry multi-drug resistant *E. coli*, compared to other community members.17 A study performed in the Midwest found methicillin-resistant *Staphylococcus aureus* (MRSA) in 70 percent of the pigs and 64 percent of the workers at one facility, while no MRSA was found in pigs or workers at a facility in another state, strongly suggesting that the MRSA strain moves between pigs and humans.18 Indeed, a careful genetic analysis has found that a particular MRSA strain found in pigs (e.g. ST398) originated as a methicillin-susceptible *S. aureus* (MSSA) in humans, jumped into pigs, where it acquired resistance to methicillin and tetracycline, and then jumped back to humans, where it's known as livestock-associated MRSA (LA-MRSA).19 This LA-MRSA (e.g. ST398) is quite prevalent in the Netherlands, where it is responsible for over 20% of all MRSA.20

However, resistant bacteria can also escape from a large livestock operation (often known as a confined animal feeding operation, or CAFO) by a number of routes, including via manure applied to fields as fertilizer,21 from trucks transporting animals,22 the wind leaving hog facilities23 or even via flies attracted to the manure which can pick up and transmit resistant bacteria.24 A recently released study of the South Platte River found that antibiotic resistance genes (coding for resistance to sulfonamides) were 10,000 times higher in river sediments downstream from larger feedlots (ones with 10,000 cattle) compared to river sediment upstream from such feedlots.25 The same study found these same antibiotic resistance genes were only 1,000 times higher from sewage treatment plants that discharge ten million gallons of effluent per day, compared to pristine sediments.

Bacteria in many environments can readily exchange genes coding for antibiotic resistance with neighboring bacteria. Antibiotic resistance genes are often located on mobile genetic elements, especially plasmids, transposons and integrons which can easily move between bacteria of the same or different species, which facilitates the spread of resistance to multiple drugs by multiple types of bacteria.26

The industry says that 40 percent of all the antibiotics used on the farm are drugs (called ionophores) not used in human medicine, so it doesn't matter if bacteria become resistant to them. However, a study by scientists from the United States Department of Agriculture (USDA) and Cornell University involving monensin, one of the most commonly used ionophores in cattle production in the U.S., demonstrated that use of monensin in cattle feed and the selection of monensin-resistant ruminal bacteria lead to a 32-fold increase in resistance to bacitracin, which is used in human medicine.27 This study demonstrates that one cannot claim that ionophores cannot select for cross resistance to any antibiotic used in human medicine. The study called for more research.28 So, it is appropriate to consider ionophore use as part of the antibiotics used in animal agriculture.

Conclusion

Use of antibiotics on the farm most definitely poses a risk to human health. Antibiotic use can promote creation of superbugs which can contaminate meat and poultry and cause hard-to-cure disease in people.

Superbugs can also exit the farm via farm workers, wind, runoff, and wildlife. Even if they don't immediately cause illness, bacteria are uniquely equipped to exchange genetic immunity via their plasmids, with other bacteria wherever they encounter them.

It is for these reasons that the public health community and FDA have been proposing to limit use of antibiotics on livestock for more than three decades (see list below). Consumers Union believes that as a prudent measure, we should drastically reduce use of antibiotics on food animals, and eliminate use altogether for growth promotion or disease prevention in healthy animals.

Some of the Organizations Supporting Restrictions on the Use of Antimicrobials in Animal Production

American Medical Association, 2001

Adopted Resolution 508, Antimicrobial Use and Resistance, which states, in part, "AMA is opposed to the use of antimicrobials at non-therapeutic levels in agriculture, or as pesticides or growth promoters, and urges that non-therapeutic use in animals of antimicrobials (that are used in humans) should be terminated or phased out".29

American Public Health Association, 1999, 2004

Policy Number 9908: Addressing the Problem of Bacterial Resistance to Antimicrobial Agents and the Need for Surveillance, which urged "FDA to work for regulations eliminating the non-medical use of antibiotics and limiting the use of antibiotics in animal feeds"30 In 2004, passed a resolution urging "bulk purchasers of foodstuffs to adopt procurement policies that encourage and, where feasible, require procurement of meat, fish, and dairy products produced without nontherapeutic use of medically important antibiotics."31

Infectious Diseases Society of America, 2009

"IDSA supports efforts to phase out the use of antimicrobial drugs for growth promotion, feed efficiency, and routine disease prevention in food animals."32

World Health Organization, 2001

The WHO Global Strategy for Containment of Antimicrobial Resistance, recommends that governments "terminate or rapidly phase out the use of antimicrobials for growth promotion if they are also used for treatment of humans."33

For the PDF version, **click here**.

---

1 Pg 5 in Interagency Task Force on Antimicrobial Resistance, 2012. A Public Health Action Plan to
Combat Antimicrobial Resistance. Washington, D.C. at: **http://www.cdc.gov /drugresistance/pdf/actionplan-2012.pdf**

2 Confirmed: 80 Percent of all antibacterial drugs used on animals, endangering human health. At: **http://www.louise.house.gov /index.php?option=com_content&task=view&id=2697&Itemid=100065**

3 Pg 5 in American Farm Bureau Federation et al June 12, 2012 letter to Congressperson Slaughter

4 Pg. 2 in Institute of Medicine (IOM). 1988. *Human Health Risks with the Subtherapeutic Use of Penicillin or Tetracyclines in Animal Feed.* National Academies Press. Washington, D.C.

5 Pg. 6 in IOM. 1998. *The Use of Drugs in Food Animals: Benefits and Risks.* National Academies Press. Washington, D.C.

6 Pg. 1 in WHO/FAO/OIE. 2003. *Joint FAO/OIE/WHO Expert Workshop on Non-Human Antimicrobial Usage and Antimicrobial Resistance: Scientific assessment, Geneva, December 1-5, 2003.* At: **http://www.who.int/foodsafety /publications/micro/en/amr.pdf**

7 Hearing: Antiobiotic Resistance and the Use of Antibiotics in Animal Agriculture, Subcommittee on
Health, Energy and Commerce Committee, U.S. House of Representatives, July 12, 2010

8 Letter from Thomas R. Frieden, Director, Centers for Disease Control and Prevention, to Keeve
Nachman, Program Director, Farming For the Future,
at **http://www.livablefutureblog.com/wp-content/uploads/2010/11 /ar-m455n_20101129_182057.pdf**

9 Pg. 3 in Food and Drug Administration (FDA). 2012. Guidance #209: the Judicious Use of Medically Important Antimicrobial Drugs in Food-Producing Animals. At: **http://www.fda.gov/downloads/animalveterinary**

/guidancecomplianceenforcement/guidanceforindustry/ucm216936.pdf

10 Pg. 738 in FDA. 2012. New Animal Drugs; Cephalosporin Drugs; Extralabel Animal Drug Use; Order of Prohibition. Federal Register, Vol. 77(4).**http://www.gpo.gov/fdsys/pkg/FR-2012-01-06/pdf/2012-35.pdf**

11 Smith KE, Besser JM, Hedberg CW, Leano FT, Bender JB, Wicklund JH, Johnson BP, Moore KA, Osterholm MT et al. 1999. Quinolone-resistant*Camplybacter jejuni* infections. *New England Journal of Medicine*, 340(20): 1525-1532. At: **http://loyce2008.free.fr/Microbiologie /diarrh%E9es%20infectieuses/Campylobacter/bla.pdf**

12 Food and Water Watch. 2012. *Antibiotic Resistance 101: How Antibiotic Misuse on Factory Farms Can Make You Sick.* 21pp. At: **http://documents.foodandwaterwatch.org/doc/AntibioticResistance.pdf**

13 Consumer Reports, 2007. Dirty Birds. January 2007, pp. 20-23. Consumers Union.

14 Consumer Reports, 2010. How safe is That Chicken. January 2010, pp. 19-23. Consumers Union.

15 Centers for Disease Control (CDC). 2011. Investigation Update: Multistate Outbreak of Human *Salmonella* Heidelberg Infections Linked to Ground Turkey. At: **http://www.cdc.gov/salmonella/heidelberg/111011/index.html**

16 CDC. 2012. Investigation Update: Multistate Outbreak of Human *Salmonella* Typhimurium infections Linked to Ground Beef. At: **www.cdc.gov/salmonella/typhimurium-groundbeef/010512/index.html**

17 Price LB, Graham JP, Lackey LG, Roess A, Vailers R and E Silbergeld. 2007. Elevated risk of carrying gentamicin-resistant *Escherichia coli* among U.S. poultry workers. *Environmental Health Perspectives*, 115(12): 1738-1742. At: **http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2137113 /pdf/ehp0115-001738.pdf**

18 Smith TC, Male MJ, Harper AL, Kroeger JS, Tinkler GP, Moritz ED, Capuano AW, Herwalt LA and DJ Diekema. 2009. Methicillin-resistant*Staphylococcus aureus* (MRSA) strain ST398 is present in midwestern U.S. swine and swine workers. *PLoS One*, 4(1): e4258. At:**http://www.plosone.org/article/info:doi /10.1371/journal.pone.0004258**

19 Price LB, Stegger M, Hasman H, Aziz M, Larsen J, Andersen PS, Pearson T, Waters AE, Foster JT et al. 2012. *Staphylococcus aureus* CC398: Host adaptation and emergence of methicillin resistance in livestock. *mBio*, 3(1): e00305-11 At: **http://mbio.asm.org/content/3/1/e00305-11.full.pdf**

20 van Loo I, Huijsdens X, Tiemersma E, de Neeling A, van de Sande-Bruinsma N, Beaujean D, Voss A and J Kluytmans. 2007. Emergence of methicillin-resistant *Staphylococcus aureus* of animal origin in humans. *Emerging Infectious Diseases*, 13(12): 1834-1839. At:

21 Chee-Sanford JC, Mackie RI, Koike S, Krapac IG, Lin Y-F, Yannarell AC, Maxwell S and RI Aminov. 2009. Fate and transport of antibiotic residues and antibiotic resistance genes following land application of manure waste. *Journal of Environmental Quality*, 38(3): 1086-1108. At:**https://www.crops.org /publications/jeq/articles/38/3/1086**

22 Rule AM, Evans SL and EK Silbergeld. 2008. Food and animal transport a potential source of community exposure to health hazards from industrial farming (CAFOs). *Journal of Infection and Public Health*, 1(1): 33-39.

At:http://www.academia.edu/591772
/Food_animal_transport_a_potential_source_of_community_exposures_to_health_hazards_from_industrial_farmi

23 Gibbs SG, Green CF, Tarwater PM, Mota LC, Mena KD and PV Scarpino. 2006. Isolation of antibiotic-resistant bacteria from the air plume downwind of a swine confined or concentrated animal feeding operation. *Environmental Health Perspectives*, 114(7): 10323-1037. At:http://www.ncbi.nlm.nih.gov /pmc/articles/PMC1513331/pdf/ehp0114-001032.pdf

24 Graham JP, Price LB, Evans SE, Graczyk TK and EK Silbergeld. 2009. Antibiotic-resistant Enterococci and Staphylococci isolated from flies collected near confined poultry feeding operations. *Science of the Total Environment*, 407(8): At: http://www.jhsph.edu/sebin/q/h/AntibioticResistantEntero.pdf

25 Pruden A, Arabi M and HN Storteboom. 2012. Correlation between upstream human activities and riverine antibiotic resistance genes. *Environmental Science & Technology*, dx.doi.org/10.1021/es302657r At: http://pubs.acs.org/doi/abs/10.1021/es302657r

26 Marshall BM and SB Levy. 2011. Food animals and antimicrobials: impacts on human health. *Clinical Microbiology Reviews*, 24(4): 718-733. At:http://cmr.asm.org/content/24/4/718.full.pdf

27 Houlihan AJ and JB Russell. 2003. The susceptibility of ionophores-resistant *Clostridium aminophilum* F to other antibiotics. *Journal of Antimicrobial Chemotherapy*, 52: 623-628. At: http://jac.oxfordjournals.org/content /52/4/623.full.pdf

28 Pg. 627 in Ibid.

29 http://www.keepantibioticsworking.com/new/KAWfiles/64_2_36325.pdf

30 http://www.keepantibioticsworking.com/new/Library/UploadedFiles /American_Public_Health_Association_Policy_Numb.htm

31 http://www.keepantibioticsworking.com/new/KAWfiles/64_2_37751.pdf

32 http://www.keepantibioticsworking.com/new/KAWfiles/64_2_107287.pdf

33 Pg. 10 in http://www.who.int/drugresistance /WHO%20Global%20Strategy%20-%20Executive%20Summary%20-%20English%20version.pdf

Related

Consumer Representatives Issue Recommendations For State And Federal Policymakers On Improving Prescription Drug Access For Consumers
August 26, 2016

Consumer and Auto Safety Groups Call for Non-Commercial Use of the Auto-Safety Spectrum and Strong Privacy and Security Protections
August 25, 2016

Consumers Union files comments in strong support of CFPB rule to limit use of forced arbitration clauses against consumers
August 22, 2016

Phone Industry Robocall Strike Force Announces Plans for Tackling Unwanted Calls
August 19, 2016

Storteboom, H., Mazdak, A., Davis, J.G., Crimi, B. and Pruden, A.: Tracking Antibiotic Resistance Genes in the South Platte River Basin Using Molecular Signatures of Urban, Agricultural, And Pristine Sources. Environ. Sci. Technol., 2010, 44 (19), pp 7397–7404

Abstract

A novel approach utilizing antibiotic-resistance-gene (ARG) molecular signatures was applied to track the sources of ARGs at sites along the Cache la Poudre (Poudre) and South Platte Rivers in Colorado. Two lines of evidence were employed: (1) detection frequencies of 2 sulfonamide and 11 tetracycline ARGs and (2) tet(W) phylotype and phylogenetic analysis. A GIS database indicating the locations of wastewater treatment plants (WWTPs) and animal feeding operations (AFOs) in the watershed was also constructed to assess congruence of the surrounding landscape with the putative sources identified by ARG molecular signatures. Discriminant analysis was performed on detection frequencies of tetARG groups that were previously identified to be associated with either WWTPs or AFOs. All but one (South Platte River-3, just downstream from the confluence with the Poudre River) of the eight sites were classified as primarily WWTP-influenced based on discriminant analysis of ARG detection frequencies. tet(W) phylotype analysis also aligned South Platte River-3 with putative AFO sources, while phylogenetic analysis indicated that it was not significantly different from the AFOs or WWTPs investigated. South Platte River-3 is situated in an intense agricultural area, but the upstream portion of the South Platte River receives substantial loading from metropolitan Denver. By contrast, tet(W) phylotype and phylogenetics of site Poudre River-4, located 4 km downstream of a WWTP, was also characterized and found to be significantly different from the AFO lagoons ($p < 0.05$), as expected. In general, a good correspondence was found between classification of the impacted river sites and the surrounding landscape. While the overall approach could be extended to other watersheds, the general findings indicate that transport of ARGs from specific sources is likely the dominant mechanism for ARG proliferation in this riverine environment relative to selection of ARGs among native bacteria by antibiotics and other pollutants.

Pruden, A., Mazdak, A., and Storteboom, H.: Correlation Between Upstream Human Activities and Riverine Antibiotic Resistance Genes. Environ. Sci. Technol., 2012, 46 (21), pp 11541–11549

Abstract

Antimicrobial resistance remains a serious and growing human health challenge. The water environment may represent a key dissemination pathway of resistance elements to and from humans. However, quantitative relationships between landscape features and antibiotic resistance genes (ARGs) have not previously been identified. The objective of this study was to examine correlations between ARGs and putative upstream anthropogenic sources in the watershed. sul1 (sulfonamide) and tet(W) (tetracycline) were measured using quantitative polymerase chain reaction in bed and suspended sediment within the South Platte River Basin, which originates from a pristine region in the Rocky Mountains and runs through a gradient of human activities. A geospatial database was constructed to delineate surface water pathways from animal feeding operations, wastewater treatment plants, and fish hatchery and rearing units to river monitoring points. General linear regression models were compared. Riverine sul1 correlated with upstream capacities of animal feeding operations ($R(2) = 0.35$, $p < 0.001$) and wastewater treatment plants ($R(2) = 0.34$, $p < 0.001$). Weighting for the inverse distances from animal feeding operations along transport pathways strengthened the observed correlations ($R(2) = 0.60\text{-}0.64$, $p < 0.001$), suggesting the importance of these pathways in ARG dissemination. Correlations were upheld across the four sampling events during the year, and averaging sul1 measurements in bed and suspended sediments over all events yielded the strongest correlation ($R(2) = 0.92$, $p < 0.001$). Conversely, a significant relationship with landscape features was not evident for tet(W), which, in contrast to sul1, is broadly distributed in the pristine region and also relatively more prevalent in animal feeding operation lagoons. The findings highlight the need to focus attention on quantifying the contribution of water pathways to the antibiotic resistance disease burden in humans and offer insight into potential strategies to control the spread of ARGs.

Antibiotic-Resistant Enterococci and Fecal Indicators in Surface Water and Groundwater Impacted by a Concentrated Swine Feeding Operation

Amy R. Sapkota,[1,2] Frank C. Curriero,[1,3] Kristen E. Gibson,[1] and Kellogg J. Schwab[1]

[1]Department of Environmental Health Sciences, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA; [2]Maryland Institute for Applied Environmental Health, College of Health and Human Performance, University of Maryland, College Park, Maryland, USA; [3]Department of Biostatistics, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA

Background: The nontherapeutic use of antibiotics in swine feed can select for antibiotic resistance in swine enteric bacteria. Leaking swine waste storage pits and the land-application of swine manure can result in the dispersion of resistant bacteria to water sources. However, there are few data comparing levels of resistant bacteria in swine manure–impacted water sources versus unaffected sources.

Objectives: The goal of this study was to analyze surface water and groundwater situated up and down gradient from a swine facility for antibiotic-resistant enterococci and other fecal indicators.

Methods: Surface water and groundwater samples (n = 28) were collected up and down gradient from a swine facility from 2002 to 2004. Fecal indicators were isolated by membrane filtration, and enterococci (n = 200) were tested for susceptibility to erythromycin, tetracycline, clindamycin, virginiamycin, and vancomycin.

Results: Median concentrations of enterococci, fecal coliforms, and *Escherichia coli* were 4- to 33-fold higher in down-gradient versus up-gradient surface water and groundwater. We observed higher minimal inhibitory concentrations for four antibiotics in enterococci isolated from down-gradient versus up-gradient surface water and groundwater. Elevated percentages of erythromycin- (p = 0.02) and tetracycline-resistant (p = 0.06) enterococci were detected in down-gradient surface waters, and higher percentages of tetracycline- (p = 0.07) and clindamycin-resistant (p < 0.001) enterococci were detected in down-gradient groundwater.

Conclusions: We detected elevated levels of fecal indicators and antibiotic-resistant enterococci in water sources situated down gradient from a swine facility compared with up-gradient sources. These findings provide additional evidence that water contaminated with swine manure could contribute to the spread of antibiotic resistance.

Key words: antibiotic resistance, CAFO, concentrated swine feeding operation, *E. coli*, enterococci, fecal coliforms, fecal indicators, groundwater, surface water. *Environ Health Perspect* 115:1040–1045 (2007). doi:10.1289/ehp.9770 available via *http://dx.doi.org/* [Online 22 March 2007]

In 2005, the United States produced > 103 million pigs at 67,000 production facilities [U.S. Department of Agriculture (USDA) 2006a, 2006b]. Facilities housing > 55,000 pigs accounted for more than half of the total U.S. swine inventory, reflecting the increasing consolidation and concentration of U.S. swine production (USDA 2006a). This trend in swine production has resulted in the concentration of large volumes of manure in relatively small geographic areas. Manure is typically stored in deep pits or outdoor lagoons and then applied to agricultural fields as a source of fertilizer. However, as a result of runoff and percolation events, components of manure, including human pathogens and chemical contaminants, can affect surface water and groundwater proximal to swine concentrated animal feeding operations (CAFOs), posing risks to human health (Anderson and Sobsey 2006; Campagnolo et al. 2002; Jongbloed and Lenis 1998; Krapac et al. 2002; Sayah et al. 2005; Thurston-Enriquez et al. 2005). Specific swine production practices, including the use of nontherapeutic levels of antibiotics in swine feed, can exacerbate the risks associated with exposures to manure-contaminated water sources.

An estimated 10.3 million pounds of antibiotics are used annually in U.S. swine production for nontherapeutic purposes such as promoting growth and improving feed efficiency (Mellon et al. 2001). These antibiotics are the same drugs that are used in human clinical medicine and include tetracycline, erythromycin, lincomycin, virginiamycin, and ampicillin, to name a few [U.S. Food and Drug Administration (FDA) 2004]. The practice of administering nontherapeutic levels of antibiotics in swine feed selects for antibiotic resistance among commensal and pathogenic bacteria in swine (Aarestrup et al. 2000; Bager et al. 1997; Wegener 2003), resulting in high levels of resistant bacteria and resistance genes in swine waste (Chee-Sanford et al. 2001; Haack and Andrews 2000; Parveen et al. 2006). Haack and Andrews (2000) detected 1.6×10^7 colony forming units (CFU)/mL of total tetracycline-resistant bacteria and 2.1×10^5 CFU/mL of tetracycline-resistant enterococci in swine waste. Parveen et al. (2006) identified resistance to at least one antibiotic in 85% of *Escherichia coli* isolates recovered from a swine lagoon. In addition, Chee-Sanford et al. (2001) detected up to eight known tetracycline resistance genes in total DNA extracted from swine lagoon samples. In the same study, a broad range of tetracycline resistance determinants were found in groundwater samples collected downstream of swine lagoons (Chee-Sanford et al. 2001). Anderson and Sobsey (2006) also detected higher percentages of antibiotic-resistant *E. coli* in groundwater collected in the vicinity of large-scale swine facilities compared with groundwater collected at reference sites. In another study, Sayah et al. (2005) found that 80.6% of *E. coli* isolates collected from surface waters located near swine and other livestock facilities were resistant to at least one antibiotic.

The presence of swine-associated resistant bacteria in rural surface water and groundwater sources is important to human health because exposure to these sources could enable the transfer of resistant bacteria from swine to humans, contributing to the spread and persistence of antibiotic resistance. However, beyond the studies of Chee-Sanford et al. (2001), Anderson and Sobsey (2006), and Sayah et al. (2005), there are few data in the published literature regarding the presence of antibiotic-resistant bacteria in surface waters and groundwater located in the vicinity of swine CAFOs. Moreover, there are few data available comparing concentrations of fecal indicators in groundwater and surface waters impacted by swine CAFOs compared with unaffected waters. Thus, the goal of this study was to analyze surface water and groundwater samples collected up gradient and down gradient from a swine CAFO for the presence of antibiotic-resistant enterococci. Enterococci are commensal bacteria (as

Address correspondence to A.R. Sapkota, Maryland Institute for Applied Environmental Health, College of Health and Human Performance, University of Maryland, College Park, 2310 HHP Building, College Park, MD 20742 USA. Telephone: (301) 405-2438. Fax: (301) 405-8397. E-mail: amy@amysapkota.com

We thank the neighbors of the swine facility who kindly provided access to their properties, surface water sources, and groundwater sources.

This research was funded by The Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health. A.R.S. was a Howard Hughes Medical Institute Predoctoral Fellow during this research.

The authors declare they have no competing financial interests.

Received 29 September 2006; accepted 22 March 2007.

well as opportunistic pathogens) that are found in the intestinal tracts of animals and humans and are often used as indicators of fecal contamination in water sources [U.S. Environmental Protection Agency (U.S. EPA) 2000]. The presence of other fecal indicators, including fecal coliforms and *E. coli,* was also investigated in surface water and groundwater samples collected throughout this study.

Materials and Methods

Study site. This study was conducted around a swine finishing CAFO located in a rural area in the Mid-Atlantic United States (Figure 1). The CAFO is composed of two tunnel-ventilated swine houses, and the full day-to-day capacity of the entire facility is 5,000 hogs. However, throughout the sampling period, approximately 3,000 hogs were present at the facility. Manure wastes from the CAFO are stored in 12-ft deep concrete manure pits that lie beneath each swine house. Once the pits are filled to maximum capacity, the waste is siphoned off and applied to agricultural fields both on-site (Figure 1) and off-site. At this facility, nontherapeutic levels of antibiotics are administered in swine feed; however, specific usage data could not be obtained from the swine grower.

Sample collection. Surface water and groundwater samples were collected during six sampling trips that took place between 2002 and 2004 (Table 1). A total of 15 surface water samples were collected from three locations situated down gradient from the swine CAFO, and a total of 4 surface water samples were recovered from one location situated up gradient from the swine CAFO (Figure 1). As indicated in Figure 1, the down-gradient surface water sampling locations were situated in a stream system that was likely affected by surface water runoff events from the swine CAFO. Sampling locations on two different, connecting tributaries in this stream system were chosen in order to determine the impacts of the swine CAFO on both of these tributaries. Down-gradient surface water samples were collected only when there was adequate flow at a sampling location such that water samples could be collected into 1-L sampling bottles in an upstream motion, midway between the surface and the stream bottom, without disturbing bottom sediment. We were unable to obtain access to an up-gradient surface water sampling location situated within the same stream system because *a*) we could not penetrate dense and deep thickets that completely surrounded the stream (on accessible property) without making major modifications to existing vegetation; or *b*) we were not allowed access to personal property farther upstream. Because of these challenges, we identified an up-gradient pond located on accessible property (Figure 1) to serve as an up-gradient surface water control site that was not affected by the swine CAFO.

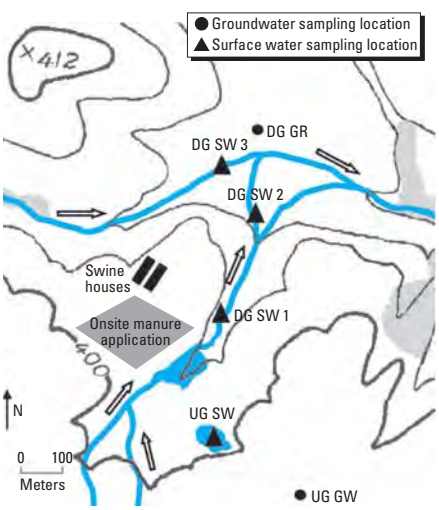


Figure 1. Map of study site and sampling locations. Abbreviations: DG GR, down-gradient groundwater sampling location; DG SW 1, first down-gradient surface water sampling location; DG SW 2, second down-gradient surface water sampling location; DG SW 3, third down-gradient surface water sampling location; UG GW, up-gradient groundwater sampling location; UG SW, up-gradient surface water sampling location. Topographic contour lines are given in feet, and contour intervals = 20 vertical ft. Arrows indicate the direction of surface water flow. Topographic data were obtained from a U.S. Geological Survey map of the study area (U.S. Geological Survey 2006).

Groundwater samples were collected from one drinking water well situated down gradient from the swine CAFO (n = 4) and one drinking water well situated up gradient from the swine CAFO (n = 5) (Figure 1). Both wells are located in the Piedmont Plateau Province of the Mid-Atlantic United States in an area characterized by unmetamorphosed bedrock composed of red shale. The up-gradient well was constructed in 1990 and is used as a primary source of drinking water by the property owners. It is 250 ft deep and lined with steel casing to a depth of 56 ft. Water is encountered at depths of 185 ft and 228 ft. The down-gradient well is an older well that was used as a primary source of drinking water by the property owners before the neighboring swine CAFO was built. Information on the precise depth and construction of this well was unavailable; however, groundwater on the property is encountered at depths of approximately 90 ft and 132 ft. None of the wells were subject to any disinfection before sampling; at each well, water was flushed for 1 min before groundwater samples were collected.

A manure pit sample was collected directly from the manure pits during one sampling trip in January 2004. All surface water, groundwater, and manure pit samples were collected in 1-L sterile Nalgene Wide Mouth Environmental Sample Bottles (Nalgene, Lima, OH); labeled; and transported back to the laboratory at 4°C. Sample processing took place within 3–6 hr after sample collection.

Isolation and enumeration of fecal indicators. *Enterococcus* spp., *E. coli*, and fecal coliforms were isolated from each water sample using standard membrane filtration methods: U.S. Environmental Protection Agency (EPA) Method 1106.1 and Method 1103 (U.S. EPA 2000), and standard method SM 9222D [American Public Health Association (APHA) 1998]. Briefly, 10-fold dilutions of each water sample were prepared (10^0, 10^{-1}, 10^{-2}, and 10^{-3}), and 10 mL of each dilution were filtered through 0.45-µm, 47-mm mixed cellulose ester filters (Millipore, Billerica, MA), which were placed onto appropriate agar plates. We used mE agar for the detection and enumeration of *Enterococcus* spp., mTEC agar for the detection of *E. coli*, and mFC agar for the detection of fecal coliforms (all from Becton Dickinson, Sparks, MD). Negative control filters and negative control agar plates were included in each membrane filtration analysis. Incubation conditions for the agar plates were as follows: mE plates, 41.5°C for 48 hr; mTEC plates, 35°C for 2 hr followed by 44.5°C for 22 hr; and mFC plates, 44.5°C for 24 hr. After 24 hr, membrane filters from mTEC agar plates were placed in 1.2 mL urea for 5 min; bright yellow colonies were considered presumptive *E. coli*. Blue colonies arising on the mFC agar plates were considered presumptive fecal coliforms. After 48 hr, membrane filters from mE agar plates were placed on esculin iron agar (EIA) plates and incubated at 41.5°C for 20 min. Colonies characteristic of *Enterococcus* spp., ranging from pink to dark red on mE agar and producing a brown to black precipitate on EIA agar, were considered presumptive *Enterococcus* spp.

Table 1. Sampling dates, sampling locations, and number of samples collected.

				DG SW			
Sampling date	UG GW	DG GW	UG SW	Site 1	Site 2	Site 3	Manure pit
29 Sep 2002					1		
31 Mar 2003	1			1	1	1	
11 Jun 2003	1	1	1	1	1	1	
24 Jun 2003	1	1	1	1	1	1	
30 Jul 2003	1	1	1		1	1	
6 Jan 2004	1	1	1	1	1	1	1

Abbreviations: DG, down gradient; GW, groundwater; SW, surface water; UG, up gradient.

(U.S. EPA 2000). All resulting colonies were counted, and concentrations of *Enterococcus* spp., *E. coli,* and fecal coliforms per 100 mL water were determined from dilution plates containing 30–300 CFU using back calculations. One to 10 presumptive *Enterococcus* spp. recovered from each sample were archived in tryptic soy broth with 20% glycerol at –80°C for additional analyses.

Identification of* Enterococcus *spp. Presumptive *Enterococcus* spp. (n = 200) were identified to the species level using isolation and identification procedures described previously (Chapin et al. 2005; Murray et al. 2003). *Enterococcus faecalis* 29212 and *Enterococcus faecium* 19434 (American Type Culture Collection, Manassas, VA) were included as quality control strains. Briefly, all isolates and control strains were streaked from –80°C archived stocks onto tryptic soy agar No. 2 amended with 5% defibrinated sheep blood (Quad Five, Ryegate, MT), and incubated for 24 hr at 37°C. Gram-positive cocci were verified by Gram stains, and the production of catalase was tested for each isolate in the presence of 3% hydrogen peroxide. All isolates were negative for catalase activity and were further tested for pyrolidonyl-arylamidase (PYRase) activity using Remel's PYR kit (Remel, Lenexa, KY). All isolates were also PYRase-positive and were distinguished further by testing for the reduction of tellurite. Isolates and quality control strains were streaked from –80°C archived stocks onto nutrient agar with 0.4% potassium tellurite (Sigma-Aldrich Corp., St. Louis, MO) and incubated for 24–72 hr at 37°C. Isolates producing a black precipitate were considered positive for tellurite reduction and identified as *E. faecalis*. The remaining isolates were identified using the following standard biochemical tests: lactose, sucrose, arabinose, sorbitol, raffinose, and mannitol carbohydrate fermentation; deamination of arginine; methyl-α-D-glucopyranoside acidification; utilization of pyruvate; and pigmentation of the isolate.

Antimicrobial susceptibility testing. We used the minimal inhibitory concentration (MIC) agar dilution method [Clinical and Laboratory Standards Institute (CLSI) 2002] to test antimicrobial susceptibility among the *Enterococcus* spp. (n = 200). *E. faecalis* 29212 was included as the quality control reference strain. We tested susceptibility to the following antibiotics: erythromycin, clindamycin, tetracycline, and virginiamycin (streptogramin A and B combination), all of which are approved for use in U.S. swine production (FDA 2004); and vancomycin, which has never been approved for use in U.S. livestock. All antibiotics were obtained from Sigma-Aldrich (St. Louis, MO), except for virginiamycin, which was purchased from Research Products International Corp. (Mt. Prospect, IL). The following concentrations of antibiotics were tested: 0.5–256 µg/mL erythromycin, 0.5–256 µg/mL tetracycline, 0.03–256 µg/mL clindamycin, 0.03–64 µg/mL virginiamycin, and 0.03–64 µg/mL vancomycin. These antibiotic test ranges were chosen to include the MIC quality control ranges of the reference strain (*E. faecalis* 29212), the antibiotic resistance break points established by the CLSI for enterococci (CLSI 2002), and antibiotic concentrations that exceeded resistance break points by at least 2-fold.

In preparation for the MIC agar dilution tests, all *Enterococcus* spp. isolates were streaked onto plates containing tryptic soy agar No. 2 amended with 5% defibrinated sheep blood (QuadFive, Rygate, MT), and incubated at 37°C for 24 hr. Each isolate was then suspended in 3 mL Mueller-Hinton broth and adjusted to a 0.5 McFarland standard using a Vitek colorimeter (Hach, Loveland, CO). Two hundred microliters of each suspension were loaded into individual wells within a Cathra replicator plate (Oxoid Inc., Ogdensburg, NY) and replicated onto a series of Mueller-Hinton agar plates amended with 2-fold increasing antibiotic concentrations. Plates were incubated at 37°C for 24 hr, and MICs were subsequently recorded as the minimum concentration of antibiotic that completely inhibited growth. Each isolate was categorized using the following MIC resistance breakpoints established for *Enterococcus* spp. by the CLSI (2002): erythromycin, ≥ 8 µg/mL; clindamycin, ≥ 4 µg/mL; tetracycline, ≥ 16 µg/mL; virginiamycin, ≥ 4 µg/mL; and vancomycin ≥ 32 µg/mL.

Statistical analyses. We compared concentrations of fecal indicators (*Enterococcus* spp., *E. coli,* and fecal coliforms) between up-gradient and down-gradient surface water samples and up-gradient and down-gradient groundwater samples using two-sample Wilcoxon rank-sum tests. Fisher's exact tests were used to compare rates of erythromycin-, tetracycline-, clindamycin-, virginiamycin-, and vancomycin-resistant *Enterococcus* spp. between up-gradient and down-gradient surface water samples and up-gradient and down-gradient groundwater samples. For the surface water analyses, data obtained from the three surface water sampling locations situated down gradient from the swine CAFO were pooled because these sites did not represent a significant source of variation in the data. Specifically, levels of fecal indicators, patterns of antimicrobial resistance, and geographic proximity were comparable among all samples obtained from these locations (data not shown), providing evidence for a shared source. Since *E. faecalis* can be intrinsically resistant to clindamycin and virginiamycin (Singh and Murray 2005), analyses

Table 2. Concentrations (CFU/100 mL) of fecal indicators in up-gradient (n = 4) and down-gradient (n = 15) surface water samples and up-gradient (n = 5) and down-gradient (n = 4) groundwater samples collected in the proximity of a swine CAFO.

Sample type and bacteria	Up-gradient samples [median (range)][a]	Down-gradient samples [median (range)][a]	p-Value[b]
Surface water			
Enterococcus spp.	35 (1–100)	610 (150–4,700)	0.003
E. coli	35 (0–40)	400 (10–3,500)	0.007
Fecal coliforms	15 (0–70)	500 (18–2,400)	0.010
Groundwater			
Enterococcus spp.	18 (0–67)	85 (16–140)	0.085
E. coli	0 (0)[c]	11.5 (3–40)	0.007
Fecal coliforms	0 (0)[c]	20.5 (3–70)	0.007

[a]Median and range summaries are reported to match more consistently with the nonparametric statistical tests performed. [b]p-Values were calculated using the two-sample Wilcoxon rank-sum test. [c]No *E. coli* or fecal coliforms were detected in these samples on any sampling trip.

Table 3. *Enterococcus* spp. isolated from groundwater, surface water, or manure pits located around or beneath a swine CAFO.

Enterococcus spp. source	No. of isolates (%)
Up-gradient groundwater	30 (15)
E. faecalis	12 (6)
E. pallens	1 (0.5)
Other *Enterococcus* spp.	17 (8.5)
Down-gradient groundwater	26 (13)
E. faecalis	21 (10.5)
E. faecium	1 (0.5)
E. gallinarum	1 (0.5)
E. raffinosus	1 (0.5)
E. sulfureus	1 (0.5)
Other *Enterococcus* spp.	1 (0.5)
Up-gradient surface water	22 (11)
E. avium	1 (0.5)
E. faecalis	14 (7)
E. faecium	2 (1)
E. hirae	1 (0.5)
E. raffinosus	1 (0.5)
Other *Enterococcus* spp.	3 (1.5)
Down-gradient surface water	107 (53.5)
E. casseliflavus	1 (0.5)
E. dispar	1 (0.5)
E. durans	5 (2.5)
E. faecalis	80 (40)
E. faecium	12 (6)
E. pallens	1 (0.5)
Other *Enterococcus* spp.	7 (3.5)
Manure pit	15 (7.5)
E. faecalis	7 (3.5)
E. hirae	5 (2.5)
E. mundtii	1 (0.5)
E. sulfureus	1 (0.5)
Other *Enterococcus* spp.	1 (0.5)
Total	200 (100)

comparing rates of clindamycin resistance and virginiamycin resistance were restricted to non–*E. faecalis* isolates. All statistical analyses were performed using Intercooled Stata 7.0 (Stata Corporation, College Station, TX).

Results

Concentrations of fecal indicators. Median concentrations of *Enterococcus* spp., *E. coli,* and fecal coliforms were 17-, 11- and 33-fold higher, respectively, in surface waters located down gradient of the swine CAFO compared with surface waters located up gradient of the CAFO; the differences were statistically significant (p = 0.003, 0.007, and 0.010, respectively) (Table 2). Likewise, median concentrations of *Enterococcus* spp., *E. coli,* and fecal coliforms were 4-, 11-, and 20-fold higher, respectively, in down-gradient groundwater samples versus up-gradient groundwater samples (p = 0.085, 0.007, and 0.007, respectively) (Table 2). Concentrations of *Enterococcus* spp., *E. coli,* and fecal coliforms found in manure pit samples were 5.2×10^5 CFUs/100 mL, 1.0×10^6 CFUs/100 mL, and 8.8×10^6 CFUs/100 mL, respectively.

Enterococcus spp. isolated from water and manure pit samples. A variety of *Enterococcus* spp. was identified in groundwater, surface water, and manure pit samples (Table 3). *E. faecalis* was the predominant species isolated from all sample types, representing 67% of all *Enterococcus* spp. that were analyzed for antibiotic susceptibility in this study. For 29 (14.5%) of the *Enterococcus* spp., results from the standard biochemical identification tests were not completely consistent with known species of enterococci. These isolates could only be identified to the genus level and are listed as "other *Enterococcus* spp." in Table 3.

Antibiotic resistance. Overall, higher erythromycin and tetracycline MICs were detected among *Enterococcus* spp. (*E. faecalis* and non–*E. faecalis*) recovered from down-gradient groundwater and surface water samples compared with up-gradient groundwater and surface water samples (Table 4). For example, erythromycin MIC_{90s} (MIC required to inhibit the growth of 90% of organisms) for *Enterococcus* spp. recovered from down-gradient groundwater and surface water samples were at least 4-fold and 128-fold higher, respectively, than that of isolates recovered from up-gradient groundwater and surface water samples. These data suggest that down-gradient surface water and groundwater sources are contaminated with *Enterococcus* spp. that express higher levels of erythromycin and tetracycline resistance. The highest erythromycin and tetracycline MICs were observed among *Enterococcus* spp. recovered from manure pits, where erythromycin and tetracycline MIC_{90s} were > 256 µg/mL and 179.2 µg/mL, respectively (Table 4). In contrast, MICs for vancomycin, a drug that has never been approved for use in U.S. swine production, were generally below the CLSI vancomycin resistance breakpoint of ≥ 32 µg/mL (CLSI 2002) among *Enterococcus* spp. recovered from all sample types. The exceptions were isolates recovered from up-gradient groundwater samples, which exhibited elevated vancomycin MICs (Table 4).

Similar to the findings for erythromycin and tetracycline, higher clindamycin and virginiamycin MICs were observed among non–*E. faecalis* isolates recovered from down-gradient groundwater and surface water samples compared with up-gradient groundwater and surface water samples (Table 5). For instance, clindamycin MIC_{90s} for non–*E. faecalis* isolated from down-gradient groundwater and surface water samples were at least 2,133-fold and 2-fold higher, respectively, than that of non–*E. faecalis* recovered from up-gradient groundwater and surface water samples. The highest clindamycin and virginiamycin MICs were observed among isolates recovered from manure pits (Table 5). As anticipated, clindamycin and virginiamycin MICs among *E. faecalis*—which have been shown to be intrinsically resistant to both of these antibiotics (Singh and Murray 2005)—were similar among isolates recovered from all sample types, except in the case of *E. faecalis* recovered from manure pits. These isolates exhibited higher levels of both clindamycin and virginiamycin resistance (Table 5).

In comparing the percentage of antibiotic-resistant *Enterococcus* spp. present in up-gradient versus down-gradient surface water samples, higher percentages of erythromycin-, tetracycline-, virginiamycin-, and vancomycin-resistant isolates were observed in down-gradient versus up-gradient surface waters (Table 6). In contrast, we observed a higher percentage of clindamycin-resistant isolates in up-gradient surface water samples. However, using Fisher's exact test, we found that only the elevated percentage of erythromycin-resistant isolates found in down-gradient surface water samples was statistically significant (p = 0.02) (Table 6). The higher percentage of tetracycline-resistant isolates observed in down-gradient surface water samples was marginally significant (p = 0.06) (Table 6).

In groundwater samples, higher percentages of tetracycline- and clindamycin-resistant *Enterococcus* spp. were observed in down-gradient versus up-gradient groundwater samples (Table 6). The elevated percentage of clindamycin-resistant isolates in down-gradient groundwater samples was highly statistically significant (p < 0.001), whereas the higher percentage of tetracycline-resistant isolates in down-gradient groundwater samples was marginally significant (p = 0.07) (Table 6). Conversely, higher percentages of erythromycin- and vancomycin-resistant *Enterococcus* spp. were observed in up-gradient versus down-gradient groundwater samples, and the differences in erythromycin resistance were statistically significant (p < 0.001).

Discussion

In this study we investigated surface water and groundwater located up gradient and down gradient of a swine CAFO for the presence of fecal indicators (*Enterococcus* spp., *E. coli,* and fecal coliforms) and antibiotic-resistant enterococci. Findings indicate that surface waters and groundwater located down gradient of the swine CAFO are contaminated with significantly higher levels of *Enterococcus* spp., *E. coli,* and fecal coliforms compared with surface water and groundwater located up gradient of the swine CAFO (Table 2). The groundwater data are in agreement with two previous studies that examined groundwater wells situated near large-scale swine facilities (Anderson and Sobsey 2006; Krapac et al. 2002). Anderson and Sobsey (2006) detected *E. coli* at a range of 0.5–32.7 CFU/100 mL in groundwater samples collected at two large-scale swine facilities in North Carolina. Krapac et al. (2002) detected fecal coliforms at a maximum concentration of 7 CFU/100 mL in shallow groundwater samples collected at a swine finishing facility in Illinois. In addition, Krapac et al.

Table 4. MIC data (µg/mL) for erythromycin, tetracycline, and vancomycin among *Enterococcus* spp. isolated from groundwater, surface water, or manure pits.

	Erythromycin[a]			Tetracycline[a]			Vancomycin[a]		
Enterococcus spp. source	MIC_{50}	MIC_{90}	MIC range	MIC_{50}	MIC_{90}	MIC range	MIC_{50}	MIC_{90}	MIC range
Up-gradient groundwater (n = 30)	16	60.8	1–128	< 1	< 1	< 1–32	0.25	58	0.25–> 64
Down-gradient groundwater (n = 26)	2	> 256	< 0.5–> 256	2	64	< 1–> 256	4	8	0.25–8
Up-gradient surface water (n = 22)	1	2	< 0.5–4	< 1	108.8	< 1–128	2	8	0.5–8
Down-gradient surface water (n = 107)	2	> 256	< 0.5–> 256	2	153.6	< 1–> 256	2	8	0.25–> 64
Manure pit (n = 15)	> 256	> 256	< 0.5–> 256	128	179.2	< 1–> 256	0.5	2	0.5–2

MIC_{50}, MIC required to inhibit the growth of 50% of organisms.
[a]CLSI resistance breakpoints are as follows: erythromycin, ≥ 8 µg/mL; tetracycline, ≥ 16 µg/mL; vancomycin, ≥ 32 µg/mL (CLSI 2002).

(2002) detected fecal streptococcus in more groundwater samples and at higher concentrations than fecal coliforms. Similarly, we identified *E. coli* and fecal coliforms in down-gradient groundwater samples at ranges of 3–40 CFU/100 mL and 3–70 CFU/100 mL, respectively, and *Enterococcus* spp. (members of the fecal streptococcus group) were consistently detected at higher concentrations than fecal coliforms (Table 2). To our knowledge, the surface water data presented here are the first data to compare levels of fecal indicators in up-gradient versus down-gradient surface waters located in the proximity of a swine CAFO.

The presence of *Enterococcus* spp., *E. coli,* and fecal coliforms in rural surface water and groundwater sources impacted by swine CAFOs may pose health risks to people who either recreate in contaminated surface waters or use the groundwater as a drinking water source. Concentrations of *Enterococcus* spp. and *E. coli* in down-gradient surface water samples collected in this study were consistently in excess of the following U.S. EPA bacterial water quality standards for recreational fresh waters: *Enterococcus* spp., 33 CFU/100 mL; and *E. coli*, 126 CFU/100 mL (U.S. EPA 2003). Throughout the sampling period for this study, young children were observed swimming and playing in surface waters located within 500 m down gradient of the swine CAFO; these children could have been exposed to elevated concentrations of *Enterococcus* spp., *E. coli,* and other more harmful microorganisms that may have been present. In addition, if the down-gradient private well tested in this study was part of a public drinking-water-system testing program, it consistently would be in violation of current maximum contaminant level standards for total coliforms (including fecal coliforms and *E. coli*) (U.S. EPA 2002). On each sampling trip, this down-gradient well tested positive for both fecal coliforms and *E. coli.* Before the swine CAFO began production, the owners of this well relied on it as their sole source of drinking water. However, after the facility reached a full working capacity of 5,000 hogs, the owners told us that they had their well tested by an independent, certified laboratory and the water was subsequently deemed nonpotable.

The results of this study also emphasize that human health risks associated with exposures to surface water and groundwater situated down gradient of swine CAFOs could be exacerbated by the presence of antibiotic-resistant bacteria. Overall findings indicate that *Enterococcus* spp. recovered from down-gradient surface water and groundwater samples express higher levels of resistance (higher MICs) to antibiotics that are commonly used in both swine production and human clinical medicine (erythromycin, tetracycline, clindamycin, and virginiamycin) compared with *Enterococcus* spp. recovered from up-gradient surface water and groundwater samples (Tables 4 and 5). In contrast, *Enterococcus* spp. recovered from all sample types (down-gradient water samples, up-gradient water samples, and manure samples) were, in general, similarly susceptible to vancomycin (Table 4), a drug that has never been approved for use in U.S. swine production.

The patterns of antibiotic resistance observed in *Enterococcus* spp. recovered from down-gradient surface water and groundwater samples were similar to those observed in isolates recovered from manure pit samples, particularly resistance patterns associated with erythromycin, tetracycline, and clindamycin (Tables 4 and 5). We also have reported similar patterns of erythromycin, tetracycline, and clindamycin resistance among *Enterococcus* spp. recovered from indoor air samples collected within the same swine CAFO during the same sampling period (Chapin et al. 2005). These data support previous findings of Chee-Sanford et al. (2001) showing that the movement of resistant bacteria and resistance determinants from swine CAFOs into the environment can be extensive. Chee-Sanford et al. (2001) found a high occurrence of tetracycline resistance determinants in groundwater wells located close to swine lagoons; however, they also detected one resistance determinant in a well situated over 250 m downstream of one of the lagoons. In the present study, antibiotic-resistant *Enterococcus* spp. were detected in a drinking water well located 400 m down gradient of a swine CAFO, as well as in surface water situated 300 m down gradient from the facility (Figure 1). The presence of resistant bacteria in both drinking water and surface water sources contaminated by swine CAFOs could contribute to the spread and persistence of both resistant bacteria and antibiotic resistance determinants in humans and the environment.

However, in rural environments, swine CAFOs are not the only potential sources of antibiotic-resistant bacteria. Other sources could include poultry farms, dairy farms, and human sources such as leaking septic tanks and land-applied biosolids. In the present

Table 5. MIC data (µg/mL) for clindamycin and virginiamycin among *E. faecalis* and non–*E. faecalis* isolated from groundwater, surface water, or manure pits

Enterococcus spp. source	Clindamycin[a]			Virginiamycin[a]		
	MIC_{50}	MIC_{90}	MIC range	MIC_{50}	MIC_{90}	MIC range
Up-gradient groundwater						
E. faecalis (*n* = 12)	8	16	0.06–16	1	1	0.5–1
Non–*E. faecalis* (*n* = 18)	< 0.03	0.06	< 0.03–0.06	0.13	0.13	0.06–0.13
Down-gradient groundwater						
E. faecalis (*n* = 21)	8	28.8	0.5–> 128	1	2	1–4
Non–*E. faecalis* (*n* = 5)	8	> 128	4–> 128	0.5	1	0.5–1
Up-gradient surface water						
E. faecalis (*n* = 14)	16	32	8–32	1.5	8	0.5–8
Non–*E. faecalis* (*n* = 8)	16	64	4–64	1	2	0.5–2
Down-gradient surface water						
E. faecalis (*n* = 80)	16	32	0.06–> 128	1	8	0.13–32
Non–*E. faecalis* (*n* = 27)	> 128	> 128	< 0.03–> 128	1	5.6	0.25–8
Manure pit						
E. faecalis (*n* = 7)	128	> 256	64–> 256	8	16	2–16
Non–*E. faecalis* (*n* = 8)	192	> 256	8–> 256	1	32	0.5–32

MIC_{50}, MIC required to inhibit the growth of 50% of organisms.
[a]CLSI resistance breakpoint for clindamycin and virginiamycin is ≥ 4 µg/mL (CLSI 2002).

Table 6. Percentage of antibiotic-resistant *Enterococcus* spp. in up-gradient (*n* = 4) versus down-gradient (*n* = 15) surface water samples and up-gradient (*n* = 5) versus down-gradient (*n* = 4) groundwater samples.

Sample type and antibiotic	Percent resistant		*p*-Value
	Up-gradient samples	Down-gradient samples	
Surface water			
Erythromycin	0	18	0.02
Tetracycline	14	33	0.06
Clindamycin[a]	100	89	0.76
Virginiamycin[a]	0	23	0.17
Vancomycin	0	1	0.83
Groundwater			
Erythromycin	67	20	< 0.001
Tetracycline	3	19	0.07
Clindamycin[a]	0	100	< 0.001
Virginiamycin[a]	0	0	—[b]
Vancomycin	10	0	0.15

p-Values were calculated using one-sided Fisher's exact tests.
[a]Analyses for clindamycin and virginiamycin resistance were restricted to non–*E. faecalis* isolates. [b]No *p*-value could be calculated due to zero counts of virginiamycin-resistant isolates in both sample types.

study, an unexpected finding was that up-gradient groundwater samples that were not impacted by the swine CAFO contained significantly higher percentages of erythromycin-resistant *Enterococcus* spp. compared with down-gradient groundwater samples (Table 6). The levels of erythromycin resistance (MICs) in these isolates were not as high as those observed in *Enterococcus* spp. recovered from down-gradient groundwater samples and manure pit samples (Table 4); however, lower-level erythromycin-resistant *Enterococcus* spp. were still present in significant numbers. After sampling was completed, the owners of this up-gradient well informed us that they had experienced problems with their septic tank and field in the past, and perhaps this may have contributed to the presence of erythromycin-resistant *Enterococcus* spp. in their well. However, the role of possible contamination from their septic tank was not confirmed.

Similarly, we found a slightly higher percentage of clindamycin-resistant non–*E. faecalis* in up-gradient surface water samples compared with down-gradient surface water samples (Table 6). Although the difference was not statistically significant and the levels of clindamycin resistance observed in these isolates were lower than those of non–*E. faecalis* recovered from down-gradient surface water samples and manure samples (Table 5), the presence of resistant non–*E. faecalis* in up-gradient surface water suggests that additional sources of resistant bacteria may exist in this environment. These sources could include human septage, companion animals, wild animals, and migratory waterfowl such as Canada geese (Middleton and Ambrose 2005; Sayah et al. 2005). These findings point to the challenges of identifying pristine, uncontaminated control sites for field studies of water sources located in rural settings, where a variety of agricultural and other human and animal activities can introduce pollutants into the surrounding environment.

Limitations of this study concern sample size and antibiotic usage data. A larger sample size would have provided more statistical power to detect differences in percentages of antibiotic-resistant bacteria present in up-gradient versus down-gradient water samples. Additional samples also would have allowed for statistical analyses regarding seasonal variations in water quality. Beyond sample size, this study would have been enhanced if we had been able to obtain specific antibiotic usage data from the swine grower. Unfortunately, the grower did not have this information because the feed used in this facility was premixed and delivered to the swine CAFO by the contracted integrator, which had deemed antibiotic usage data proprietary information. Instead, we used general FDA data describing the types of antibiotics approved for use in U.S. swine production (FDA 2004) to determine which antibiotics to test in this study. In future studies, we plan to improve the sample design (including sample size) so that statistical analyses can be used to explore spatial and temporal variation in antibiotic-resistant bacteria as it relates to surrounding swine CAFOs. However, the difficulties in obtaining specific antibiotic usage data from swine growers could continue to be a challenge for environmental health researchers in the absence of federal and/or state regulations that require growers or integrators to report these data.

Conclusions

We observed high levels of erythromycin, tetracycline, and clindamycin resistance in *Enterococcus* spp. recovered from surface water and groundwater situated down gradient from a swine CAFO compared with surface water and groundwater located up gradient of the facility. Significantly elevated concentrations of all three fecal indicators tested in this study were also observed in down-gradient surface water and groundwater samples compared with up-gradient surface water and groundwater samples. Although the specific source or sources of these contaminants was not definitively determined, it is likely that swine manure pit leakage or runoff from swine manure–applied fields (Thurston-Enriquez et al. 2005) contributed to these findings. Swine manure management practices, as well as swine feeding practices such as the administration of nontherapeutic levels of antibiotics in swine feeds, continue to pose both environmental and public health challenges, particularly in the immediate environment of swine CAFOs, where vast amounts of swine manure are produced and applied to agricultural fields.

References

Aarestrup FM, Kruse H, Tast E, Hammerum AM, Jensen LB. 2000. Associations between the use of antimicrobial agents for growth promotion and the occurrence of resistance among *Enterococcus faecium* from broilers and pigs in Denmark, Finland, and Norway. Microb Drug Resist 6:63–70.

Anderson ME, Sobsey MD. 2006. Detection and occurrence of antimicrobially resistant *E. coli* in groundwater on or near swine farms in eastern North Carolina. Water Sci Tech 54:211–218.

APHA. 1998. Standard Methods for the Examination of Water and Wastewater. 20th ed. Washington, DC:American Public Health Association.

Bager F, Madsen M, Christensen J, Aarestrup FM. 1997. Avoparcin used as a growth promoter is associated with the occurrence of vancomycin-resistant *Enterococcus faecium* on Danish poultry and pig farms. Prev Vet Med 31:95–112.

Campagnolo ER, Johnson KR, Karpati A, Rubin CS, Kolpin DW, Meyer MT, et al. 2002. Antimicrobial residues in animal waste and water resources proximal to large-scale swine and poultry feeding operations. Sci Total Environ 299:89–95.

Chapin A, Rule A, Gibson K, Buckley T, Schwab K. 2005. Airborne multidrug-resistant bacteria isolated from a concentrated swine feeding operation. Environ Health Perspect 113:137–142.

Chee-Sanford JC, Aminov RI, Krapac IJ, Garrigues-Jeanjean N, Mackie RI. 2001. Occurrence and diversity of tetracycline resistance genes in lagoons and groundwater underlying two swine production facilities. Appl Environ Microbiol 67:1494–1502.

CLSI (Clinical and Laboratory Standards Institute). 2002. Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals; Approved Standard—Second edition. Wayne, PA:National Committee for Clinical Laboratory Standards.

FDA (U.S. Food and Drug Administration). 2004. FDA Approved Animal Drug Products. Blacksburg, VA:Drug Information Laboratory, Virginia/Maryland Regional College of Veterinary Medicine.

Haack BJ, Andrews RE Jr. 2000. Isolation of Tn916-like conjugal elements from swine lot effluent. Can J Microbiol 46:542–549.

Jongbloed AW, Lenis NP. 1998. Environmental concerns about animal manure. J Anim Sci 76:2641–2648.

Krapac IG, Dey WS, Roy WR, Smyth CA, Storment E, Sargent SL et al. 2002. Impacts of swine manure pits on groundwater quality. Environ Pollution 120:475–492.

Mellon M, Benbrook C, Benbrook KL. 2001. Hogging It:! Estimates of Antimicrobial Abuse in Livestock. Cambridge, MA:Union of Concerned Scientists. Available: http://www.ucsusa.org/food_and_environment/antibiotics_and_food/hogging-it-estimates-of-antimicrobial-abuse-in-livestock.html [accessed 15 September 2006].

Middleton JH, Ambrose A. 2005. Enumeration and antibiotic resistance patterns of fecal indicator organisms isolated from migratory Canada geese (*Branta canadensis*). J Wildl Dis 41:334–341.

Murray PR, Baron EJ, Jorgensen JH, Pfaller MA, Yolken RH. 2003. Manual of Clinical Microbiology. 8th ed. Washington, DC:American Society for Microbiology Press.

Parveen S, Lukasik J, Scott TM, Tamplin ML, Portier KM, Sheperd S, et al. 2006. Geographical variation in antibiotic resistance profiles of *Escherichia coli* isolated from swine, poultry, beef and dairy cattle farm water retention ponds in Florida. J Appl Microbiol 10050–10057.

Sayah RS, Kaneene JB, Johnson Y, Miller R. 2005. Patterns of antimicrobial resistance observed in *Escherichia coli* isolates obtained from domestic- and wild-animal fecal samples, human septage, and surface water. Appl Environ Microbiol 71:1394–1404.

Singh KV, Murray BE. 2005. Differences in the *Enterococcus faecalis lsa* locus that influence susceptibility to quinupristin-dalfopristin and clindamycin. Antimicrob Agents Chemother 49:32–39.

Thurston-Enriquez JA, Gilley JE, Eghball B. 2005. Microbial quality of runoff following land application of cattle manure and swine slurry. J Water Health 3:157–171.

USDA. 2006a. Farms, Land in Farms, and Livestock Operations: 2005 Summary. Washington, DC:U.S. Department of Agriculture. Available: http://usda.mannlib.cornell.edu/nass/FarmLandIn/2000s/2005/FarmLandIn-01-31-2005.pdf [accessed 13 September 2006].

USDA. 2006b. Meat Animals Production, Disposition, and Income: 2005 Summary. Washington, DC:U.S. Department of Agriculture. Available: http://usda.mannlib.cornell.edu/usda/nass/MeatAnimPr//2000s/2006/MeatAnimPr-04-27-2006.pdf [accessed 13 September 2006].

U.S. EPA. 2000. Improved Enumeration Methods for the Recreational Water Quality Indicators: Enterococci, and *Escherichia coli*. EPA/821/R-97/004. Washington, DC:U.S. Environmental Protection Agency. Available: www.epa.gov/nerlcwww/RecManv.pdf [accessed 13 September 2006].

U.S. EPA (U.S. Environmental Protection Agency). 2002. Drinking Water Contaminants. List of Drinking Water Contaminants & Their MCLs. EPA 816-F-02-013. Available: http://www.epa.gov/safewater/mcl.html#4 [accessed 13 September 2006].

U.S. EPA. 2003. Bacterial Water Quality Standards for Recreational Waters (Freshwater and Marine Waters). EPA-823-R-03-008. Washington, DC:U.S. Environmental Protection Agency. Available: http://www.epa.gov/waterscience/beaches/local/statrept.pdf [accessed 12 September 2006].

U.S. Geological Survey. 2006. USGS Topographic Maps. Reston, VA:U.S. Geological Survey.

Wegener HC. 2003. Antibiotics in animal feed and their role in resistance development. Curr Opin Microbiol 6:439–445.

Antibiotic Resistance Threat and CAFOs

By Deniza Gertsberg | Jan 15, 2014 | 0 Comments

G+1

When we think of scrapes, tooth abscesses, urinary tract infections, diarrhea or even botox and liposuctions , we don't automatically worry about the risk of death because medical professionals rely on antibiotics to rid the body of infections. "Right now, if you want to be a sharp-looking hipster and get a tattoo, you're not putting your life on the line," said the Centers for Disease Control & Prevention's (CDC) Dr. Michael Bell to Maryn McKenna of FERNnews. But that may soon change as antibiotics are rapidly losing their effectiveness.

In a first of its kind report released this past September, CDC calculated that each year in the United States, "at least 2 million people become infected with bacteria that are resistant to antibiotics and at least 23,000 people die each year as a direct result of these infections. Many more people die from other conditions that were complicated by an antibiotic-resistant infection."

Antibiotic resistance develops when pathogens survive application of antibiotic agents and go on to reproduce resistant strains, at times spreading the resistance to other pathogens. Over-prescribing drugs in human population, common use of antibiotics in household products such as soaps, and, more significantly, unnecessary use of antibiotics on food animals are the leading causes for the declining effectiveness of these miracle drugs.

What's most alarming is how little has been done in the United States to stop the resistance. While some antibiotics are used in human populations, a whopping 80 percent of antibiotics sold by volume in the United States are used in meat and poultry production as per the Food and Drug Administration (FDA) statistics. According to Pew Charitable Trust, about 70 percent of such antibiotics are used on healthy animals and most are used in animal feed without supervision of a veterinarian. Even those antibiotics not used or used less frequently for human disease treatment (e.g., ionophores, tetracyclenes, respectively) may be promoting antibiotic resistance when overused in animal farming according to an article by Dr. Robert Lawrence of John Hopkins' Center for Living Future (CFL).

Antibiotics are administered to animals in small daily doses primarily to promote growth and improve "food efficiency" (when nutrient absorption is improved with the application of certain antibiotics animals need less food to gain weight), and to prevent diseases. With many food animals raised in deplorable dirty conditions, often with tens of thousands crammed in pens at a single facility, disease control becomes a major issue and animals are drugged further as illnesses spread quickly in confined quarters.

Furthermore, as a recent report by CFL highlighted, the overuse of antibiotics in animals goes beyond the direct administration of drugs. Compounding this is the practice of feeding animal byproducts to animals. Feather meal, for example, "a poultry byproduct used as a feed additive in poultry, swine, ruminant, and fish feed, has been found to be a source of numerous antimicrobial (and other pharmaceutical) residues."

Such wide unmonitored and unjustified use of medically important antibiotics is outright dangerous. Some in the industry fight back stating that not all of these drugs have dual application for human treatments and that FDA put a voluntary guidance to restrict subtherapeutic antibiotic use. However, FDA's voluntary guidelines have been broadly criticized as toothless. Even the FDA doubts their efficacy as they lack specificity, monitoring, and rely entirely on drug companies and farmers finding it in their best interests to cooperate.

While reducing over-prescription of antibiotics in hospitals and doctor's offices is important, the focus of combating antibiotic resistance needs to be firmly on the methods of animal production. "Practices such as confining animals in spaces too small to allow for natural behaviors, altering animals without pain relief, and providing animal feeds that promote growth at the expense of animal health have become routine," noted the CLF report. This model of cramming large numbers of animals in small spaces — the concentrated animal feeding operation (CAFOs) model — is responsible for not only the looming antibiotics crisis, but for maltreatment of animals. It is also detrimental to people who work at CAFOs, as well as to consumers and our environment.

Even if horrific images and stories about CAFOs do not tug at your heart-strings, and you close your eyes at the externalized costs of CAFOs and believe that veganism is something reserved for denizens of Los Angeles, New York and Portland, it is no longer possible to ignore how what happens out of sight in CAFOs impacts human health.

Antibiotic-resistant bacteria easily migrate from CAFOs into the air, water, and soils surrounding these sites, explains the CFL report. The transporting agents could be anything from meat transportation trucks, wild animals, and the use of fertilizer or water containing animal feces and drug-resistant bacteria on food crops. Humans exposure to drug resistant bacteria comes from multiple sources, including direct contact with animals at CAFOs, contact with soil, air, or water contaminated with animal waste, and consumption or handling of contaminated food.

If you are still not concerned, give this a thought. The Centers For Disease Control and Prevention's's Director, Dr. Tom Frieden, recently spoke of a "nightmare bacteria" — CRE, carbapenem — resistant enterobacteriaceae most common in hospital and in-patient medical facilities. CREs, Dr. Frieden said, pose a "triple threat" as they are resistant to all or nearly all antibiotics, even some last-resort drugs, have high mortality rates, and can spread their resistance to other bacteria.

Plasmid-Mediated Quinolone Resistance Genes and Antibiotic Residues in Wastewater and Soil Adjacent to Swine Feedlots: Potential Transfer to Agricultural Lands

Juan Li,[1,2,3] Thanh Wang,[4] Bing Shao,[5,6] Jianzhong Shen,[1] Shaochen Wang,[2,3] and Yongning Wu[1,2,3]

[1]Key Laboratory of Development and Evaluation of Chemical and Herbal Drugs for Animal Use, College of Veterinary Medicine, China Agricultural University, Beijing, China; [2]Ministry of Health Key Laboratory, China National Center for Food Safety Risk Assessment, Beijing, China; [3]Key Laboratory of Chemical Safety and Health, Chinese Center for Disease Control and Prevention, Beijing, China; [4]Research Center for Eco-Environment Science, Chinese Academy of Science, Beijing, China; [5]Beijing Key Laboratory of Food Poison Diagnostic and Traceability, Beijing Center for Disease Control and Prevention, Beijing, China; [6]College of Public Health and Family Medicine, Capital Medical University, Beijing, China

Background: Inappropriate use of antibiotics in swine feed could cause accelerated emergence of antibiotic resistance genes, and agricultural application of swine waste could spread antibiotic resistance genes to the surrounding environment.

Objectives: We investigated the distribution of plasmid-mediated quinolone resistance (PMQR) genes from swine feedlots and their surrounding environment.

Methods: We used a culture-independent method to identify PMQR genes and estimate their levels in wastewater from seven swine feedlot operations and corresponding wastewater-irrigated farm fields. Concentrations of (fluoro)quinolones in wastewater and soil samples were determined by ultra-performance liquid chromatography–electrospray tandem mass spectrometry.

Results: The predominant PMQR genes in both the wastewater and soil samples were *qnr*D, *qep*A, and *oqx*B, whereas *qnr*S and *oqx*A were present only in wastewater samples. Absolute concentrations of all PMQR genes combined ranged from 1.66×10^7 to 4.06×10^8 copies/mL in wastewater and 4.06×10^6 to 9.52×10^7 copies/g in soil. Concentrations of (fluoro)quinolones ranged from 4.57 to 321 ng/mL in wastewater and below detection limit to 23.4 ng/g in soil. Significant correlations were found between the relative abundance of PMQR genes and (fluoro)quinolone concentrations ($r = 0.71$, $p = 0.005$) and the relative abundance of PMQR genes in paired wastewater and agricultural soil samples ($r = 0.91$, $p = 0.005$).

Conclusions: Swine feedlot wastewater may be a source of PMQR genes that could facilitate the spread of antibiotic resistance. To our knowledge, this is the first study to examine the occurrence of PMQR genes in animal husbandry environments using a culture-independent method.

Key words: agricultural soil, culture-independent method, environmental health, (fluoro)quinolones, PMQR genes, swine feedlot, wastewater. *Environ Health Perspect* 120:1144–1149 (2012). http://dx.doi.org/10.1289/ehp.1104776 [Online 8 May 2012]

The growth of the swine-breeding industry has led to the increased use of antibiotics for therapeutic purposes and to promote growth and improve feed efficiency, including some antibiotics that are important in human clinical medicine. The use of subtherapeutic concentrations of antibiotics for nontherapeutic purposes could drive the selection of bacterial resistance in the gastrointestinal tracts of swine (Chee-Sanford et al. 2001; Mackie et al. 2006). Under chronic antimicrobial pressure, resistance may increase because of the rapid reproduction and spread of resistant strains (Silbergeld et al. 2008). Jensen et al. (2006) and Bager et al. (1997) found that the agricultural use of antibiotics had a significant effect on the prevalence of antibiotic-resistant bacteria in swine waste. A large proportion of swine waste is typically stored in open-air lagoons and subsequently applied to surrounding agricultural fields through irrigation or fertilization (Sapkota et al. 2007) although some may be discharged into surrounding rivers via drainage ditches. These activities might pose a risk to public health if they result in the spread of genetic elements encoding antibiotic resistance and the spread of unabsorbed antibiotics into the environment (Pruden et al. 2006).

Antibiotic resistance genes (ARGs) released from dead microorganisms can persist in the environment for an extended period of time (Pote et al. 2003) and spread among bacteria through vertical transfer (generation) or horizontal transfer (conjugation, transduction, transformation, and transposition). The ARGs could therefore be considered to be emerging environmental "contaminants" as defined by Pruden et al. (2006), and they have the potential to be further distributed to various environmental compartments (Agerso and Sandvang 2005; Rodriguez et al. 2006). There have been various strategies for investigating environmental ARGs. One such strategy is by a culture-independent method that analyzes DNA extracted from all the microorganisms present in environmental samples (Riesenfeld et al. 2004). This avoids bias that results from the non-culturability of a large proportion of microorganisms in standard culture conditions (Rappe and Giovannoni 2003) and from variation in the effects of environmental media on the success of culture-based techniques (Allen et al. 2010). Seyfried et al. (2010) identified tetracycline resistance (*tet*^{R}) genes associated with oxytetracycline use in aquaculture facilities. They also demonstrated that Class 1 integron gene and *tet*^{R} genes (*tet*A and *tet*C) were disseminated in different aquatic environments in Jiangsu Province in China (Zhang et al. 2009). The various *tet*^{R} genes and erythromycin resistance genes found in different environmental compartments appeared to be influenced by surrounding swine feedlots (Chen et al. 2010; Wu et al. 2010). Moreover, some studies have reported that the absolute concentrations of *tet*^{R} genes were significantly correlated with the concentrations of corresponding antibiotic residues in the environment (Peak et al. 2007; Wu et al. 2010).

(Fluoro)quinolones are broad-spectrum antimicrobial agents that predominantly have been used to treat various infections in humans and animals. Their current use has been extended to employment as a growth enhancer in pigs (Danish Integrated Antimicrobial Resistance Monitoring and Research Programme 1999). The expanded usage of (fluoro)quinolones has also lead to serious cases of widespread resistance to these agents (Strahilevitz et al. 2009). Before the emergence of bacterial plasmid-mediated quinolone resistance (PMQR) genes, research on the resistance mechanisms of (fluoro)quinolones were confined to mutations of chromosomal genes coding DNA gyrase or topoisomerase IV in the quinolone resistance determining region

Address correspondence to Y. Wu, China Agricultural University, China National Center for Food Safety Risk Assessment, Chinese Center for Disease Control and Prevention, 7 Panjiayuan Nanli, Beijing 10021 China. Telephone: 86-10-67776790. Fax: 86-10-67776790. E-mail: wuyncdc@yahoo.com.cn

Supplemental Material is available online (http://dx.doi.org/10.1289/ehp.1104776).

This work was supported by grants from the National Natural Science Foundation of China (20837003), the National Basic Research Program of China (973 Program; 2012CB720804), and the Ministry of Health, China (200902009).

The authors declare they have no actual or potential competing financial interests.

Received 23 November 2011; accepted 8 May 2012.

(QRDR) (Hopkins et al. 2005). Currently, three types of PMQR genes and their variations have been more frequently reported in various bacterial pathogens around the world. These are the quinolone resistance determinant (*qnr*) genes (*qnr*A, *qnr*B, *qnr*C, *qnr*D, and *qnr*S), variant aminoglycoside acetyltransferase gene [*aac(6′)-Ib-cr*], and efflux pumps-encoding genes (*qep*A and *oqx*AB) (Cattoir et al. 2008; Hernandez et al. 2011; Strahilevitz et al. 2009). The gene *qnr*A was one of the first identified PMQR genes (Martinez-Martinez et al. 1998), and research on the PMQR genes has since expanded in environmental and health science (Robicsek et al. 2006; Strahilevitz et al. 2009). The presence of *qnr* genes may increase the selection of mutations with high-level (fluoro)quinolone resistance (Rodriguez-Martinez et al. 2007). Furthermore, PMQR genes usually combine with other resistance genes in the same plasmid, so the presence of any other antibiotics for which the plasmid confers resistance will select for quinolone resistance as well (Hernandez et al. 2011). The PMQR genes may also be horizontally transmitted among bacterial isolates of different origins (Martinez-Martinez et al. 1998; Zhao et al. 2010).

To our knowledge, only two previous publications have reported the study of the environmental occurrence of PMQR genes (Cummings et al. 2011; Kristiansson et al. 2011). In contrast to those studies, we used a culture-independent genomics study method to investigate the occurrence of PMQR genes in wastewater samples collected from swine feedlots and corresponding soil samples from nearby agricultural fields where the wastewaters were used for irrigation.

Materials and Methods

Sampling procedure. Wastewater samples (about 2.5 L for each site) were collected from the effluent of seven conventional swine feedlots located in three districts of Beijing: Fangshan District (defined as F_1-w, F_2-w, and F_3-w), Daxing District (D_1-w, D_2-w, and D_3-w), and Shunyi District (S-w), during August 2010. These feedlot effluents are periodically used for irrigation in surrounding agricultural fields and are occasionally discharged into surrounding rivers. Before collecting the wastewater samples, samplers and sample bottles were rinsed three times with ethanol, once with sterile deionized water, and three times with the wastewater. At each site, three swine feedlot wastewater samples were collected at 1–2 hr intervals and then combined to form one composite sample for each site. The wastewater samples were stored in presterilized 500-mL amber polypropylene high-density bottles (Embalator AB, Ulricehamn, Sweden) equipped with Teflon-lined polypropylene caps.

Concurrent with the collection of wastewater samples, soil samples (about 500 g for each site) were collected from agricultural fields adjacent to the seven swine feedlots (defined as F_1-s, F_2-s, F_3-s, D_1-s, D_2-s, D_3-s, and S-s) using a shovel and sterilized amber plastic bags. For each site, the top 15 cm of the surface soil from three different locations were pooled to form one composite sample. For example, F_1-w and F_1-s are paired wastewater and soil samples from the same site; this also applies for samples from the other sample sites.

Additionally, surface river water and corresponding farm soil samples collected at sites upstream from the swine feedlots were used as control samples (and defined as being uncontaminated by wastewater from swine feedlot operations).

Sampling was kept as sterile as possible, and all samples were immediately stored in a cooler box until returned to the laboratory for immediate processing (< 12 hr).

Sample processing and DNA extraction. Each composite water or soil sample was divided into two aliquots under aseptic conditions. One aliquot was used for quantification of (fluoro)quinolone residues after storage at 4°C for ≤ 1 week. The other was used for quantification of PMQR genes. Each aliquot was further divided into three subsamples. Sample processing for molecular analyses was always carried out first.

Power Water DNA Kits (MO BIO Laboratories Inc., Carlsbad, CA, USA) were used to extract total DNA from each wastewater subsample after pretreatment to remove particulates via layered filtration with Whatman grade 4 qualitative filter paper (20–25 µm), Whatman grade 3 qualitative filter paper (6 µm) and glass-fiber Whatman GF/B (1 µm). Approximately 200 mL of each prefiltered wastewater subsample was immediately concentrated in duplicate using the sterile filter (0.2 µm) from the Power Water DNA Kit (MO BIO). We followed the manufacturer's protocol for the subsequent extraction steps.

Soil subsamples were aseptically equilibrated and homogenized at room temperature. All thawed soil subsamples were passed through a 2.0-mm sieve, and about 1 g of homogenized soil was extracted in duplicate using a commercial Power Soil DNA Kit (MO BIO) in accordance with the manufacturer's instructions.

We performed DNA extractions for each subsample in duplicate, and the duplicate extracts were then pooled to form a single composite sample for that site that was stored at –80°C until subsequent molecular analyses.

Polymerase chain reaction (PCR) assays for PMQR genes. Qualitative PCR assays were used to assess the presence of nine PMQR genes [*qnr*A, *qnr*B, *qnr*C, *qnr*D, *qnr*S, *qep*A, *oqx*A, *oqx*B, *aac(6′)-Ib-cr*] in all environmental and control subsamples. All primers were previously validated [for primer sequences, amplicon sizes, annealing temperatures, references for each sequence, and additional details regarding PCR conditions, see Supplemental Material, Table S1 (http://dx.doi.org/10.1289/ehp.1104776)]. To ensure reproducibility, two replicates for each sample were performed in parallel with a control sample in each run. To prevent false-negative results due to PCR-inhibiting substances such as humic acids, 2 ng of DNA extract from each sample that did not show amplification of each target gene was spiked with positive-control template at 10^2 copies/µL. There was no evidence of PCR inhibition in any extracts (data not shown). An Agilent 2100 bioanalyzer (Agilent Technologies, Santa Clara, CA, USA) was used to analyze DNA fragments (Panaro et al. 2000). Chips in the DNA 7500 LabChip kit (Agilent Technologies) were loaded with PCR amplification products according to the manufacturer's instructions, with minor modifications. Briefly, microchannels on the chips were filled by pipetting 9 µL of gel-dye mixture into the appropriate well and then forcing the mixture into the microchannels by applying pressure to the well via a 1-mL syringe. The ladder well was subsequently loaded with 5 µL of marker mixture plus 1 µL of molecular size ladder, while sample wells were loaded with 5 µL of marker mixture plus 1 µL of PCR amplification products. The marker mixture for the Agilent DNA 7500 Lab Chip contains lower and upper molecular size markers of 50 bp and 10,380 bp, respectively. After vortexing for 1 min, the chip (with 12 PCR amplification products) could be read within 30 min by the Agilent 2100 bioanalyzer.

Amplification products from each positive sample were purified with PCR quick spin™ PCR Product Purification Kit (Tiangen Biotech Co. Ltd., Beijing, China) and ligated into pGEM-T Easy Vector (Promega, Madison, WI, USA) before being cloned into *Escherichia coli* DH5α using the pEASY-T1 Simple Cloning Kit (TransGen Biotech Co. Ltd., Beijing, China). Clones containing target gene inserts were selected and confirmed by PCR. Plasmids carrying target genes were extracted and purified with the MiniBEST Plasmid Purification Kit (TaKaRa, Dalian, China) and sequenced by Invitrogen Ltd./Applied Biosystems Ltd. (Beijing, China), and the resulting sequences were compared with GenBank (http://www.ncbi.nlm.nih.gov/nuccore/) sequences for the target genes using the BLAST alignment tool (http://www.ncbi.nlm.nih.gov/blast/). These plasmids were used to generate standard curves for subsequent quantification of each gene in the subsamples as described below.

Quantitation of PMQR genes. The quantitative PCR (qPCR) reactions were conducted using SYBR Green I chemistry and

the Bio-Rad Chromo4 real-time PCR instrument (both from Bio-Rad, Hercules, CA, USA) with the Analysis software version 3.0 (BioRad) to quantify levels of the PMQR genes and 16S rRNA in all subsamples. Sample-derived standards were diluted serially in molecular biology-grade water. The qPCR reactions were conducted in 96-well plates. Optimal qPCR conditions were determined empirically [for details, see Supplemental Material, pp. 2–3 (http://dx.doi.org/10.1289/ehp.1104776)]. DNA extracts were amplified against the 10-fold serially diluted calibration curve over seven orders of magnitude and DNA-free negative control on the same real-time PCR plate in triplicate. Standard error values of the measurements were determined from these parallel data. 16S rRNA was also quantified (Graham et al. 2011; Peak et al. 2007; Smith et al. 2004) on the same plate, using the SybrGreen (BioRad) approach. Following qPCR, melting curves for the amplicons were measured by slowly raising the temperature while monitoring fluorescence to verify that nonspecific amplification did not occur (data not shown). Matrix effects associated with extraction of DNA from environmental samples were corrected as described by Pei et al. (2006). The presence of inhibitory substances in the sample matrix was assessed by spiking the samples with defined amounts of DNA template and comparing concentration thresholds between the matrix and controls, whose difference was always < 1. The qPCR efficiencies (90–102% in this study) were examined by comparing plasmid controls and serial dilutions of selected samples, using a 16S rRNA assay as described in the Supplemental Material (pp. 2–3). There was very low inhibition in these samples (data not shown). Results from the assays were analyzed based on the slope for the qPCR calibration curve. R^2 values were greater than 0.992 for all calibration curves.

Copy numbers of target PMQR genes were normalized to the 16S rRNA copy number (defined as relative abundances) and to 1 g for soil samples or 1 mL for wastewater samples (defined as absolute concentrations: copies per gram or copies per milliliter) to take into account any temporal variations among sites, overall extraction efficiencies, total bacterial community, and potential sample degradation (Graham et al. 2011). We used the term "levels" to describe findings that relate to both relative abundances and absolute concentrations.

Quantitation of (fluoro)quinolones. In this study, extraction and quantitative analysis of (fluoro)quinolone residues in wastewater and soil samples was performed according to Shao et al. (2009). The method is based on solid-phase extraction (SPE) and analysis by ultra performance liquid chromatography–tandem mass spectrometry (UPLC-MS/MS; Acquity UPLC; Waters Corporation, Milford, MA, USA). Orbifloxacin, danofloxacin, pipemidic acid, marbofloxacin, lomefloxacin, pefloxacin, enrofloxacin, norfloxacin, ciprofloxacin, and ofloxacin were purchased from Sigma (St. Louis, MO, USA) with purities > 97%. The recoveries for (fluoro)quinolones based on matrix-matched calibration ranged between 100% and 117% in aqueous solution and between 77% and 114% in soil samples, and the quantification limits were in the range of 0.2–10 pg/mL for water and 0.38–2.00 ng/g for soil samples. The analytical method is described in detail in Supplemental Material, p. 2 (http://dx.doi.org/10.1289/ehp.1104776).

Statistical analysis. Data analysis was conducted using SPSS Statistics version 16.0 (IBM, Armonk, NY, USA). A one-way analysis of variance test and independent-sample *t*-tests were used to compare samples with

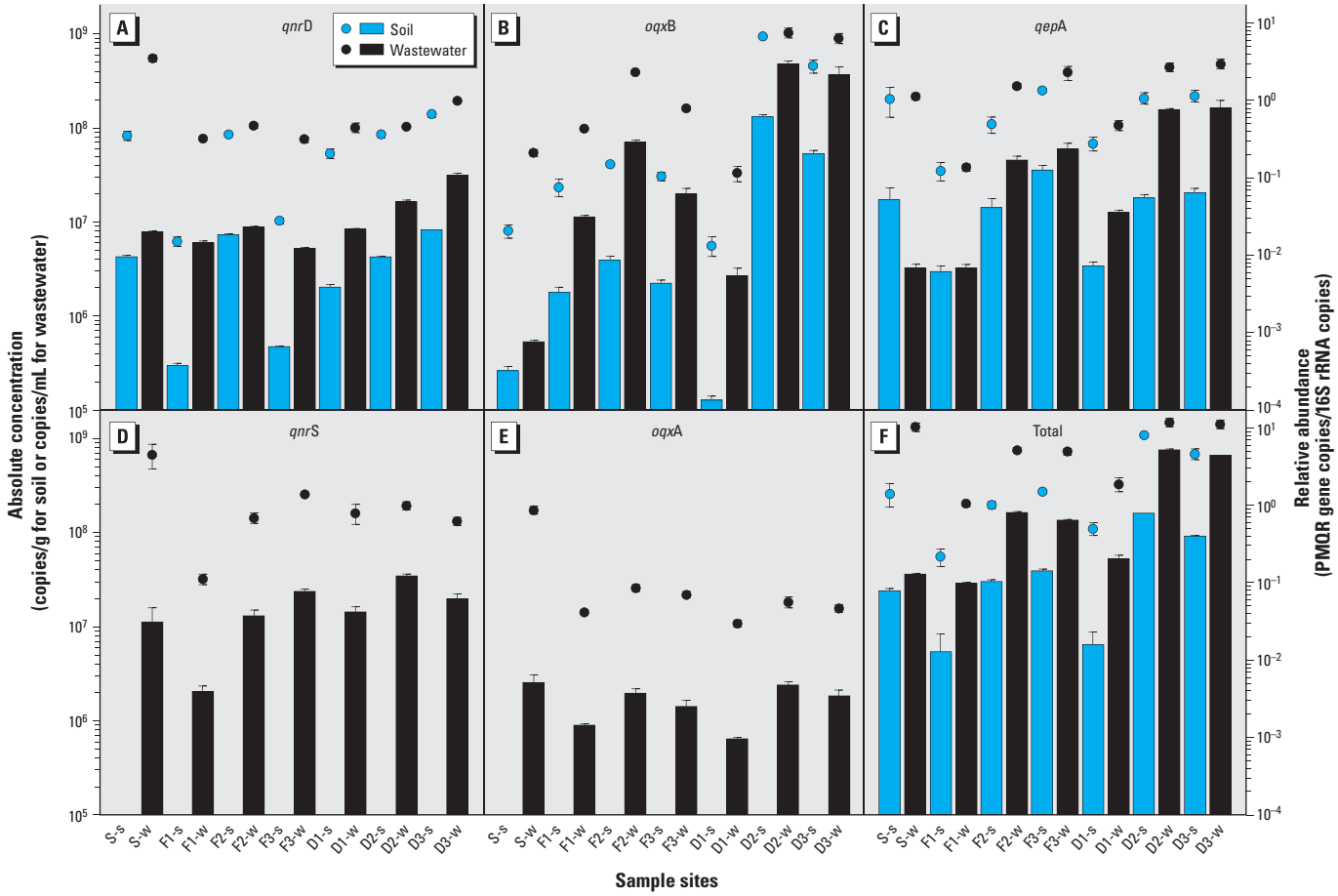


Figure 1. Levels of five PMQR genes among the soil and wastewater samples. (*A*) *qnr*D. (*B*) *oqx*B. (*C*) *qep*A. (*D*) *qnr*S. (*E*) *oqx*A. (*F*) Total of the five PMQR genes. Bars represent absolute concentrations and circles represent relative abundances. Values shown are mean ± SE of three analytical replicates.

controls (the level for statistical significance was set at $p < 0.05$). Data were log-transformed when necessary to obtain a normal distribution before statistical analysis. A two-tailed Pearson's bivariate correlation analysis was used to compare levels of total PMQR genes in soil and wastewater samples and to compare levels of total PMQR genes and (fluoro)quinolone concentrations.

Results

Occurrence and levels of PMQR genes. Among the nine PMQR genes investigated, *qnr*D, *oqx*B, and *qep*A were found in all environmental samples from the target sites; *qnr*S and *oqx*A were only detected in wastewater samples; *qnr*B was found in only three wastewater samples (F_3-w, D_2-w, and D_3-w); and *qnr*A, *qnr*C, and *aac(6´)-Ib-cr* were not detected at all [see Supplemental Material, Figure S1 and Table S2 (http://dx.doi.org/10.1289/ehp.1104776)]. In addition, no PMQR genes were detected in control samples. The positively identified PMQR genes were identical to the corresponding sequences deposited in the GenBank database (data not shown).

Absolute concentrations and relative abundances of the five major PMQR genes (*qnr*D, *oqx*B, *qep*A, *qnr*S, and *oqx*A) are shown in Figure 1 and reported in Supplemental Material Tables S3 and S4, respectively (http://dx.doi.org/10.1289/ehp.1104776).

Concentrations of (fluoro)quinolones. Ten (fluoro)quinolones were detected in the samples (orbifloxacin, danofloxacin, pipemidic acid, marbofloxacin, lomefloxacin, pefloxacin, enrofloxacin, norfloxacin, ciprofloxacin, and ofloxacin) with concentrations ranging from below the limit of detection (LOD) to 244 ng/mL in wastewater samples and 20.4 ng/g in soil samples [see Supplemental Material, Table S5 (http://dx.doi.org/10.1289/ehp.1104776)]. All (fluoro)quinolones were < LODs in all control samples. Norfloxacin was detected in all target samples with the exception of three soil samples (F_1-s, F_3-s, and D_1-s) in which none of the (fluoro)quinolones was detected (Figure 2). The frequencies of detection were thereafter followed by ofloxacin, ciprofloxacin, enrofloxacin, and lomefloxacin. Other (fluoro)quinolones (marbofloxacin, pipemidic acid, danofloxacin, and orbifloxacin) were detected only in the S-w wastewater sample, whereas pefloxacin was found in S-w and F_2-w. The average concentration of norfloxacin was 1.16 ng/g in soil and 40.6 ng/mL in wastewater samples (see Supplemental Material, Table S5). Ciprofloxacin was identified in the wastewater and soil samples from the D_3 site at the highest concentration of any of the (fluoro)quinolones measured in wastewater (244 ± 2.04 ng/mL in D_3-w) and soil (and 20.4 ng/g in D_3-s) samples, respectively (see Supplemental Material, Table S5). Total (fluoro)quinolone concentrations were highest in S-w (321 ng/mL) among the wastewater samples and at the D_3-s site (23.4 ng/g) among soils (see Supplemental Material, Table S5).

Correlation analysis. Significant positive correlations between paired wastewater and soil samples were observed for the relative abundances of *qep*A ($r = 0.94$, $p = 0.001$), *oqx*B ($r = 0.96$, $p = 0.001$), and total PMQR genes (sum of five PMQR genes: *qnr*D, *qep*A, *oqx*B, *qnr*S, and *oqx*A; $r = 0.91$, $p = 0.005$) but not *qnr*D ($r = 0.56$, $p = 0.19$). Absolute concentrations were significantly correlated between paired soil and water samples for *oqx*B ($r = 0.95$, $p = 0.001$) and total PMQR genes ($r = 0.91$, $p = 0.005$), but not *qep*A ($r = 0.63$, $p = 0.13$) or *qnr*D ($r = 0.72$, $p = 0.07$).

The relative abundance of total PMQR genes (sum of the five genes: *qnr*D, *oqx*B, *qep*A, *qnr*S, and *oqx*A) and measured concentrations of total (fluoro)quinolones were significantly correlated ($r = 0.71$, $p = 0.005$) (Figure 3). Significant correlations also were observed for some but not all concentrations of individual (fluoro)quinolones and the relative abundance of individual PMQR genes and for total (fluoro)quinolones and four of five individual PMQR genes [see Supplemental Material, Table S6 (http://dx.doi.org/10.1289/ehp.1104776)].

Discussion

We investigated wastewater from seven different swine feedlots and corresponding agricultural soil samples for the presence of PMQR genes. The findings indicate that *qnr*D, *oqx*B, *qep*A, *qnr*S, and *oqx*A genes were widespread in almost all of the wastewater samples. In another study, some of these PMQR genes were also found in environmental *E. coli* strains from swine (Liu et al. 2008), and *oqx*A and *oqx*B have been found in a conjugative plasmid that conferred resistance to the antibiotic olaquindox, which has been used as a swine growth enhancer (Hansen et al. 2007). Additionally, *qnr*S has been found in *E. coli* strains from swine in China (Xia et al. 2010). In a survey by Cummings et al. (2011), *qep*A and *qnr*S were commonly observed PMQR genes in microbial DNA extracted from surface sediments of the Tijuana River Estuary in San Diego County, California, USA. Less information is available on the environmental occurrence of

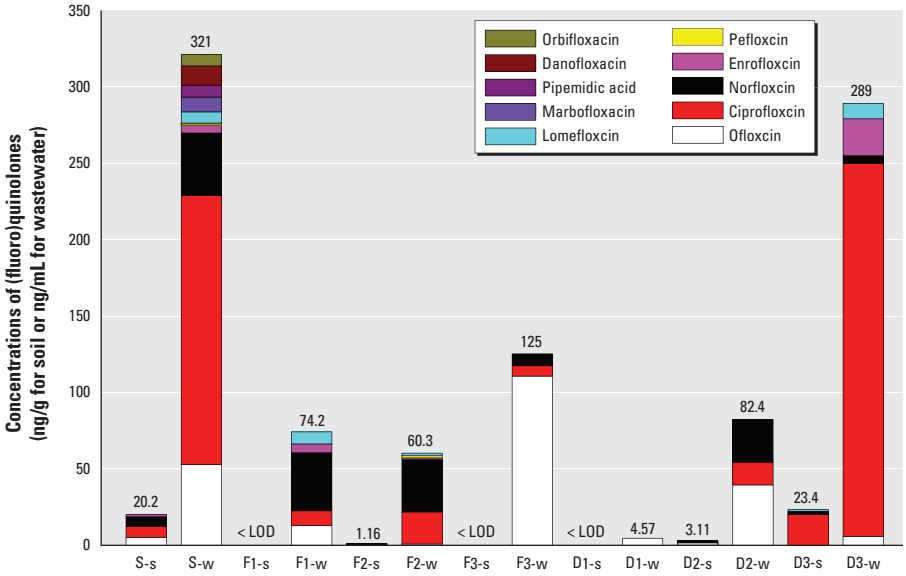


Figure 2. Concentrations of 10 (fluoro)quinolones (ng/mL or ng/g) in study samples. Bars represent mean concentrations of the 10 (fluoro)quinolones. Numbers above bars show the total concentration of (fluoro)quinolones in each composite sample. The concentrations of the 10 (fluoro)quinolones were < LOD in all control samples.

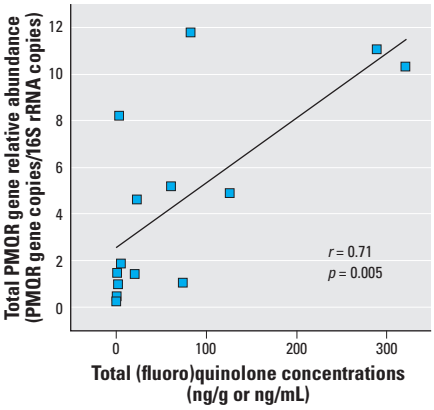


Figure 3. Correlation between the relative abundance of total combined PMQR genes (*qnr*D, *oqx*B, *qep*A, *qnr*S, and *oqx*A) and the total combined (fluoro)quinolone concentration (orbifloxacin, danofloxacin, pipemidic acid, marbofloxacin, lomefloxacin, pefloxacin, enrofloxacin, norfloxacin, ciprofloxacin, and ofloxacin).

the PMQR gene, *qnr*D, which previously has been identified in samples from humans and companion animals only (Zhu et al. 2010) but was observed in all samples in the present study. Interestingly, the *aac(6′)-Ib-cr* gene, which has been reported as the most common PMQR gene among clinical *Enterobacteriaceae* isolates (Strahilevitz et al. 2009), was absent in all samples in the present study.

Although levels of the three PMQR genes (*qnr*D, *oqx*B, and *qep*A) varied among the environmental samples, they were identified in all wastewater samples and corresponding farm soil samples. In contrast, no PMQR genes were detected in control samples, supporting the hypothesis that swine feedlot wastewater may be a source of PMQR genes in the surrounding environment. These genes could have migrated along with quinolone-resistant bacteria and horizontally mobile genetic elements and transferred from swine feedlots to agricultural fields during agricultural applications of swine waste and wastewater. The significant positive correlation between PMQR genes in paired wastewater and soil samples further supports the possibility that swine feedlots are sources of PMQR gene contamination in adjacent farm fields.

Some (fluoro)quinolone residues were also commonly detected among the swine wastewater samples, probably reflecting their frequent usage in swine feeding practices. The wastewater concentrations among the different swine feedlots varied by about two orders of magnitude, which could be related to differences in antibiotics usage and operational scales of the swine feedlots.

Significant correlations were found between some individual (fluoro)quinolones and individual PMQR genes as well as between total (fluoro)quinolones and PMQR genes among all the paired samples, which is consistent with the hypothesis that exposure to antibiotics could lead to selective pressure for resistance genes (Wu et al. 2010). However, the correlations were not as strong as those found in other studies (Smith et al. 2004), which may reflect a variation in the fate and transport of resistance genes and antibiotics after their release into the environment (Peak et al. 2007).

Swine wastewater that contains PMQR genes and (fluoro)quinolone residues and is applied to agricultural fields or released to surrounding rivers might increase the risk that nearby residents will be exposed during farming or through their use of contaminated river water. Our sampling campaign coincided with the rainy season, and thus some of the field-applied swine waste could have been transferred by rain and wind to surrounding rivers and other environmental compartments. Sapkota et al. (2007) suggested that resistant bacteria in surface water sources contaminated by swine waste could contribute to the spread of antibiotic resistance in humans and the environment. In addition, Wilcks et al. (2004) confirmed that antibiotic resistance genes could be transferred between agricultural fields and plants that could enter into the human food cycle. During our sampling campaign we often observed young children playing in the river around the swine feedlots, probably increasing their risk of exposure. In addition, local residents informed us that they used to wash vegetables or fruit in the contaminated river. Rural environments and life styles might thus increase the risk of exposure to water and soil contaminated by PMQR genes and (fluoro)quinolones and could have health implications for local residents.

There were several limitations to our study. The swine producers declined to provide us with antibiotic usage data for proprietary reasons, thus, we chose to analyze the samples for some commonly used (fluoro)quinolones. A more extensive sampling campaign including crops, waste from humans, and additional river water samples collected at different distances from the point sources would permit a more detailed assessment of the environmental health risk of PMQR genes. In addition, phylotype and phylogenetic analyses should be conducted in future studies to track the fate of specific PMQR genes from swine feedlots to the environment.

Conclusions

To our knowledge, this is the first study to examine PMQR genes in environmental samples collected from swine production facilities using a culture-independent method. It is also, to our knowledge, the first report on the occurrence of *qnr*D, *oqx*A, and *oqx*B in environmental samples. Our findings are consistent with the hypothesis that the PMQR genes found in fields adjacent to swine feedlots were transported from the feedlots through waste amendment and irrigation, and highlight the potential role of swine feedlots as a source of antibiotic resistance genes identified in other environment compartments. The correlations observed between PMQR genes and (fluoro)quinolone residues in soil and wastewater samples would also be consistent with the positive selection of antibiotic resistance genes as a consequence of antibiotic residues in the environment. Therefore, selection for PMQR genes could occur both in the animal gut (as a result of feeding practices) and after the environmental release of (fluoro)quinolones.

The rapid expansion of swine production and its potential role as a source of PMQR genes in the environment highlights the importance of international cooperation to promote the prudent use of antibiotics in medical therapy, agriculture, and animal husbandry and supports the need for effective treatment of husbandry wastewater before its release into the environment. The correlation of PMQR genes between wastewater and paired farm soil is a valuable first step in the environmental risk assessment of PMQR genes, but further research is needed to better understand transfer mechanisms. We also recommend the establishment of programs to monitor antibiotic resistance genes in the environment on a global scale in order to clarify the extent of potential risks to public health.

References

Agerso Y, Sandvang D. 2005. Class 1 integrons and tetracycline resistance genes in *Alcaligenes, Arthrobacter,* and *Pseudomonas* spp. isolated from pigsties and manured soil. Appl Environ Microbiol 71:7941–7947.

Allen HK, Donato J, Wang HH, Cloud-Hansen KA, Davies J, Handelsman J. 2010. Call of the wild: antibiotic resistance genes in natural environments. Nat Rev Microbiol 8:251–259.

Bager F, Madsen M, Christensen J, Aarestrup FM. 1997. Avoparcin used as a growth promoter is associated with the occurrence of vancomycin-resistant *Enterococcus faecium* on Danish poultry and pig farms. Prev Vet Med 31:95–112.

Cattoir V, Poirel L, Aubert C, Soussy CJ, Nordmann P. 2008. Unexpected occurrence of plasmid-mediated quinolone resistance determinants in environmental *Aeromonas* spp. Emerg Infect Dis 14:231–237.

Chee-Sanford JC, Aminov RI, Krapac IJ, Garrigues-Jeanjean N, Mackie RI. 2001. Occurrence and diversity of tetracycline resistance genes in lagoons and groundwater underlying two swine production facilities. Appl Environ Microbiol 67:1494–1502.

Chen J, Michel FC, Sreevatsan S, Morrison M, Yu ZT. 2010. Occurrence and persistence of erythromycin resistance genes (*erm*) and tetracycline resistance genes *(tet)* in waste treatment systems on swine farms. Microb Ecol 60:479–486.

Cummings DE, Archer KF, Arriola DJ, Baker PA, Faucett KG, Laroya JB, et al. 2011. Broad dissemination of plasmid-mediated quinolone resistance genes in sediments of two urban coastal wetlands. Environ Sci Technol 45:447–454.

Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP). 1999. Resistance monitoring in Denmark, 1997—DANMAP. Wkly Epidemiol Rec 74:125–127.

Graham DW, Olivares-Rieumont S, Knapp CW, Lima L, Werner D, Bowen E. 2011. Antibiotic resistance gene abundances associated with waste discharges to the Almendares River near Havana, Cuba. Environ Sci Technol 45:418–424.

Hansen LH, Jensen LB, Sorensen HI, Sorensen SJ. 2007. Substrate specificity of the *oqx*AB multidrug resistance pump in *Escherichia coli* and selected enteric bacteria. J Antimicrob Chemother 60:145–147.

Hernandez A, Sanchez MB, Martinez JL. 2011. Quinolone resistance: much more than predicted. Front Microbiol 2:22; doi:10.3389/fmicb.2011.00022 [Online 11 February 2011].

Hopkins KL, Davies RH, Threlfall EJ. 2005. Mechanisms of quinolone resistance in *Escherichia coli* and *Salmonella:* recent developments. Int J Antimicrob Agents 25:358–373.

Jensen VF, Jakobsen L, Emborg HD, Seyfarth AM, Hammerum AM. 2006. Correlation between apramycin and gentamicin use in pigs and an increasing reservoir of gentamicin-resistant *Escherichia coli*. J Antimicrob Chemother 58:101–107.

Kristiansson E, Fick J, Janzon A, Grabic R, Rutgersson C, Weijdegard B, et al. 2011. Pyrosequencing of antibiotic-contaminated river sediments reveals high levels of resistance and gene transfer elements. Plos One 6(2):e17038; doi:10.1371/journal.pone.0017038 [Online 16 February 2011].

Liu JH, Deng YT, Zeng ZL, Gao JH, Chen L, Arakawa Y, et al. 2008. Coprevalence of plasmid-mediated quinolone resistance determinants *qepA, qnr, and aac(6′)-Ib-cr* among 16S rRNA methylase rmtB-producing *Escherichia coli* isolates from pigs. Antimicrob Agents Chemother 52:2992–2993.

Mackie RI, Koike S, Krapac I, Chee-Sanford J, Maxwell S, Aminov RI. 2006. Tetracycline residues and tetracycline resistance genes in groundwater impacted by swine production facilities. Anim Biotechnol 17:157–176.

Martinez-Martinez L, Pascual A, Jacoby GA. 1998. Quinolone resistance from a transferable plasmid. Lancet 351:797–799.

Panaro NJ, Yuen PK, Sakazume T, Fortina P, Kricka LJ, Wilding P. 2000. Evaluation of DNA fragment sizing and quantification by the Agilent 2100 bioanalyzer. Clin Chem 46:1851–1853.

Peak N, Knapp CW, Yang RK, Hanfelt MM, Smith MS, Aga DS, et al. 2007. Abundance of six tetracycline resistance genes in wastewater lagoons at cattle feedlots with different antibiotic use strategies. Environ Microbiol 9:143–151.

Pei RT, Kim SC, Carlson KH, Pruden A. 2006. Effect of river landscape on the sediment concentrations of antibiotics and corresponding antibiotic resistance genes (ARG). Water Res 40:2427–2435.

Pote J, Ceccherini MT, Van VT, Rosselli W, Wildi W, Simonet P, et al. 2003. Fate and transport of antibiotic resistance genes in saturated soil columns. Eur J Soil Biol 39:65–71.

Pruden A, Pei RT, Storteboom H, Carlson KH. 2006. Antibiotic resistance genes as emerging contaminants: studies in northern Colorado. Environ Sci Technol 40:7445–7450.

Rappe MS, Giovannoni SJ. 2003. The uncultured microbial majority. Annu Rev Microbiol 57:369–394.

Riesenfeld CS, Schloss PD, Handelsman J. 2004. Metagenomics: genomic analysis of microbial communities. Annu Rev Genet 38:525–552.

Robicsek A, Jacoby GA, Hooper DC. 2006. The worldwide emergence of plasmid-mediated quinolone resistance. Lancet Infect Dis 6:629–640.

Rodriguez C, Lang L, Wang A, Altendorf K, Garcia F, Lipski A. 2006. Lettuce for human consumption collected in Costa Rica contains complex communities of culturable oxytetracycline- and gentamicin-resistant bacteria. Appl Environ Microbiol 72:5870–5876.

Rodriguez-Martinez JM, Velasco C, Garcia I, Cano ME, Martinez-Martinez L, Pascual A. 2007. Mutant prevention concentrations of fluoroquinolones for *Enterobacteriaceae* expressing the plasmid-carried quinolone resistance determinant *qnr*A1. Antimicrob Agents Chemother 51:2236–2239.

Sapkota AR, Curriero FC, Gibson KE, Schwab KJ. 2007. Antibiotic-resistant *enterococci* and fecal indicators in surface water and groundwater impacted by a concentrated swine feeding operation. Environ Health Perspect 115:1040–1045.

Seyfried EE, Newton RJ, Rubert KF, Pedersen JA, McMahon KD. 2010. Occurrence of tetracycline resistance genes in aquaculture facilities with varying use of oxytetracycline. Microb Ecol 59:799–807.

Shao B, Chen D, Zhang J, Wu Y, Sun C. 2009. Determination of 76 pharmaceutical drugs by liquid chromatography-tandem mass spectrometry in slaughterhouse wastewater. J Chromatogr A 1216:8312–8318.

Silbergeld EK, Graham J, Price LB. 2008. Industrial food animal production, antimicrobial resistance, and human health. Annu Rev Public Health 29:151–169.

Smith MS, Yang RK, Knapp CW, Niu YF, Peak N, Hanfelt MM, et al. 2004. Quantification of tetracycline resistance genes in feedlot lagoons by real-time PCR. Appl Environ Microbiol 70:7372–7377.

Strahilevitz J, Jacoby GA, Hooper DC, Robicsek A. 2009. Plasmid-mediated quinolone resistance: a multifaceted threat. Clin Microbiol Rev 22:664–689.

Wilcks A, van Hoek AH, Joosten RG, Jacobsen BB, Aarts HJ. 2004. Persistence of DNA studied in different ex vivo and in vivo rat models simulating the human gut situation. Food Chem Toxicol 42:493–502.

Wu N, Qiao M, Zhang B, Cheng WD, Zhu YG. 2010. Abundance and diversity of tetracycline resistance genes in soils adjacent to representative swine feedlots in China. Environ Sci Technol 44:6933–6939.

Xia LN, Li L, Wu CM, Liu YQ, Tao XQ, Dai L, et al. 2010. A survey of plasmid-mediated fluoroquinolone resistance genes from *Escherichia coli* isolates and their dissemination in Shandong, China. Foodborne Pathog Dis 7:207–215.

Zhang XX, Wu B, Zhang Y, Zhang T, Yang LY, Fang H, et al. 2009. Class 1 integronase gene and tetracycline resistance genes *tet*A and *tet*C in different water environments of Jiangsu Province, China. Ecotoxicology 18:652–660.

Zhao JJ, Chen ZL, Chen S, Deng YT, Liu YH, Tian W, et al. 2010. Prevalence and dissemination of *oqx*AB in *Escherichia coli* isolates from animals, farmworkers, and the environment. Antimicrob Agents Chemother 54:4219–4224.

Zhu H-Q, Liao X-P, Sun J, Li L, Zhang M-J, Liu B-T, et al. 2010. New plasmid-mediated quinolone resistance gene *qnr*D found in an isolate of *Escherichia coli* from pet animals [in Chinese]. Sci Agric Sinica 43:4317–4322.

EDITORIAL

Antibiotics Overuse in Animal Agriculture: A Call to Action for Health Care Providers

Recently, the World Health Organization called antimicrobial resistance "an increasingly serious threat to global public health that requires action across all government sectors and society."[1]

Of all antibiotics sold in the United States, approximately 80% are sold for use in animal agriculture; about 70% of these are "medically important" (i.e., from classes important to human medicine).[2] Antibiotics are administered to animals in feed to marginally improve growth rates and to prevent infections, a practice projected to increase dramatically worldwide over the next 15 years.[3] There is growing evidence that antibiotic resistance in humans is promoted by the widespread use of nontherapeutic antibiotics in animals. Resistant bacteria are transmitted to humans through direct contact with animals, by exposure to animal manure, through consumption of undercooked meat, and through contact with uncooked meat or surfaces meat has touched.[4]

The practice of medicine and the state of public health would be catastrophically affected if antibiotics were not generally effective in treating bacterial illnesses. Physicians and health care institutions are regularly cautioned to avoid unnecessary or incomplete treatment in an effort to stem potential antibiotic resistance, and antibiotic prescriptions are increasingly scrutinized as part of antimicrobial stewardship programs. However, the inappropriate overuse of antibiotics in animals also should be addressed as another important source of antibiotic resistance. To the degree that antibiotic overuse in food animals exacerbates problems with resistance, this overuse is a factor contributing to the increased costs to treat antibiotic-resistant infections in humans. According to the Infectious Diseases Society of America, longer, more expensive hospital stays for treating antibiotic resistance cost the US health care sector an estimated $21 to $34 billion and eight million additional hospital days annually.

LEGISLATION AND REGULATIONS

Many countries have already restricted antibiotic use in animal agriculture. In 2006, the European Union banned the use of antimicrobial growth promoters in animal food and water. Denmark, the world's largest exporter of pork, has further restricted use of antibiotics for growth promotion and for the routine prevention of diseases caused by overcrowded and unsanitary feedlot conditions. Researchers documented a subsequent decrease in antibiotic resistance in Danish livestock and retail meat, and within the general Danish population. For example, after Denmark banned avoparcin, an antibiotic similar to vancomycin that was only used in food animal production, levels of vancomycin-resistant enterococci found in Danish livestock and humans dropped within two years. Moreover, there have been no adverse effects on Danish pork production levels because of restrictions on antibiotic use.[5]

In the United States, progress in restricting antibiotic use in livestock has been slow at the federal level. The Preservation of Antibiotics for Medical Treatment Act (PAMTA), a bill that would phase out the use in animal feed of eight classes of medically important antibiotics—aminoglycosides, cephalosporins, lincosamides, macrolides, penicillins, streptogramins, sulfonamides, and tetracyclines—has routinely stalled in Congress. The US Food and Drug Administration has finally issued guidance documents for industry to follow in volunteering to no longer sell their antibiotic products for "growth promotion" (effective December 2016). However, the routine use of identical or nearly identical antibiotic feed additives in the same dose range to prevent disease will still be permitted.

In 2014, in response to recommendations from the President's Council of Advisors on Science and Technology (PCAST), the White House released the National Strategy to Combat Antibiotic-Resistant Bacteria. Although it acknowledges the antibiotic resistance crisis, the Strategy fails to set national targets to reduce antibiotic use in animal agriculture and does not mandate the collection of antibiotic usage data. It also defers to the voluntary guidelines set by the Food and Drug Administration that allow routine use of antibiotics for disease prevention.

Because the actions of federal legislators and regulators remain insufficient, it is time for the health care sector to expand its stewardship over these life-saving drugs beyond clinical practice.

HOSPITAL FOOD PROCUREMENT: AN AVENUE FOR ACTION

Individuals and institutions can discourage the use of nontherapeutic antibiotics in animal agriculture by only purchasing meats from animals raised without the use of nontherapeutic antibiotics. Now is the time for health care providers to leverage our substantial professional and economic clout. We should encourage, persuade, and even pressure our health care institutions to phase out the purchase of meat from animals raised with nontherapeutic antibiotics.

The primary arguments against implementing such actions relate to (1) the availability of meat from animals not subject to routine, nontherapeutic antibiotics, and (2) potential cost increases. However, if individuals and institutions favor meats raised without antibiotics, the supply and availability of these meats will grow to meet the demand, and cost differences will narrow over time. In 1998 the National Research Council estimated that eliminating nontherapeutic use of antibiotics in the United States would cost less than $10 per person annually (in 2015 dollars).[6] Costs can also be kept down by reducing the amount of meat served, which will have added health and environmental benefits.[7]

BUILDING ON PAST ACHIEVEMENTS

Health care providers and institutions have previously taken the lead in areas such as exposure to secondhand smoke and the risks of nuclear weapons, where the health of individuals and the general population has been at risk. These actions are easily justified because health care providers have an ethical imperative to promote health and prevent illness in both individuals and the population. This ethical imperative should now guide health care providers to push for restrictions by health care institutions on the purchase of meat raised with nontherapeutic antibiotics. This action will stimulate similar action by other individuals, institutions, and government agencies.

THE UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

The University of California, San Francisco (UCSF) has taken a leadership role in the movement toward limiting the use of meat raised with excessive antibiotic use. In 2013, UCSF's Academic Senate passed a resolution calling for a phase-out of the purchase of meat raised with nontherapeutic antibiotics. Responding to this resolution, the hospital's Food and Nutrition Services convinced a major food distributor to carry new sustainably raised meat products, and is currently purchasing chicken breasts, eggs, and ground beef that have been raised without the routine use of antibiotics. In addition, the Academic Senate resolution generated media attention and highlighted within and outside the university the issues related to nontherapeutic uses of antibiotics in animal agriculture. Other institutions, including the University of California, Los Angeles, are following suit.

The above actions taken by UCSF have not drawn attention or emphasis away from the ongoing efforts to control antibiotic use in clinical settings at UCSF. In fact, at UCSF and around the country some of the strongest proponents of similar policies have been leaders of antimicrobial stewardship programs.

A CALL TO ACTION

The current indiscriminate use of antibiotics for animal agriculture is irresponsible and misguided. In order to prevent adverse consequences to public health, health care providers and health care institutions can and should logically, ethically, and culturally take responsibility to reduce nontherapeutic use of antibiotics in animal agriculture. Health care providers and health care institutions can start this process by refusing to buy meat raised with nontherapeutic antibiotic use. Health care providers can also encourage their individual patients to purchase meat that is sustainably raised without the overuse of antibiotics. ■

Michael J. Martin, MD, MPH, MBA
Sapna E Thottathil, PhD
Thomas B. Newman, MD, MPH

About the Authors

Michael J. Martin is with the Department of Epidemiology and Biostatistics, University of California, San Francisco. Sapna E Thottathil is with Supply Chain Programming, School Food FOCUS, a program of the Tides Center, San Francisco. Thomas B. Newman is with the Department of Epidemiology and Biostatistics and the Department of Pediatrics, University of California, San Francisco.

Correspondence should be sent to Michael J. Martin, Assistant Clinical Professor, Department of Epidemiology & Biostatistics, Mission Hall: Global Health & Clinical Sciences Building, 550 16th Street, 2nd floor, San Francisco, CA 94158-2549 (e-mail: MichaelMartin@cal.berkeley.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This editorial was accepted August 12, 2015.

doi:10.2105/AJPH.2015.302870

Contributors

All of the authors contributed substantially and significantly to this editorial. M. J. Martin wrote most of the article and coordinated with the other authors to incorporate their contributions. S. E. Thottathil wrote portions of the article and provided editorial comments and input throughout the writing process. She also was helpful in gathering some of the key references. T. B. Newman wrote portions of the article and provided editorial comments and input throughout the writing process.

Acknowledgments

We thank Amy J. Markowitz, JD, for her editorial support. We also thank David Wallinga, MD, MPH, senior health officer at the Natural Resources Defense Council, Health Program for his input to the article.

References

1. Antimicrobial resistance. April 2015. Available at: http://www.who.int/mediacentre/factsheets/fs194/en. Accessed September 14, 2015.

2. Summary Report On Antimicrobials Sold or Distributed for Use in Food-Producing Animals. 2014. Available at: http://www.fda.gov/downloads/ForIndustry/UserFees/AnimalDrugUserFeeActADUFA/UCM338170.pdf. Accessed June 15, 2015.

3. Van Boeckel TP, Brower C, Gilbert M, et al. Global trends in antimicrobial use in food animals. *Proc Natl Acad Sci U S A.* 2015;112:5649–5654.

4. Antibiotic Resistance from the Farm to the Table. September 11, 2014. Available at: http://www.cdc.gov/foodsafety/from-farm-to-table.html. Accessed September 14, 2015.

5. Levy S. Reduced antibiotic use in livestock: how Denmark tackled resistance. *Environ Health Perspect.* 2014;122:A160–A165.

6. The Use of Drugs in Food Animals. Benefits and Risks 1998. Available at: http://www.nap.edu/openbook.php?record_id=5137&page=184. Accessed March 13, 2015.

7. Scientific Report of the 2015 Dietary Guidelines Advisory Committee. Office of Disease Prevention and Health Promotion, 2015. Available at: http://www.health.gov/dietaryguidelines/2015-scientific-report. Accessed June 15, 2015.

The Potential Role of Concentrated Animal Feeding Operations in Infectious Disease Epidemics and Antibiotic Resistance

Mary J. Gilchrist,[1] Christina Greko,[2] David B. Wallinga,[3] George W. Beran,[4] David G. Riley,[5] and Peter S. Thorne[5]

[1]University Hygienic Laboratory, Iowa City, Iowa, USA; [2]National Veterinary Institute, Uppsala, Sweden; [3]Institute for Agriculture and Trade Policy, Minneapolis, Minnesota, USA; [4]Iowa State University, Ames, Iowa, USA; [5]College of Public Health, The University of Iowa , Iowa City, Iowa, USA

The industrialization of livestock production and the widespread use of nontherapeutic antimicrobial growth promotants has intensified the risk for the emergence of new, more virulent, or more resistant microorganisms. These have reduced the effectiveness of several classes of antibiotics for treating infections in humans and livestock. Recent outbreaks of virulent strains of influenza have arisen from swine and poultry raised in close proximity. This working group, which was part of the Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions, considered the state of the science around these issues and concurred with the World Health Organization call for a phasing-out of the use of antimicrobial growth promotants for livestock and fish production. We also agree that all therapeutic antimicrobial agents should be available only by prescription for human and veterinary use. Concern about the risk of an influenza pandemic leads us to recommend that regulations be promulgated to restrict the co-location of swine and poultry concentrated animal feeding operations (CAFOs) on the same site and to set appropriate separation distances. ***Key words:*** **antibiotic resistance, influenza, manure lagoon, poultry, swine, zoonotic disease.** ***Environ Health Perspect*** **115:313–316 (2007). doi:10.1289/ehp.8837 available via** ***http://dx.doi.org/*** **[Online 14 November 2006]**

Background and Recent Developments

As a general principle, the concentration of humans or animals in proximity enhances potential transmission of microorganisms among members of the group. It also creates greater potential for infecting surrounding life forms, even those of different species. The conditions created also may be a breeding ground for new, more infectious, or more resistant microorganisms.

As the human population increases, and mega cities grow, there is greater risk that infectious diseases will evolve, emerge, or spread readily among the populace. The increasing food needs of the growing human population likely will lead to greater populations of livestock. The concentration of animals may augment the risk of zoonoses, diseases transmissible from animals to humans. All segments of livestock production might potentially contribute to zoonotic disease, including transportation of livestock, manure handling practices, veterinary medicine, meat processing and animal rendering. Ideally, everyone involved in each of these components of the industry should be cognizant of the infectious disease risks to animals and humans alike.

Among the many examples of existing risks, some of the more recent are highly pertinent. Nipah virus infections, which occurred in concentrated swine herds in Malaysia and Singapore, killed swine and swine workers (Chua et al. 1999; Paton et al. 1999). Avian influenza has recently infected and caused deaths among poultry and poultry workers in Asia, South America, North America, and Europe [Centers for Disease Control and Prevention 2005; World Health Organization (WHO) 2004]. Many zoonoses may not be related solely to concentrated animal husbandry, but this workshop was devoted to those at least partially attributable to concentration and practices associated with them. While there are many known potential risks for human infection that may result from high concentrations of animals, this article will focus on two—influenza and antibiotic resistance. In addition, we briefly discuss the means of transmission or propagation of infectious agents, including water, animal feed, and human food.

Antibiotic resistance. **State of science.** Antibiotic resistance is increasing among most human pathogens. The many bacteria resistant to multiple antibiotics in particular has heightened concern. In some cases there are few or no antibiotics available to treat resistant pathogens [Institute of Medicine (IOM) 1998; Mølbak et al. 1999]. Development of new antibiotic classes has lagged behind pharmaceutical innovation in other areas, and some innovative new approaches to combating infection are still immature and unproven (Infectious Diseases Society of America 2005; IOM 1998). Escalating resistance has raised concern that we are entering the "post antibiotic era," meaning we may be entering a period where there would be no effective antibiotics available for treating many life-threatening infections in humans. If this proves true, deaths due to infection will once again become a very real threat to substantial numbers of children and young adults as well as the sick and the elderly.

Increased antibiotic resistance can be traced to the use and overuse of antibiotics. Much of that use occurs in human medicine. Health care policy and practice changes designed to minimize this phenomenon are in place in many countries, yet much more can be done. Although antibiotic overuse in animals is problematic, the magnitude of the problem is unknown. There is no national mechanism for collecting data on antibiotic use in many countries and the pharmaceutical industry treats production and sales figures as confidential business information. However, the Union of Concerned Scientists (2001) has estimated that 11.2 million kg of the antibiotics used annually in the United States are administered to livestock as growth promoters. This compares with their estimate of 1.4 million kg for human medical use. Their estimates indicate that 87% of all antibiotic use is for animals, while 13% is for human therapeutic and nontherapeutic use. One researcher suggests lower figures for antibiotic use in growth promotion, stating that no more than 40% of antibiotics in the United States is for animals (Levy 1998). As the IOM recently concluded,

> Clearly, a decrease in antimicrobial use in human medicine alone will have little effect on the current situation. Substantial efforts must be made to decrease inappropriate overuse in animals and agriculture as well. [National Academy of Sciences (NAS) 2003]

Therapeutic antibiotic administration at high levels for the duration of an illness is obviously an important aspect of veterinary care. However, most animal antibiotic use is

This article is part of the mini-monograph "Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions."

Address correspondence to P.S. Thorne, College of Public Health, The University of Iowa, 100 Oakdale Campus, 176 IREH, Iowa City, IA 52242-5000 USA. Telephone: (319) 335-4216. Fax: (319) 335-4006. E-mail: peter-thorne@uiowa.edu

This workshop was supported by grant no. P30 ES05605-14S from the Environmental Health Sciences Research Center at The University of Iowa and the National Institute of Environmental Health Sciences.

The authors declare they have no competing financial interests.

Received 10 November 2005; accepted 13 November 2006.

designed to promote growth and improve feed conversion ratio. However, the growth rate gains with antibiotic growth promotants are less significant with currently used breeds of swine and poultry (Wegener 2003). This prolonged use of antibiotics, especially at low levels, presents a risk of not killing the bacteria while promoting their resistance by selecting for resistant populations. The resistance genes can pass readily from one kind of bacteria to another (Levy 1998). Thus, workers in the animal units may become colonized with resistant organisms and can pass them on to co-workers and family members or friends. Consumers of meat may also become colonized through mishandling of raw meat or through insufficient cooking. Ultimately, these genes may pass into pathogens, and diseases that were formerly treatable will be capable of causing severe illness or death (NAS 2003).

Evidence of resistance associated with antimicrobial growth promotants has been emerging over the past three decades. Tetracycline-resistant organisms were found in 1976 in chickens raised on feed supplemented with tetracycline, a human-use antibiotic. In a prospective study of 11 poultry farm members and 24 neighbors, Levy and co-workers (1976a) found that before the use of tetracycline on the farm neither the farmers nor the animals were positive for tetracycline-resistant intestinal flora. Within 5 months of the introduction of tetracycline in the poultry feed, 31.3% of fecal samples from farm members harbored intestinal flora that were resistant to tetracycline even though none had been treated clinically with tetracycline. Tetracycline-resistant bacteria were found in only 6.8% of the samples from neighbors. Vancomycin-resistant enterococci arose in livestock in Europe in the 1970s because of use of Avoparcin as an antibiotic growth promotant. Neither Avoparcin nor vancomycin was approved for use in livestock in the United States, and vancomycin-resistant enterococci did not emerge in U.S. livestock (Levy et al. 1976b). White and co-workers purchased 200 samples of ground meat in the Washington, DC, area and found that 20% contained culturable *Salmonella*. Of these, 84% of the organisms were resistant to at least one antibiotic tested, and 53% were resistant to three or more (White et al. 2001). Tetracycline resistance genes were identified in a swine CAFO and also in the manure lagoon serving that CAFO and in groundwater 250 m downstream of the lagoon (Chee-Sanford et al. 2001). Using a medicated feed containing tylosin (a macrolide antibiotic), Zahn et al. (2001) compared swine CAFOs with CAFOs using a nonmedicated feed and observed a 3-fold higher concentration of tylosin-resistant bacteria in the exhaust air from the CAFOs. Antibiotics have also been measured in the dust from swine CAFOs (Hamscher et al. 2003).

Several recent studies clearly demonstrate the transmission of multidrug-resistant pathogens from swine to humans. A French group studied 44 nasal *Staphylococcus aureus* isolates from healthy pig farmers and 21 healthy controls. Five isolates were found in pig farmers that were methicillin resistant. Other isolates were resistant to penicillin, lincomycin, erythromycin, pristinamycin, kanamycin, pefloxacin (Armand-Lefevre et al. 2005). By comparing these findings with analyses of isolates from swine infections, the authors concluded that transmission of these resistant organisms from swine to pig farmers may be frequent. Voss and co-workers (2005) in the Netherlands studied methicillin-resistant *S. aureus* (MRSA) among 26 Dutch farmers living nearby a sentinel case of MRSA. Their study demonstrated transmission of three strains of MRSA from swine to pig farmers, from pig farmers to their family members, and from a hospitalized patient (the sentinel case) to a nurse. Investigators in the United States collected air samples via liquid impingers in a swine CAFO and analyzed the samples for viable isolates of antibiotic resistant bacteria (Chapin et al. 2005). Enterococci, staphylococci, and streptococci were analyzed for resistance to erythromycin, clindamycin, virginiamycin, tetracycline, and vancomycin. None of the isolates were resistant to vancomycin, which has never been approved for use in livestock in the United States. In contrast, 98% of the isolates displayed resistance to two or more of the other four antibiotics that are commonly used as growth promotants in swine. It is important to note that 37 of 124 isolates were resistant to all four of these antibiotics (Chapin et al. 2005).

Sweden banned the use of antibiotics as feed additives for growth promotion in 1985 (Swedish Veterinary Antimicrobial Resistance Monitoring 2003). At that time Sweden used 20 metric tons of antibiotics for growth promotion, 14 metric tons for group treatment and 17 metric tons for treating individual sick animals. In 2003, with no use allowed for growth promotion, the amount of antibiotics used for group treatment was 2 metric tons (down from 14 metric tons), accompanied by a decrease, rather than an increase, of individual treatment use from 17 to 14 metric tons. This demonstrates that the banning of growth promotants did not lead to increased antibiotic use in other categories. In Denmark, veterinary researchers observed a 74% incidence of vancomycin-resistant *Enteroccocus faecium* in broiler chickens in 1995. Following a 1997 ban, the level of resistance fell to 2% by 2000 [Aarestrup et al. 2001; Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP) 2004]. In the European Union, antibiotics also used for human medicine were removed from animal use in 1998, and all use of antibiotics as growth promotants are being phased out by 2006 (Casewell et al. 2003). Currently, Sweden and Denmark use less than 3 g of antimicrobial agents per pig slaughtered, whereas the United States uses 47 g (WHO 2003). The experience from the antibiotic bans for broiler chickens demonstrates that the decrease in production—in terms of decreased feed efficiency—is small and is offset by the savings in the cost of antimicrobial growth promotants (Wegener 2003). According to the WHO the increased cost to producers of producing pigs without antibiotic growth promotants is approximately 1% (WHO 2003) and should be compared with the "likely human health benefits to society of antimicrobial growth promoter termination" (WHO 2003).

Animal crowding, CAFO hygiene, temperature and ventilation control, and stress all have an impact on growth rate and the ability of animals to resist disease. Research on the use of other treatments such as probiotics and vaccines holds promise. Probiotics involve the deliberate use of harmless or even beneficial colonizing organisms in food production. It will be important to provide solutions for the spread of antibiotic resistance via air, water, and direct contact to CAFO workers.

The WHO has called for human and veterinary antimicrobial agents to be sold only under prescription. They have also recommended that all countries establish monitoring programs for tracking use and resistance to antimicrobials. The WHO has also called for a rapid phase-out of the use of antimicrobial growth promotants and the creation of prudent use guidelines for veterinary care (WHO 2003).

These practices are not limited to CAFOs. However, it is widely recognized that antibiotic resistance can be staunched only if every effort is made to limit inappropriate use, both with humans and animals.

Risk assessment. Microbial risk assessment is an evolving discipline. Methods have not been developed for estimating risks associated with more than one antibiotic and one bacterium at a time. This approach does not fully address the reality of the CAFO environment, where animals harbor multiple microbial species that are exposed to multiple antibiotics over the course of their lives. Moreover, the existence of genetic multidrug resistance determinants (e.g., plasmids carrying genes coding for resistance to multiple drugs) means that exposure to one antibiotic may lead to increased reservoirs of multiple other antibiotics as well. The fact that resistance determinants may be transferred from benign to pathogenic bacteria means that

exposure of one bacterium to antibiotics today hypothetically could result in manifestation of human disease only months to years later. Reservoirs of resistance may develop relatively rapidly and may not be completely reversible. This suggests that reducing antibiotic usage may not lead to equivalent reductions in resistance among all bacteria of concern. Thus, research should be concurrent with new public policies to reduce antibiotic overuse and ensure the protection of public health.

Vaccines. Development of vaccines could reduce our reliance on antibiotics. The timing of vaccine administration with respect to maternal antibody levels in infants should be studied. Human vaccine administration is undergoing a revolution in anticipation of mass vaccination strategies that may be required to respond to a bioterrorism event. These strategies may also be applicable to animals in veterinary disease prevention. Several diseases afflicting livestock require further research, including necrotic enteritis in poultry (and the use of ionophores for coccidiostats); pasteurella respiratory disease, and; swine ileitis and swine dysentery, as well as diseases of swine at weaning.

Policy initiatives. A number of policy initiatives should be explored to establish consistent and responsible operating practices as well as to promote a shift in current thinking about the value of antibiotic-free meat products. These policies should address all levels of CAFO operation, from the CAFO operators themselves to local, state, and federal governments, veterinarians, agricultural and pharmaceutical industries, and the scientific research community. To ensure sensible use of antibiotics, these issues should also be included in the curricula of pharmacists, doctors, and other medical providers. Furthermore, patients must be suitably informed on the proper use of antibiotics including safe disposal.

Producers and industry leaders can and should be afforded the opportunity to assume a leadership role in reducing antibiotic overuse. This should be encouraged by identifying existing producers—either domestic or international—who are using no or reduced antibiotics and might assume demonstration projects. Along with this, a mentoring system could be created for the purpose of sharing practices that have proven successful in established CAFOs. For example, partners in Sweden and Denmark—countries that have experienced successful transitions to antibiotic-free meat production—might be visited by demonstration team producers, along with veterinarians from the respective countries. Where possible, Danish immigrants or American producers of Danish descent might be paired with Danish producers and veterinarians. These collaborative efforts would require travel funds and the availability of antibiotic-free feed at market prices for the duration of the project. Costs should be tracked and producers reimbursed at the outset so that the interval of adjustment to the new antibiotic-free regimen is not burdensome.

Measures to improve the domestic market for meat raised without routine antibiotics should be sought to promote its vitality as a marketable commodity in the United States. At the same time, new overseas markets should be identified, and these special U.S. products heavily promoted as imports of value and interest to the global economy. In addition, product labeling could be made more comprehensive and explicit so that consumers can identify the product and make selections according to their value system. In fact, such improvements in labeling could be an integral part of an overall quality assurance program that drives the label.

Infectious diseases. **Influenza.** Zoonoses can be transmitted via water, air, consumption or handling of meat products, or by direct transmission from animals to humans. Recent work by Myers and colleagues demonstrated significantly elevated seroprevalence of antibodies against H1N1 and H1N2 swine influenza virus in occupationally exposed adults compared with controls without swine exposure (Myers et al. 2006). Odds ratios for swine H1N1 infection were 35.3 for farmers, 17.8 for veterinarians, and 6.5 for meat processors. For H1N2 infection odds ratios were 13.8, 9.5, and 2.7, respectively (all significant).

The transmission of influenza is a continuing concern. Whether it comes to humans from avian species or swine, or from avian species via swine, or perhaps from humans to swine, strains of high transmissibility and pathogenicity are likely to evolve and create another pandemic (Nature 2005; Webster and Hulse 2005). Recent outbreaks in Asia have shown that transmission of infectious agents can arise from small farms raising poultry in proximity to domiciles and to other animals. However, because CAFOs tend to concentrate large numbers of animals close together, they facilitate rapid transmission and mixing of viruses. There is a concern that increasing the numbers of swine facilities adjacent to avian facilities could further promote the evolution of the next pandemic. The swine industry has adopted a set of guidelines to minimize these risks, including *a*) entry of wild birds and rodents into CAFOs should be limited; *b*) untreated surface water that may have influenza viruses from aquatic birds should not be used for washing facilities, and *c*) waterfowl use of farm lagoons should be minimized. Such prudent practices will minimize risk. To avoid their becoming a mixing vessel for swine or poultry viruses with human viruses, CAFO workers should be immunized against influenza routinely, preferably with the killed vaccine.

The best means to limit transmission of influenza may already be inferred from available data. However, new questions may arise as practices change. What distances should be established between CAFOs housing swine and those housing poultry? Is there a definable, small farm size with minimal numbers of animals that may be allowed?

Surveillance programs should be instituted that maintain biosecurity in CAFOs while maximizing the ability to identify and respond to animal and zoonotic disease outbreaks quickly and effectively.

Waterborne diseases. Concerns persist about surface and groundwater contamination that may have ecosystem and human health impacts. Optimal siting and improved construction practices of CAFOs would reduce the potential for contamination. Escrow accounts or insurance policies that would ensure restoration of a vacated manure lagoon to previous conditions should be imposed on those considering building a CAFO. Solid tanks or reservoirs rather than earthen waste lagoons and municipal-style waste treatment are needed to prevent manure contamination of surface and groundwater with infectious agents or antibiotic resistance genes.

Animal feed containing animal by-products. Animal feed containing animal tissues and by-products is a major concern, as sporeforming bacteria likely will be present even after processing. Included are feathers, offal, carcasses, bone and blood meal, and nervous system and brain tissue. Gram-negative enterobacteria of the genus *Salmonella* will multiply in the food when it is reintroduced at the feeding unit. *Salmonella* can be transmitted to humans through the slaughtering process. Meat packing and CAFO workers are at greater risk of acquiring infection because of their close access to animals and feed. CAFOs are so large and densely populated that when a pathogen is introduced into the system, it is difficult to eliminate. Biosecurity should be rigorous, and extreme quality assurance systems are warranted in these large operations.

Meat for human consumption. Pathogens tend to be amplified in animals raised in CAFOs and, thus, are more difficult to eliminate in meat packing processes. Research is needed to develop better ways of controlling pathogen growth in meat. Studies should investigate measures to control *Salmonella* cycling within a CAFO. Improved hygiene and ventilation may be sufficient measures. Better controls on the food processing environment are also indicated. Organisms can amplify very efficiently in a holding pen containing live animals. Multidrug-resistant pathogens are of grave concern and are more likely to arise in animal feeding operations that rely on nontherapeutic antibiotic use instead of enhanced hygiene, air filtration, biosecurity and disease surveillance.

Finally, research needs include developing better means to reduce colonization of animals and meat with *Campylobacter*, *Salmonella*, *Escherichia coli*, and other organisms.

Workshop Recommendations

Priority research needs.

- Discontinue nontherapeutic use in the United States: The practice of feeding antibiotics to animals as growth enhancers should be phased out in the United States as it has in the European Union and as called for by the WHO, the IOM, and many scientific and public health organizations. Research studies should monitor the discontinuation to ensure that the ban on antibiotic use for growth promotion is not supplanted by increased therapeutic use.
- Surveillance programs: Coordinated nationwide surveillance programs (Aarestrup 2004) should be instituted to fully assess the contribution of antibiotic use in livestock production to the creation of ecological reservoirs of resistance, or the transmission of that resistance to humans.
- Strain identification: Fingerprinting of isolates of antibiotic-resistant bacteria and the resistance elements should be conducted to establish relationships among members of the same species. Results should be used to identify unknown sources of resistance and to track changes in resistance profiles in response to diminished antibiotic use.
- Influenza risk: Countries and states should establish minimum separation distances for swine and poultry facilities to reduce the risk of influenza outbreaks.
- Manure storage and waste processing: Livestock production facilities should incorporate solid tanks for manure storage and municipal style waste treatment to limit microbial and nutrient contamination of surface and groundwater.

References

Aarestrup FM. 2004. Monitoring of antimicrobial resistance among food animals: principles and limitations. J Vet Med B 51:380–388

Aarestrup FM, Seyfarth AM, Emborg H-D, Pedersen K, Hendriksen RS, Bager F. 2001. Effect of abolishment of the use of antimicrobial agents for growth promotion on occurrence of antimicrobial resistance in fecal enterococci from food animals in Denmark. Antimicrob Agents Chemother 45:2054–2059.

Armand-Lefevre L, Ruimy R, Andremont A. 2005. Clonal comparison of *Staphylococcus aureus* isolates from healthy pig farmers, human controls, and pigs. Emerg Infect Dis 11:711–714.

Casewell M, Friis, C Marco E, McMullin P, Phillips I. 2003. The European ban on growth-promoting antibiotics and emerging consequences for human and animal health. J Antimicrob Chemother 52:159–161.

Centers for Disease Control and Prevention.2005. Avian Influenza Infection in Humans. Available: http://www.cdc.gov/flu/avian/gen-info/avian-flu-humans.htm [accessed 26 September 2005].

Chapin A, Rule A, Gibson K, Buckley T, Schwab K. 2005. Airborne multidrug-resistant bacteria isolated from a concentrated swine feeding operation. Environ Health Perspect 113:137–142.

Chee-Sanford JC, Aminov RI, Krapac IJ, Garrigues-Jeanjean N, Mackie RI. 2001. Occurrence and diversity of tetracycline resistance genes in lagoons and groundwater underlying two swine production facilities. Appl Environ Microbiol 67(4):1494–1502.

Chua KB, Goh KJ, Wong KT, Kamarulzaman A, Tan PS, Ksiazek TG, et al. 1999. Fatal encephalitis due to Nipah virus among pig-farmers in Malaysia. Lancet 354(9186):1257–1259.

DANMAP. 2004. Use of Antimicrobial Agents and Occurrence of Antimicrobial Resistance in Bacteria from Food Animals, Foods and Humans in Denmark (Emborg H-D , Heuer OE, Larsen PB, eds). Søborg, Denmark:Danish Integrated Antimicrobial Resistance Monitoring and Research Programme. Available: http://www.vetinst.dk [accessed 26 September 2005].

Hamscher B, Pawelzick HT, Sczesny S, Nau H, Hartung J. 2003. Antibiotics in dust originating from a pig-fattening farm: a new source of health hazard for farmers? Environ Health Perspect111:1590–1594.

Infectious Diseases Society of America. 2005. Bad Bugs, No Drugs Executive Summary: Antibiotic-Resistant Bacterial Pathogens: Why We Are Concerned. Available: http://www.idsociety.org/ [accessed 26 September 2005].

IOM (Institute of Medicine). 1998. Antimicrobial Resistance: Issues and Options. Forum on Emerging Infections (Harrison PF, Lederberg J, eds). Washington, DC:National Academy Press.

Levy SB. 1998. The challenge of antibiotic resistance. Sci Am 278(3):46–53.

Levy SB, Fitzgerald GB, Macone AB. 1976a. Changes in intestinal flora of farm personnel after introduction of a tetracycline-supplemented feed on a farm. N Engl J Med 295(11):583–588.

Levy SB, Fitzgerald GB, Macone AB. 1976b. Spread of antibiotic-resistant plasmids from chicken to chicken and from chicken to man. Nature 260:40–42.

Mølbak K, Baggesen DL, Aarestrup FM, Ebbesen JM, Engberg J, Frydendahl K, et al. 1999. An outbreak of multidrug-resistant, quinolone-resistant *Salmonella enterica* serotype typhimurium DT104. N Engl J Med 341:1420–1425.

Myers KP, Olsen CW, Setterquist SF, Capuano AW, Donham KJ, Thacker EL, et al. 2006. Are swine workers in the United States at increased risk of infection with zoonotic influenza virus? Clin Infect Dis 42(1):14–20.

NAS (National Academy of Sciences). 2003. Microbial Threats to Health: Emergence, Detection and Response (Smolinski MS, Hamburg MA, Lederberg J, eds). Committee on Emerging Microbial Threats to Health in the 21st Century, Board on Global Health. Washington, DC:Institute of Medicine of the National Academies, National Academies Press.

Nature. 2005. On a wing and a prayer [Editorial]. Nature 435(7041):385–386.

Paton NI, Leo YS, Zaki SR, Auchus AP, Lee KE, Ling AE, et al. 1999. Outbreak of Nipah-virus infection among abattoir workers in Singapore. Lancet 354(9186):1253–1256.

Swedish Veterinary Antimicrobial Resistance Monitoring. 2003. National Veterinary Institute Home Page. Uppsala, Sweden:The National Veterinary Institute. Available: http://www.sva.se/ [accessed 26 September 2005].

Union of Concerned Scientists. 2001. Hogging It! Estimates of Antimicrobial Abuse in Livestock (Mellon M, Benbrook C, Benbrook KL, eds). Cambridge, MA:UCS Publications. Available: http://ucsusa.org/publications [accessed 5 January 2007].

Voss A, Loeffen F, Bakker J, Klaassen C, Wulf M. Methicillin-resistant *Staphylococcus aureus* in pig farming. Emerg Infect Dis 11:1965–1966.

Webster R, Hulse D. 2005. Controlling avian flu at the source. Nature 435:415–416.

Wegener HC. 2003. Antibiotics in animal feed and their role in resistance development. Curr Opin Microbiol 6(5):439–445.

White DG, Zhao S, Sudler R, Ayers S, Friedman S, Chen S, et al. 2001. The isolation of antibiotic-resistant *Salmonella* from retail ground meats. N Engl J Med 345:1147–1154.

WHO. 2003. Impacts of Antimicrobial Growth Promoter Termination in Denmark:World Health Organization International Review Panel's Evaluation of the Termination of the Use of Antimicrobial Growth Promoters in Denmark, 6–8 November 2002, Foulum, Denmark. WHO/CDS/CPE/ZFK/2003.1. Copenhagen:World Health Organization.

WHO . 2004. Avian Influenza A (H5N1)—Update 31. World Health Organization. Available: http://www.who.int/csr/don/2004_03_02/en/ [accessed 26 September 2005].

Zahn JA, Anhalt J, Boyd E. 2001. Evidence for transfer of tylosin and tylosin-resistant bacteria in air from swine production facilities using sub-therapeutic concentrations of tylan in feed [Abstract]. J Anim Sci 79:189.

Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality

JoAnn Burkholder,[1] Bob Libra,[2] Peter Weyer,[3] Susan Heathcote,[4] Dana Kolpin,[5] Peter S. Thorne,[3] and Michael Wichman[6]

[1]North Carolina State University, Raleigh, North Carolina, USA; [2]Iowa Geological Survey, Iowa City, Iowa, USA; [3]The University of Iowa, Iowa City, Iowa, USA; [4]Iowa Environmental Council, Des Moines, Iowa, USA; [5]Toxic Substances Hydrology Program, U.S. Geological Survey, Iowa City, Iowa, USA; [6]University Hygienic Laboratory, Iowa City, Iowa, USA

Waste from agricultural livestock operations has been a long-standing concern with respect to contamination of water resources, particularly in terms of nutrient pollution. However, the recent growth of concentrated animal feeding operations (CAFOs) presents a greater risk to water quality because of both the increased volume of waste and to contaminants that may be present (e.g., antibiotics and other veterinary drugs) that may have both environmental and public health importance. Based on available data, generally accepted livestock waste management practices do not adequately or effectively protect water resources from contamination with excessive nutrients, microbial pathogens, and pharmaceuticals present in the waste. Impacts on surface water sources and wildlife have been documented in many agricultural areas in the United States. Potential impacts on human and environmental health from long-term inadvertent exposure to water contaminated with pharmaceuticals and other compounds are a growing public concern. This workgroup, which is part of the Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions, identified needs for rigorous ecosystem monitoring in the vicinity of CAFOs and for improved characterization of major toxicants affecting the environment and human health. Last, there is a need to promote and enforce best practices to minimize inputs of nutrients and toxicants from CAFOs into freshwater and marine ecosystems. ***Key words:*** **ecology, human health, poultry, swine, water contaminants, wildlife.** ***Environ Health Perspect*** **115:308–312 (2007). doi:10.1289/ehp.8839 available via** ***http://dx.doi.org/*** **[Online 14 November 2006]**

Background and Recent Developments

Concentrated animal feed operations and water quality. Animal cultivation in the United States produces 133 million tons of manure per year (on a dry weight basis) representing 13-fold more solid waste than human sanitary waste production [U.S. Environmental Protection Agency (U.S. EPA) 1998]. Since the 1950s (poultry) and the 1970s–1980s (cattle, swine), most animals are now produced for human consumption in concentrated animal feeding operations (CAFOs). In these industrialized operations, the animals are held throughout their lives at high densities in indoor stalls until they are transported to processing plants for slaughter. There is substantial documentation of major, ongoing impacts on aquatic resources from CAFOs, but many gaps in understanding remain.

Contaminants detected in waste and risk of water contamination. Contaminants from animal wastes can enter the environment through pathways such as through leakage from poorly constructed manure lagoons, or during major precipitation events resulting in either overflow of lagoons and runoff from recent applications of waste to farm fields, or atmospheric deposition followed by dry or wet fallout (Aneja 2003). The magnitude and direction of transport depend on factors such as soil properties, contaminant properties, hydraulic loading characteristics, and crop management practices (Huddleston 1996). Many contaminants are present in livestock wastes, including nutrients (Jongbloed and Lenis 1998), pathogens (Gerba and Smith 2005; Schets et al. 2005), veterinary pharmaceuticals (Boxall et al. 2003; Campagnolo et al. 2002; Meyer 2004), heavy metals [especially zinc and copper; e.g., Barker and Zublena (1995); University of Iowa and Iowa State Study Group (2002)], and naturally excreted hormones (Hanselman et al. 2003; Raman et al. 2004). Antibiotics are used extensively not only to treat or prevent microbial infection in animals (Kummerer 2004), but are also commonly used to promote more rapid growth in livestock (Cromwell 2002; Gaskins et al. 2002; Liu et al. 2005). In addition, pesticides such as dithiocarbamates are applied to sprayfields (Extension Toxicology Network 2003). Although anaerobic digestion of wastes in surface storage lagoons can effectively reduce or destroy many pathogens, substantial remaining densities of microbial pathogens in waste spills and seepage can contaminate receiving surface- and groundwaters (e.g., Burkholder et al. 1997; Mallin 2000). Pharmaceuticals can remain present as parent compounds or degradates in manure and leachates even during prolonged storage. Improper disposal of animal carcasses and abandoned livestock facilities can also contribute to water quality problems. Siting of livestock operations in areas prone to flooding or where there is a shallow water table increases the potential for environmental contamination.

The nutrient content of the wastes can be a desirable factor for land application as fertilizer for row crops, but overapplication of livestock wastes can overload soils with both macronutrients such as nitrogen (N) and phosphorous (P), and heavy metals added to feed as micronutrients (e.g., Barker and Zublena 1995). Overapplication of animal wastes or application of animal wastes to saturated soils can also cause contaminants to move into receiving waters through runoff and to leach through permeable soils to vulnerable aquifers. Importantly, this may happen even at recommended application rates. As examples, Westerman et al. (1995) found 3–6 mg nitrate (NO_3)/L in surface runoff from sprayfields that received swine effluent at recommended rates; Stone et al. (1995) measured 6–8 mg total inorganic N/L and 0.7–1.3 mg P/L in a stream adjacent to swine effluent sprayfields. Evans et al. (1984) reported 7–30 mg NO_3/L in subsurface flow draining a sprayfield for swine wastes, applied at recommended rates. Ham and DeSutter (2000) described export rates of up to 0.52 kg ammonium m^{-2} $year^{-1}$ from lagoon seepage; Huffman and Westerman (1995) reported that groundwater near swine waste lagoons averaged 143 mg inorganic N/L, and estimated export rates at 4.5 kg inorganic N/day. Thus, nutrient losses into receiving waters can be excessive relative to levels (~ 100–200 µg inorganic N or P/L)

This article is part of the mini-monograph "Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions."

Address correspondence to P.S. Thorne, College of Public Health, 100 Oakdale Campus, The University of Iowa, 176 IREH, Iowa City, IA 52242 USA. Telephone: (319) 335-4216. Fax: (319) 335-4225. E-mail: peter-thorne@uiowa.edu

This workshop was supported by grant no. P30 ES05605-14S from the Environmental Health Sciences Research Center at The University of Iowa and the National Institute of Environmental Health Sciences.

The authors declare they have no competing financial interests.

Received 10 November 2005; accepted 13 November 2006.

known to support noxious algal blooms (Mallin 2000). In addition to contaminant chemical properties, soil properties and climatic conditions can affect transport of contaminants. For example, sandy, well-drained soils are most vulnerable to transport of nutrients to underlying groundwater (Mueller et al. 1995). Nutrients can also readily move through soils under wet conditions (McGechan et al. 2005).

Presence of contaminants in water sources. The presence of many contaminants from livestock waste has been documented in both surface water and groundwater supplies in agricultural areas within the United States (e.g., Campagnolo et al. 2002; Kolpin et al. 2002; Meyer 2004). Urban wastewater streams also contain these contaminants, and efforts to accurately determine sources of contamination are under way (Barnes et al. 2004; Cordy et al. 2004; Kolpin DW, unpublished data). The U.S. Geological Survey (USGS) began pilot surveillance programs for organic wastewater contaminants in 1999 and expanded that effort to a national scale over the past 5 years (Kolpin et al. 2002). Recent USGS efforts have focused specifically on water quality in agricultural locations (Kolpin DW, unpublished data). Nutrient levels have been detected in high parts per million (milligrams per liter) levels; pharmaceuticals and other compounds are generally measured in low levels (ppb [micrograms per liter]). In Europe, surveillance efforts conducted in Germany documented the presence of veterinary pharmaceuticals in water resources (Hirsch et al. 1999).

Animal wastes are also rich in organics and high in biochemical oxygen-demanding materials (BOD); for example, treated human sewage contains 20–60 mg BOD/L, raw sewage contains 300–400 mg BOD/L, and swine waste slurry contains 20,000–30,000 mg BOD/L (Webb and Archer 1994). Animal wastes also carry parasites, viruses, and bacteria as high as 1 billion/g (U.S. EPA 1998). Swine wastes contain > 100 microbial pathogens that can cause human illness and disease [see review in Burkholder et al. (1997)]. About one-third of the antibiotics used in the United States each year is routinely added to animal feed to increase growth (Mellon et al. 2001). This practice is promoting increased antibiotic resistance among the microbial populations present and, potentially, increased resistance of naturally occurring pathogens in surface waters that receive a portion of the wastes.

Contaminant impacts. Some contaminants pose risks for adverse health impacts in wildlife or humans. The effects of numerous waterborne pathogens on humans are well known, although little is known about potential impacts of such microorganisms on aquatic life. With respect to nutrients, excessive phosphorus levels can contribute to algal blooms and cyanobacterial growth in surface waters used for recreation and as sources of drinking water. Research is beginning to investigate the environmental effects, including endocrine disruption and antibiotic resistance issues (Burnison et al. 2003; Delepee et al. 2004; Fernandez et al. 2004; Halling-Sorensen et al. 2003; Sengelov et al. 2003; Soto et al. 2004; Wollenberger et al. 2000). However, knowledge is limited in several crucial areas. These areas include information on metabolites or environmental degradates of some parent compounds; the environmental persistence, fate, and transport and toxicity of metabolites or degradates (Boxall et al. 2004); the potential synergistic effects of various mixtures of contaminants on target organisms (Sumpter and Johnson 2005); and the potential transport and effects from natural and synthetic hormones (Hanselman et al. 2003; Soto et al. 2004). Further, limited monitoring has been conducted of ecosystem health in proximity to CAFOs, including monitoring the effects on habitats from lagoon spills during catastrophic flooding (Burkholder et al. 1997; Mallin et al. 1997; Mallin et al. 2000).

Ecologic and wildlife impacts. Anoxic conditions and extremely high concentrations of ammonium, total phosphorus, suspended solids, and fecal coliform bacteria throughout the water column for approximately 30 km downstream from the point of entry have been documented as impacts of waste effluent spills from CAFOs (Burkholder et al. 1997; Mallin et al. 2000). Pathogenic microorganisms such as *Clostridium perfringens* have been documented at high densities in receiving surface waters following CAFO waste spills (Burkholder et al. 1997). These degraded conditions, especially the associated hypoxia/anoxia and high ammonia, have caused major kills of freshwater fish of all species in the affected areas, from minnows and gar to largemouth bass, and estuarine fish, including striped bass and flounder (Burkholder et al. 1997). Waste effluent spills also stimulated blooms of toxic and noxious algae. In freshwaters, these blooms include toxic and noxious cyanobacteria while in estuaries, harmful haptophytes and toxic dinoflagellates arise. Most states monitor only water-column fecal coliform densities to assess whether waterways are safe for human contact. World Health Organization (WHO) guidelines for cyanobacteria in recreational water are 20,000 cyanobacterial cells/mL, which indicates low probability of adverse health effects, and 100,000 cyanobacterial cells/mL, which indicates moderate probability of adverse health effects (WHO 2003). Yet fecal bacteria and other pathogenic microorganisms typically settle out to the sediments where they can thrive at high densities for weeks to months following CAFO waste effluent spills (Burkholder et al. 1997).

The impacts from CAFO pollutant loadings to direct runoff are more substantial after such major effluent spills or when CAFOs are flooded and in direct contact with surface waters (Wing et al. 2002). Although the acute impacts are often clearly visible—dead fish floating on the water surface, or algal overgrowth and rotting biomass—the chronic, insidious, long-term impacts of commonly accepted practices of CAFO waste management on receiving aquatic ecosystems are also significant (U.S. EPA 1998). One purpose of manure storage basins is to reduce the N content of the manure through volatilization of ammonia and other N-containing molecules. Many studies have shown, for example, that high nutrient concentrations (e.g., ammonia from swine CAFOs, or ammonia oxidized to NO_3, or phosphorus from poultry CAFOs) commonly move off-site to contaminate the overlying air and/or adjacent surface and subsurface waters (Aneja et al. 2003; Evans et al. 1984; Sharpe and Harper 1997; Sharpley and Moyer 2000; Stone et al. 1995; U.S. EPA 1998; Webb and Archer 1994; Westerman et al. 1995; Zahn et al. 1997). Inorganic N forms are added to the atmosphere during spray practices, and both ammonia and phosphate can also adsorb to fine particles (dust) that can be airborne. The atmospheric depositions are noteworthy, considering that a significant proportion of the total ammonium from uncovered swine effluent lagoons and effluent spraying (an accepted practice in some states) reenters surface waters as local precipitation or through dry fallout (Aneja et al. 2003; U.S. EPA 1998, 2000). The contributed nutrient concentrations from the effluent greatly exceed the minimal levels that have been shown to promote noxious algal blooms (Mallin 2000) and depress the growth of desirable aquatic habitat species (Burkholder et al. 1992). The resulting chronically degraded conditions of nutrient overenrichment, while not as extreme as during a major waste spill, stimulate algal blooms and long-term shifts in phytoplankton community structure from desirable species (e.g., diatoms) to noxious species.

A summary of the findings from a national workshop on environmental impacts of CAFOs a decade ago stated that there was "a surprising lack of information about environmental impacts of CAFOs to adjacent lands and receiving waters" (Thu K, Donham K, unpublished data). Although the knowledge base has expanded since that time, especially regarding adverse effects of inorganic N and P overenrichment and anoxia, impacts of many CAFO pollutants on receiving aquatic ecosystems remain poorly understood. As examples, there is poor understanding of the impacts of fecal bacteria and other microbial pathogens from CAFO waste effluent contamination on

aquatic communities; impacts of antibiotic-resistant bacteria created from CAFO wastes on aquatic life; impacts of organic nutrient forms preferred by certain noxious plankton; impacts from the contributed pesticides and heavy metals; and impacts from these pollutants acting in concert, additively or synergistically. This lack of information represents a critical gap in our present ability to assess the full extent of CAFO impacts on aquatic natural resources.

Despite their widespread use, antibiotics have only recently received attention as environmental contaminants. Most antibiotics are designed to be quickly excreted from the treated organism. Thus, it is not surprising that antibiotics are commonly found in human and animal waste (Christian et al. 2003; Dietze et al. 2005; Glassmeyer et al. 2005; Meyer 2004) and in water resources affected by sources of waste (Glassmeyer et al. 2005; Kolpin et al. 2002). Although some research has been conducted on the environmental effects from antibiotics (e.g., Brain et al. 2005; Jensen et al. 2003), much is yet to be understood pertaining to long-term exposures to low levels of antibiotics (both individually and as part of complex mixtures of organic contaminants in the environment). The greatest risks appear to be related to antibiotic resistance (Khachatourians 1998; Kummerer 2004) and natural ecosystem functions such as soil microbial activity and bacterial denitrification (Costanzo et al. 2005; Thiele-Bruhn and Beck 2005).

Human health impacts. Exposure to waterborne contaminants can result from both recreational use of affected surface water and from ingestion of drinking water derived from either contaminated surface water or groundwater. High-risk populations are generally the very young, the elderly, pregnant women, and immunocompromised individuals. Recreational exposures and illnesses include accidental ingestion of contaminated water that may result in diarrhea or other gastrointestinal tract distress from waterborne pathogens, and dermal contact during swimming that may cause skin, eye, or ear infections. Drinking water exposures to pathogens could occur in vulnerable private wells; under normal circumstances community water utilities disinfect water sufficiently before distribution to customers. Cyanobacteria (blue–green algae) in surface water can produce toxins (e.g., microcystins) that are known neurotoxins and hepatotoxins. Acute and chronic health impacts from these toxins can occur from exposures to both raw water and treated water (Carmichael et al. 2001; Rao et al. 2002). Removal of cyanotoxins during drinking water treatment is a high priority for the drinking water industry (Hitzfield et al. 2000; Rapala et al. 2002). The WHO has set a provisional drinking water guideline of 1 µg microcystin-LR/L (Chorus and Bartram 1999). While there are no drinking water standards in the United States for cyanobacteria, they are on the U.S. EPA Unregulated Contaminant Monitoring Rule List 3 (U.S. EPA 2006).

Exposure to chemical contaminants can occur in both private wells and community water supplies, and may present health risks. High nitrate levels in water used in mixing infant formula have been associated with risk for methemoglobinemia (blue-baby syndrome) in infants under 6 months of age, although other health factors such as diarrhea and respiratory disease have also been implicated (Ward et al. 2005). The U.S. EPA drinking water standard of 10 mg/L NO_3–N and the WHO guideline of 11 mg/L NO_3–N were set because of concerns about methemoglobinemia. (Note: "nitrate" refers to nitrate–nitrogen). Epidemiologic studies of noncancer health outcomes and high nitrate levels in drinking water have reported an increased risk of hyperthyroidism (Seffner 1995) from long-term exposure to levels between 11–61 mg/L (Tajtakova et al. 2006). Drinking water nitrate at levels < 10 mg/L has been associated with insulin-dependent diabetes (IDDM; Kostraba et al. 1992), whereas other studies have shown an association with IDDM at nitrate levels > 15 mg/L (Parslow et al. 1997) and > 25 mg/L (van Maanen et al. 2000). Increased risks for adverse reproductive outcomes, including central nervous system malformations (Arbuckle et al. 1988) and neural tube defects (Brender et al. 2004; Croen et al. 2001), have been reported for drinking water nitrate levels < 10 mg/L.

Anecdotal reports of reproductive effects of nitrate in drinking water include a case study of spontaneous abortions in women consuming high nitrate water (19–26 mg/L) from private wells (Morbidity and Mortality Weekly Report 1996).

While amassing experimental data suggest a role for nitrate in the formation of carcinogenic *N*-nitroso compounds, clear epidemiologic findings are lacking on the possible association of nitrate in drinking water with cancer risk. Ecologic studies have reported mixed results for cancers of the stomach, bladder, and esophagus (Barrett et al. 1998; Cantor 1997; Eicholzer and Gutzwiller 1990; Morales-Suarez-Varela et al. 1993, 1995) and non-Hodgkin lymphoma (Jensen 1982; Weisenburger 1993), positive findings for cancers of the nasopharynx (Cantor 1997), prostate (Cantor 1997), uterus (Jensen 1982; Thouez et al. 1981), and brain (Barrett et al. 1998), and negative findings for ovarian cancer (Jensen 1982; Thouez et al. 1981). Positive findings have generally been for long-term exposures at > 10 mg/L nitrate. Case–control studies have reported mixed results for stomach cancer (Cuello et al. 1976; Rademacher et al. 1992; Yang et al. 1998); positive results for non-Hodgkin lymphoma at > 4 mg/L nitrate (Ward et al. 1996) and colon cancer at > 5 mg/L (De Roos et al. 2003); and negative results for cancers of the brain (Mueller et al. 2001; Steindorf et al. 1994), bladder (Ward et al. 2003), and rectum (De Roos et al. 2003), all at < 10 mg/L. Cohort studies have reported no association between nitrate in drinking water and stomach cancer (Van Loon et al. 1998); positive associations with cancers of the bladder and ovary at long-term exposures > 2.5 mg/L (Weyer et al. 2001); and inverse associations with cancers of the rectum and uterus, again at > 2.5 mg/L (Weyer et al. 2001).

Exposure to low levels of antibiotics and other pharmaceuticals in drinking water (generally at micrograms per liter or nanograms per liter) represent unintentional doses of substances generally used for medical purposes to treat active disease or prevent disease. The concern is more related to possible cumulative effects of long-term low-dose exposures than on acute health effects (Daughton and Ternes 1999). A recent study conducted in Germany found that the margin between indirect daily exposure via drinking water and daily therapeutic dose was at least three orders of magnitude, concluding that exposure to pharmaceuticals via drinking water is not a major health concern (Webb et al. 2003). It should be noted that when prescribing medications, providers ensure patients are not taking incompatible drugs, but exposure via drinking water is beyond their control.

Endocrine-disrupting compounds are chemicals that exhibit biological hormonal activity, either by mimicking natural estrogens, by canceling or blocking hormonal actions, or by altering how natural hormones and their protein receptors are made (McLachlan and Korach 1995). Although very low levels of estrogenic compounds can stimulate cell activity, the potential for human health effects, such as breast and prostate cancers, and reproductive effects from exposure to endocrine disruptors, is in debate (Weyer and Riley 2001).

Workshop Recommendations

Priority research needs.

- Ecosystems monitoring: Systematic sustained studies of ecosystem health in proximity to large CAFOs are needed, including effects of input spikes during spills or flooding events.
- Toxicologic assessment of contaminants: Identification and prioritization of contaminants are needed to identify those that are most significant to environmental and public health. Toxicity studies need to be conducted to identify and quantify contaminants

(including metabolites), and to investigate interactions (synergistic, additive, and antagonistic effects).

- Fate and transport: Studies of parent compounds and metabolites in soil and water must be conducted, and the role of sediment as a carrier and reservoir of contaminants must be evaluated.
- Surveillance programs: Programs should be instituted to assess private well water quality in high-risk areas. Biomonitoring programs should be designed and implemented to assess actual dose from environmental exposures.

Translation of science to policy.

- Wastewater and drinking water treatment: Processes for water treatment must be monitored to ensure adequate removal or inactivation of emerging contaminants.
- Pollution prevention: Best management practices should be implemented to prevent or minimize release of contaminants into the environment.
- Education: Educational materials should be continued to be developed and distributed to agricultural producers.

References

Aneja VP, Nelson DR, Roelle PA, Walker JT. 2003. Agricultural ammonia emissions and ammonium concentrations associated with aerosols and precipitation in the southeast United States. J Geophys Res 108(D4):ACH12-1–12-11.

Arbuckle TE, Sherman GJ, Corey PN, Walters D, Lo B. 1988. Water nitrates and CNS birth defects: a population-based case-control study. Arch Environ Health 43:162–167.

Barker JC, Zublena JP. 1995. Livestock Manure Nutrient Assessment in North Carolina. Final Report. Raleigh, NC: North Carolina Agricultural Extension Service, North Carolina State University.

Barnes KK, Christenson SC, Kolpin DW, Focazio MJ, Furlong ET, Zaugg SD, et al. 2004. Pharmaceuticals and other organic wastewater contaminants within a leachate plume downgradient of a municipal landfill. Ground Water Monitoring Rev 24:119–126.

Barrett JH, Parslow RC, McKinney PA, Law GR, Forman D. 1998. Nitrate in drinking water and the incidence of gastric, esophageal, and brain cancer in Yorkshire, England. Cancer Causes Control 9:153–159.

Boxall ABA, Kolpin DW, Halling-Sorenson B, Tolls J. 2003. Are veterinary medicines causing environmental risks? Environ Sci Technol 37:286A–294A.

Boxall ABA, Sinclair CJ, Fenner K, Kolpin DW, Maund SJ. 2004. When synthetic chemicals degrade in the environment. Environ Sci Technol 38:369A–375A.

Brain RA, Wilson CJ, Johnson DJ, Sanderson H, Bestari K, Hanson ML, et al. 2005. Effects of a mixture of tetracyclines to *Lemna gibba* and *Miriophyllum sibiricum* evaluated in aquatic microcosms. Environ Pollution 138:425–442.

Brender JD, Olive JM, Felkner M, Suarez L, Marckwardt W, Hendricks KA. 2004. Dietary nitrites and nitrates, nitrosable drugs, and neural tube defects. Epidemiology 15:330–336.

Burkholder JM, Mallin MA, Glasgow HB, Larsen LM, McIver MR, Shank GC, et al. 1997. Impacts to a coastal river and estuary from rupture of a large swine waste holding lagoon. J Environ Qual 26:1451–1466.

Burkholder JM, Mason KM, Glasgow HB. 1992. Water-column nitrate enrichment promotes decline of eelgrass (*Zostera marina* L.): evidence from seasonal mesocosm experiments. Mar Ecol Prog Ser 81:163–178.

Burnison BK, Hartmann A, Lister A, Servos MR, Ternes T, Van der Kraak G. 2003. A toxicity identification evaluation approach to studying estrogenic substances in hog manure and agricultural runoff. Environ Toxicol Chem 22:2243–2250.

Campagnolo ER, Johnson KR, Karpati A, Rubin CS, Kolpin DW, Meyer MT, et al. 2002. Antimicrobial residues in animal waste and water resources proximal to large-scale swine and poultry feeding operations. Sci Total Environ 299:89–95.

Cantor KP. 1997. Drinking water and cancer. Cancer Causes Control 8:292–308.

Carmichael WW, Azevedo SMFO, An JS, Molica RJR, Jochimsen EM, Lau S, et al. 2001. Human fatalities from cyanobacteria: chemical and biological evidence for cyanotoxins. Environ Health Perspect 109:663–668.

Chorus I, Bartram J, eds. 1999. Toxic Cyanobacteria in Water—A Guide to their Public Health Consequences, Monitoring and Management. Geneva:World Health Organization. Available: http://www.who.int/water_sanitation_health/resourcesquality/toxicyanbact/en/ [accessed 5 January 2007].

Christian T, Schneider RJ, Barber HA, Skutlarek D, Meyer GT, Goldrach HE. 2003. Determination of antibiotic residues in manure, soil, and surface waters. Acta Hydrochim Hydrobiol 31:36–44.

Cordy G, Duran N, Bower H, Rice R, Kolpin DW, Furlong ET, et al. 2004. Do pharmaceuticals, pathogens, and other organic wastewater compounds persist when wastewater is used for recharge? Ground Water Monitoring Rev 24:58–69.

Costanzo SD, Murby J, Bates J. 2005. Ecosystem response to antibiotics entering the aquatic environment. Marine Pollut Bull 51:218–223.

Croen LA, Todoroff K, Shaw GM. 2001. Maternal exposure to nitrate from drinking water and diet and risk for neural tube defects. Am J Epidemiol 153:325–331.

Cromwell GL. 2002. Why and how antibiotics are used in swine production. Anim Biotechnol 13:7–27.

Cuello C, Correa P, Haenszel W, Gordillo G, Brown C, Archer M, et al. 1976. Gastric cancer in Columbia. 1. Cancer risk and suspect environmental agents. J Natl Cancer Inst 57:1015–1020.

Daughton CG, Ternes TA. 1999. Pharmaceuticals and personal care products in the environment: agents of subtle change? Environ Health Perspect 107:907–938.

Delepee R, Pouliquen H, Le Bris H. 2004. The bryophyte *Fontinalis antipyretica* Hedw. bioaccumulates oxytetracycline, flumequine and oxolinic acid in the freshwater environment. Sci Total Environ 322:243–253.

De Roos AJ, Ward MH, Lynch CF, Cantor KP. 2003. Nitrate in public water supplies and the risk of colon and rectum cancers. Epidemiology 14:640–649.

Dietze JE, Scribner EA, Meyer MT, Kolpin DW. 2005. Occurrence of antibiotics in water from 13 fish hatcheries, 2001–03. Intern J Environ Anal Chem 85:1141–1152.

Eicholzer M and Gutzwiller F. 1990. Dietary nitrates, nitrites and *N*-nitroso compounds and cancer risk: a review of the epidemiologic evidence. Nutr Rev 56:95–105.

Evans, RO, Westerman PW, Overcash MR. 1984. Subsurface drainage water quality from land application of swine lagoon effluent. Trans Am Soc Agric Eng 27:473–480.

Extension Toxicology Network. 2003. Exotoxnet—A Pesticide Information Project of the Cooperative Extension Offices of Cornell University, Michigan State University, Oregon State University, and the University of California at Davis. U.S. Department of Agriculture, Extension Service, and the National Agricultural Pesticide Impact Assessment Program. Available: http://ace.orst.edu/info/extoxnet/ [accessed 26 September 2005].

Fernandez C, Alonso C, Babin MM, Pro J, Carbonell G, Tarazona JV. 2004. Ecotoxicological assessment of doxycycline in aged pig manure using multispecies soil systems. Sci Total Environ 323:63–69.

Gaskins HR, Collier CT, Anderson DB. 2002. Antibiotics as growth promoters: mode of action. Anim Biotechnol 13:29–42.

Gerba CP, Smith JE Jr. 2005. Sources of pathogenic microorganisms and their fate during land application of wastes. J Environ Qual 34:42–48.

Glassmeyer ST, Furlong ET, Kolpin DW, Cahill JD, Werner SL, Meyer MT, et al. 2005. Transport of chemical and microbial contaminants from known wastewater discharges: Potential for use as indicators of human fecal contamination. Environ Sci Technol 39:5157–5169.

Halling-Sorensen B, Sengelov G, Ingerslev F, Jensen LB. 2003. Reduced antimicrobial potencies of oxytetracycline, tylosin, sulfadiazine, streptomycin, ciprofloxacin, and olaquindox due to environmental processes. Arch Environ Contam Toxicol 44:7–16.

Ham JM, DeSutter TM. 2000. Toward site-specific design standards for animal-waste lagoons: protecting ground water quality. J Environ Qual 29:1721–1732.

Hanselman TA, Graetz DA, WIlkie AC. 2003. Manure-borne estrogens as potential environmental contaminants: a review. Environ Sci Technol 37:5471–5478.

Hirsch R, Ternes T, Haberer K, Kratz KL. 1999. Occurrence of antibiotics in the aquatic environment. Sci Total Environ 225:109–118.

Hitzfield BC, Hoger SJ, Dietrich DR. 2000. Cyanobacterial toxins: Removal during drinking water treatment, and human risk assessment. Environ Health Perspect 108:113–122.

Huddleston JH. 1996. How Soil Properties Affect Groundwater Vulnerability to Pesticides Contamination. Oregon State Extension Service. Available: http://wwwagcomm.ads.orst.edu/AgComWebFile/EdMat/EM8559.pdf [accessed 26 September 2005].

Huffman RL, Westerman PW. 1995. Estimated seepage losses from established swine waste lagoons in the lower coastal plain of North Carolina. Transact Am Soc Agric Eng 38:449–453.

Jensen K, Krogh PH, Sverdup LE. 2003. Effects of the antibacterial agents tiamulin, olanquindox and metronidazole and the antihelminthic ivermectin on the soil invertebrate species *Folsomia fimeteria* (Collembola) and *Enchytraeus crypticus* (Enchytraeidae). Chemosphere 50:437–443.

Jensen OM. 1982. Nitrate in drinking water and cancer in northern Jutland, Denmark, with special reference to stomach cancer. Ecotoxicol Environ Saf 9:258–267.

Jongbloed AW, Lenis NP. 1998. Environmental concerns about animal manure. J Anim Sci 76:2641–2648.

Khachatourians GG. 1998. Agricultural use of antibiotics and the evolution and transfer of antibiotic-resistant bacteria. Can Med Assoc J 159:1129–1136.

Kolpin DW, Furlong ET, Meyer MT, Thurman EM, Zaugg SD, Barber LB, et al. 2002. Pharmaceuticals, hormones and other organic wastewater contaminants in U.S. streams, 1999–2000: a national reconnaissance. Environ Sci Technol 36:1202–1211.

Kostraba JN, Gay EC, Rewers M, Hamman RF. 1992. Nitrate levels in community drinking waters and risk of IDDM: an ecological analysis. Diabetes Care 15:1505–1508.

Kummerer K. 2004. Resistance in the environment. J Antimicrob Chemother 54:311–320.

Liu X, Miller GY, McNamara PE. 2005. Do antibiotics reduce production risk for U.S. pork producers? J Agric Appl Econ 37:565–575.

Mallin MA. 2000. Impacts of industrial-scale swine and poultry production on rivers and estuaries. Am Sci 88:26–37.

Mallin, MA, Burkholder JM, Shank GC, McIver MR, Glasgow HB, Springer J, et al. 1997. Comparative impacts of effluent from poultry and swine waste holding lagoon spills on receiving rivers and tidal creeks. J Environ Qual 26:1622–1631.

McGechan MB, Lewis DR, Hooda PS. 2005. Modelling through-soil transport of phosphorous to surface waters from livestock agriculture at the field and catchment scale. Sci Total Environ 344:185–199.

McLachlan JA, Korach KS. 1995. Symposium on Estrogens in the Environment, III. Environ Health Perspect 103:3–4.

Mellon MC, Benbrook C, Benbrook KL. 2001. Estimates of antimicrobial abuse in livestock. Cambridge, MA:Union of Concerned Scientists.

Meyer MT. 2004. Use and Environmental Occurrence of Veterinary Pharmaceuticals in the United States. In: Pharmaceuticals in the Environment: Sources, Fate, Effects, and Risks (Kummerer K, ed). New York:Springer-Verlag,155–163.

Morales-Suarez-Varela M, Llopis-Gonzales A, Tejerizo-Perez ML, Ferrandiz Ferragud J. 1993. Concentration of nitrates in drinking water and its relationship with bladder cancer. J Environ Pathol Toxicol Oncol 12:229–236.

Morales-Suarez-Varela MM, Llopis-Gonzalez A, Tejerizo-Perez ML. 1995. Impact of nitrates in drinking water on cancer mortality in Valencia, Spain. Eur J Epidemiol 11:15–21.

Morbidity and Mortality Weekly Report (MMWR). 1996. Spontaneous abortions possibly related to ingestion of nitrate-contaminated well water—LaGrange County, Indiana, 1991–1994. MMWR 45:569–572.

Mueller BA, Newton, K, Holly EA, Preston-Martin S. 2001. Residential water source and the risk of childhood brain tumors. Environ Health Perspect 109:551–556.

Mueller DK, Hamilton PA, Helsel DR, Hitt KJ, Ruddy BC. 1995.

Nutrients in groundwater and surface water of the United States—an analysis of data through 1992. US Geological Survey Water Resour Invest Rep 95–4031.

Parslow RC, McKinney PA, Law GR, Staines A, Williams B, Bodansky HJ. 1997. Incidence of childhood diabetes mellitus in Yorkshire, northern England, is associated with nitrate in drinking water: an ecological analysis. Diabetologia 40(5):550–556.

Rademacher JJ, Young TB, Kanarek MS. 1992. Gastric cancer mortality and nitrate levels in Wisconsin drinking water. Arch Environ Health 47:292–294.

Raman DR, Williams EL, Layton AC, Burns RT, Easter JP, Daugherty AS, et al. 2004. Estrogen content of dairy and swine wastes. Environ Sci Technol 38:3567–3573.

Rao PV, Gupta N, Bhaskar AS, Jayaraj R. 2002. Toxins and bioactive compounds from cyanobacteria and their implications on human health. J Environ Biol 23:215–224.

Rapala J, Lahti K, Rasanen LA, Esala AL, Niemela SI, Sivonen K. 2002. Endotoxins associated with cyanobacteria and their removal during drinking water treatment. Water Res 36:2627–2635.

Schets FM, During M, Italiaander R, Heijnen L, Rutjes SA, van der Zwaluw WK, et al. 2005. *Escherichia coli* O157:H7 in drinking water from private water supplies in the Netherlands. Water Res 39:4485–4493.

Seffner W. 1995. Natural water contents and endemic goiter. Zantralblatt Hyg Umwelt 196:381–398.

Sengelov G, Agerso Y, Halling-Sorensen B, Baloda SB, Andersen JS, Jensen LB. 2003. Bacterial antibiotic resistance levels in Danish farmland as a result of treatment with pig manure slurry. Environ Int 28:587–595.

Sharpe RR and Harper LA. 1997. Ammonia and nitrous oxide emissions from sprinkler irrigation applications of swine effluent. J Environ Qual 26:1703–1706.

Sharpley A, Moyer B. 2000. Phosphorus forms in manure and compost and their release during simulated rainfall. J Environ Qual 29:1462–1469.

Soto AM, Calabro JM, Prechtl NV, Yau AY, Orlando EF, Daxenberger A, et al. 2004. Androgenic and estrogenic activity in water bodies receiving cattle feedlot effluent in eastern Nebraska, USA. Environ Health Perspect 112:346–352.

Steindorf K, Schlehofer B, Becher H, Hornig G, Wahrendorf J. 1994. Nitrate in drinking water: a case-control study on primary brain tumours with an embedded drinking water survey in Germany. Int J Epidemiol 23:451–457.

Stone KC, Hunt PG, Coffey SW, Matheny TA. 1995. Water quality status of A USDA water quality demonstration project in the Eastern Coastal Plain. J Soil Wat Conserv 50:567–571.

Sumpter JP, Johnston AC. 2005. Lessons from endocrine disruption and their application to other issues concerning trace organics in the aquatic environment. Environ Sci Technol 39:4321–4332.

Tajtakova M, Semanova Z, Tomkova Z, Szokeova E, Majoroa J, Radikova Z, et al. 2006. Increased thyroid volume and frequency of thyroid disorders signs in schoolchildren from nitrate polluted area. Chemosphere 62:559–564.

Thiele-Bruhn S, Beck IC. 2005. Effects of sulfonamide and tetracycline antibiotics on soil microbial activity and microbial biomass. Chemosphere 59:457–465.

Thouez J-P, Beauchamp Y, Simard A. 1981. Cancer and the physicochemical quality of drinking water in Quebec. Soc Sci Med 15D:213–223.

University of Iowa and Iowa State Study Group. 2002. Iowa Concentrated Animal Feeding Operations Air Quality Study. Iowa City, IA:The University of Iowa College of Public Health.

U.S. EPA. 1998. Environmental Impacts of Animal Feeding Operations. Washington, DC:U.S. Environmental Protection Agency, Office of Water, Standards and Applied Sciences Division. Available: http://www.epa.gov/ostwater/guide/feedlots/envimpct.pdf [accessed 26 September 2005].

U.S. EPA. 2000. Deposition of Air Pollutants to the Great Waters. 3rd Report to the U.S. Congress. (1) Section A. Washington, DC:U.S. Environmental Protection Agency.

U.S. EPA. 2006. Approved Methods for Unregulated Contaminants. U.S. Environmental Protection Agency. Available: http://www.epa.gov/ogwdw/methods/unregtbl.html [accessed 5 January 2007].

Van Loon AJM, Botterweck AAM, Goldbohm RA, Brants HAM, van Klaveren JD, van den Brandt PA. 1998. Intake of nitrate and nitrite and the risk of gastric cancer: a prospective cohort study. Br J Cancer 7:129–135.

Van Maanen JM, Albering HJ, de Kok TM, van Breda SG, Curfs DM, Vermeer IT, et al. 2000. Does the risk of childhood diabetes mellitus require revision of the guideline values for nitrate in drinking water? Environ Health Perspect 108(5):457–461.

Ward MH, Cantor KP, Riley D, Merkle S, Lynch CF. 2003. Nitrate in public water supplies and risk of bladder cancer. Epidemiology 14:183–190.

Ward MH, deKok TM, Levallois P, Brender J, Gulis G, Nolan BT, et al. 2005. Workgroup report: drinking-water nitrate and health—recent findings and research needs. Environ Health Perspect 113:1607–1614.

Ward MH, Mark SD, Cantor KP, Weisenburger DD, Correa-Villasenore A, Zahm SH. 1996. Drinking water and the risk of non-Hodgkin's lymphoma. Epidemiology 7:465–471.

Webb J, Archer JR. 1994. Pollution of soils and watercourses by wastes from livestock production systems. In: Pollution in Livestock Production Systems (Dewi IA, Axford RFE, Marai IFM, Omed HM, eds). Oxfordshire, UK:CABI Publishing, 189–204.

Webb S, Ternes T, Gibert M, Olejniczak K. 2003. Indirect human exposure to pharmaceuticals via drinking water. Toxicol Lett 142:157–167.

Weisenburger D. 1993. Potential health consequences of ground-water contamination of nitrates in Nebraska. Nebr Med J 78:7–10.

Westerman PW, Huffman RL, Feng JS. 1995. Swine-lagoon seepage in sandy soil. Transact ASAE 38(6):1749–1760.

Weyer P, Riley D. 2001. Endocrine Disruptors and Pharmaceuticals in Drinking Water. Denver, CO:AWWA Research Foundation and the American Water Works Association.

Weyer PJ, Cerhan JR, Kross BC, Hallberg GR, Kantamneni J, Breuer G, et al. 2001. Municipal drinking water nitrate level and cancer risk in older women: the Iowa Women's Health Study. Epidemiology 11:327–338.

WHO. 2003. Algae and cyanobacteria in fresh water. In: Guidelines for Safe Recreational Water Environments. Vol 1: Coastal and Fresh Waters. Geneva:World Health Organization, 136–138.

Wing S, Freedman S, Band, L. 2002. The potential impact of flooding on confined animal feeding operations in eastern North Carolina. Environ Health Perspect 110:387–391.

Wollenberger L, Halling-Sorensen B, Kusk KO. 2000. Acute and chronic toxicity of veterinary antibiotics to *Daphnia magna*. Chemosphere 40:723–730.

Yang C-Y, Cheng M-F, Tsai S-S, Hsieh Y-L. 1998. Calcium, magnesium, and nitrate in drinking water and gastric cancer mortality. Jpn J Cancer Res 89:124–130.

Zahn JA, Hatfield JL, Do YS. 1997. Characterization of volatile organic emissions and wastes from a swine production facility. J Environ Qual 26:1687–1696.

Blackmore, W.: "The Meat Industry Can't Stop Buying More and More Antibiotics". TakePart. April 15, 2015. www.takepart.com/article/2015/04/10/antibiotics-sales-livestock-rise

In 2013, the Food and Drug Administration managed to actually do something it had vowed to accomplish since 1977: Limit the nontherapeutic use of antibiotics in livestock.

Since farmers first discovered in the 1950s that feeding cattle, pigs, and chickens a small, steady stream of antibiotics somehow fattened up healthy livestock, it's become the status quo—and turned feedlots into breeding grounds for drug-resistant bacteria. In 2011, the industry bought 30 million pounds of antibiotics, close to four times as much as were used in human medicine in the United States that year.

Amazingly, that number has continued to climb. New figures were announced by FDA Friday, and overall sales are up to 32.6 million pounds. Furthermore, annual sales of medically important drugs have climbed 20 percent since 2009. In 2013, 62 percent of the antibiotics purchased by the industry—more than 20 million pounds—were drugs that are imporant to human medicine. The only figure the industry is required to report is the volume that's sold and distributed—no federal data on usage is collected.

"The data released today shows us that use of human antibiotics on the farm has continued to rise, including the use of cephalosporins, which FDA specially added new use restrictions to in 2012," Steve Roach, a senior analyst with the health advocacy group Keep Antibiotics Working, said in a statement. "This reaffirms just how timid FDA's approach to addressing the problem of antibiotic overuse really is, and suggests that it may have limited impact."

The FDA's voluntary measures were announced in December 2013, and the continued increase (save for cephalosporins) cannot be pegged to the many issues with the regulations that critics have pointed out. Still, the regulations allow the status quo to continue with a simple turn in language: Instead of growth promotion, routine antibiotic use is recast as "preventative." As long as that's the case, it's likely that the upward trend will continue. In a recent study, researchers estimated that global antibiotics in livestock will increase by 67 percent come 2030.

"Implementing this strategy is an important step forward in addressing antimicrobial resistance. The FDA is leveraging the cooperation of the pharmaceutical industry to voluntarily make these changes because we believe this approach is the fastest way to achieve our goal," Michael Taylor, FDA deputy commissioner for foods and veterinary medicine, said in a statement back when the regulations were announced.

A 20 percent increase in antibiotic sales between 2009 and 2013 would suggest that might not be the case, and not very much is actually being done to address antimicrobial resistance, a sentiment that none other than Congress' only microbiologist agrees with. Rep. Louise Slaughter's Preservation of Antibiotics for Medical Treatment Act, which was once again reintroduced in March, would keep eight classes of antibiotics used in human medicine out of farming operations—an involuntary regulation.

The new data from the FDA is just the latest statistic to point toward a growing public-health crisis—the post-antibiotic era, as higher-ups at Centers for Disease Control and Prevention have called it. Two million people suffer infections from antibiotic-resistant bacteria annually, according to the CDC, and every year, 23,000 of those cases prove fatal.

Dr. Don Kelley

605-578-3857 | kim_don2001@yahoo.com | 12637 MERRITT ESTES RD DEADWOOD, SD 57732-7407

Education

- Research and Teaching fellowships, Harvard Medical School, 1966-1970
- Pathology residency Peter Bent Brigham Hospital, Boston, MA 1966-1970 (Board certified in Anatomic and Clinical Pathology)
- Medical degree (MD) Baylor College of Medicine 1962-1966
- Undergraduate BS (pre-med) Nebraska Wesleyan U. 1959-1963

Work Experience

- State Board Chairman, Dakota Rural Action, 2014-Present
- Homesteader/farmer near Nemo, SD 1987-Present
- Volunteer pathologist with Project Hope, Grenada, West Indies, 1985-1987
- Private practice of general pathology, Rapid City, SD 1972-1985
- US Army medical corps draftee (Viet Nam and San Francisco, CA) 1970-1972

Bibliography

1. U.S. DEP'T OF HEALTH & HUMAN SERVICES, CENTERS FOR DISEASE CONTROL & PREVENTION, *Antibiotic Resistance Threats in the United States* (2013).
2. PEW COMM'N ON INDUSTRIAL FARM ANIMAL PRODUCTION, Silbergeld, E.K., Price, L., and Graham, J., *Antimicrobial Resistance and Human Health* (2008).
3. Food Marketing Institute, FMI Backgrounder, *Low-Level Use of Antibiotics in Livestock and Poultry* (2004).
4. Consumers Union: Policy & Action from Consumer Reports, "The Overuse of Antibiotics in Food Animals Threatens Public Health (2013), *available at* http://consumersunion.org/news/the-overuse-of-antibiotics-in-food-animals-threatens-public-health-2/.
5. Storteboom, H., Mazdak, A., Davis, J.G., Crimi, B. and Pruden, A., *Tracking Antibiotic Resistance Genes in the South Platte River Basin Using Molecular Signatures of Urban, Agricultural, And Pristine Sources*, ENVIRON. SCI. TECHNOL. Vol. 44 Issue 19, pp. 7397–7404 (2010).
6. Pruden, A., Mazdak, A., and Storteboom, H., *Correlation Between Upstream Human Activities and Riverine Antibiotic Resistance Genes*, ENVIRON. SCI. TECHNOL. Vol. 46 Issue 21, pp 11,541–11,549 (2012).
7. Amy R. Sapkota, Frank C. Curriero, Kristen E. Gibson, and Kellogg J. Schwab, *Antibiotic-Resistant Enterococci and Fecal Indicators in Surface Water and Groundwater Impacted by a Concentrated Swine Feeding Operation*, ENVIRON. HEALTH PERSPECTIVES Vol. 115 Issue 7, pp. 1040-45 (July 2007).

8. Deniza Gertsberg, *Antibiotic Resistance Threat and CAFOS*, GMO Journal: Food Safety Politics (Jan. 15, 2014), *available at* http://gmo-journal.com/2014/01/15/antibiotic-resistance-threat-and-cafos/.
9. Juan Li, Thanh Wang, Bing Shao, Jianzhong Shen, Shaochen Wang, and Yongning Wu, *Plasmid-Mediated Quinolone Resistance Genes and Antibiotic Residues in Wastewater and Soil Adjacent to Swine Feedlots: Potential Transfer to Agricultural Lands*, ENVIRON. HEALTH PERSPECTIVES Vol. 120 Issue 8, pp. 1144-49 (Aug. 2012).
10. Martin, M.J., Thottathil, S.E., and Newman, T.B., *Antibiotics Overuse in Animal Agriculture: A Call to Action for Health Care Providers*, AM. J. PUB. HEALTH Vol. 105 Issue 12, pp. 2409-10 (2015).
11. Gilchrist, M.J., Greko, C., Wallinga, D.B., Beran, G.W., Riley, D. G. and Thorne, P.S., *The Potential Role of Concentrated Animal Feeding Operations in Infectious Disease Epidemics and Antibiotic Resistance*, ENVIRON. HEALTH PERSPECTIVES Vol. 115 Issue 2, pp. 313–16 (Feb. 2007).
12. Burkholder, J., Libra, B., Weyer, P., Heathcote, S., Kolpin, D., Thorne, P.S., and Wichman, M., *Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality*, ENVIRON. HEALTH PERSPECTIVES Vol. 115 Issue 2, pp. 308-12 (Feb. 2007).
13. Willy Blackmore, "The Meat Industry Can't Stop Buying More and More Antibiotics," Takepart.com (Apr. 2015), *available at* http://www.takepart.com/article/2015/04/10/antibiotics-sales-livestock-rise.

Kennette Rogers Exhibits 65 through 82

03/06/2015

19/04/2016

29/04/2016

19/04/2016

19/04/2016

29/04/2016

19/04/2016

19/04/2016

29/04/2016

"CRUNCHY!"

19/04/2016

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Submitter copy to:

Date: 8/4/2015

ROGERS,ROD-112201
21210 349TH AVE
REE HEIGHTS, SD 57371

Spec #: E15EC004137
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

ROGERS,ROD

Date Rcvd: 7/27/2015
Time Rcvd: 0942
Date Coll: 7/27/2015
Time Coll: 0900
Spec Type: WATER

Coll Site: WELL
Coll By: ROD ROGERS
Location NORTH DAM
Supply Type: PRIVATE
Sample Purpose: ROUTINE

Final Results

Nitrate-N	<0.2 mg/L	Limit: 10.0 MG/L

NITRITE IS ABOVE RECOMMENDED LIMIT OF 1.0 mg/L. NITRITE = 1.81 mg/L

Sulfate	74.5 mg/L
Conductivity	1260 umho/cm

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Submitter copy to:

Date: 6/24/2016

ROGERS,ROD-112201
21210 349TH AVE
REE HEIGHTS, SD 57371

Spec #: E16EC003537
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

ROGERS,ROD

Date Rcvd: 6/20/2016
Time Rcvd: 1537
Date Coll: 6/20/2016
Time Coll: 1000
Spec Type: WATER

Location NORTH DAM
Site Location: NORTH DAM
Source: STOCK DAM
Type of Sample: RAW
medium water

Final Results

Nitrate EPA 353.2	(Nitrate + Nitrite)-N	<0.2 mg/L	Limit: <10.0

NITRATE RESULT: SAFE AT TIME OF SAMPLING.

Hardness	420 mg/L
Sulfate	68.4 mg/L
Alkalinity-M	291 mg/L
Alkalinity-P	0 mg/L
Conductivity	976 umho/cm
Sodium	41.5 mg/L

SOUTH DAKOTA DEPARTMENT OF HEALTH

DIVISION OF ADMINISTRATION

Public Health Laboratory

615 East Fourth Street
Pierre, South Dakota 57501-1700
605/773-3368 FAX: 605/773-6129
www.state.sd.us/doh/lab/index.htm

Date: 8/4/2015

Submitter copy to:

ROGERS,ROD-112201
21210 349TH AVE
REE HEIGHTS, SD 57371

Spec #: E15EC004138
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

ROGERS,ROD

Date Rcvd: 7/27/2015
Time Rcvd: 0942
Date Coll: 7/27/2015
Time Coll: 0900

Spec Type: WATER
Coll By: ROD ROGERS
Location SOUTH DAM

Final Results

Nitrate-N	1.2 mg/L	Limit: 10.0 MG/L

NITRATE RESULT: SAFE AT TIME OF SAMPLING.

Sulfate	95.7 mg/L	over 200
Conductivity	554 umho/cm	high [illegible]

07/04/2016

14/04/2015

Laura Krebsbach Exhibit 83