HCA ANALYSIS & DRINKING WATER UNUSUALLY SENSITIVE AREA ASSESSMENT
MANAGING DOLLARS AND SENSE

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Julienne Franco
Houston, Texas
Perceptions of Environmental

Expense$$$$
Liability!!!

Savings$$$$$
Protection!!!
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs) 
MANAGING DOLLARS AND SENSE

Outline

• Intro to pipeline and risks
• High Consequence Areas (HCAs) and their significance
• Unusually Sensitive Areas (USAs)
  ➢ The regulations
  ➢ Standard practices, risks, and expense
  ➢ A better approach for identifying and defining them
  ➢ The pipeline contents matter also!
• Conclusions
Petroleum Pipelines and Risks

- Natural gas,
- Crude oil, and
- High volatile liquids (HVL), including natural gas liquids.
Federal Regulations (49 CFR 192 and 49 CFR 195) require additional maintenance for, and protection to, High Consequence Areas (HCAs).
For federally-regulated liquid pipelines, HCAs include human and natural resource receptors:

*High consequence area* means:

1. A *commercially navigable waterway*, which means a waterway where a substantial likelihood of commercial navigation exists;
2. A *high population area*, which means an urbanized area, as defined and delineated by the Census Bureau, that contains 50,000 or more people and has a population density of at least 1,000 people per square mile;
3. An *other populated area*, which means a place, as defined and delineated by the Census Bureau, that contains a concentrated population, such as an incorporated or unincorporated city, town, village, or other designated residential or commercial area;

From § 195.450
Regulations (§ 195.452) specifically address managing hazardous liquid pipelines in HCAs.  

*Which pipelines are covered by this section?* This section applies to each hazardous liquid pipeline and carbon dioxide pipeline that could affect a high consequence area, including any pipeline located in a high consequence area unless the operator effectively demonstrates by risk assessment that the pipeline could not affect the area.

What this means is that if a worst case release from a portion of pipeline could reach an HCA, that portion is treated as HCA pipeline. A worst case release is typically modeled by a guillotine cut through the pipe during weather conditions that would promote the widest possible dispersal of the product.
If a release from a segment of a pipeline could affect an HCA, that portion of the pipeline is subject to seven pages of additional regulations:

<table>
<thead>
<tr>
<th>Pipeline and Hazardous Materials Safety Admin., DOT</th>
<th>$195.462</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) A defect located on the top of the pipeline above the 4-inch (100-mm) diameter) with a depth greater than 6% of the nominal pipe diameter.</td>
<td></td>
</tr>
<tr>
<td>(B) A defect located on the top of the pipeline above the 4-inch (100-mm) diameter) with a depth greater than 6% of the nominal pipe diameter.</td>
<td></td>
</tr>
<tr>
<td>(C) A defect located on the bottom of the pipeline above the 4-inch (100-mm) diameter) with a depth greater than 6% of the nominal pipe diameter.</td>
<td></td>
</tr>
<tr>
<td>(D) A defect located on the top of the pipeline above the 4-inch (100-mm) diameter) with a depth greater than 6% of the nominal pipe diameter.</td>
<td></td>
</tr>
<tr>
<td>(E) A defect located on the bottom of the pipeline above the 4-inch (100-mm) diameter) with a depth greater than 6% of the nominal pipe diameter.</td>
<td></td>
</tr>
<tr>
<td>(F) A defect located on the bottom of the pipeline above the 4-inch (100-mm) diameter) with a depth greater than 6% of the nominal pipe diameter.</td>
<td></td>
</tr>
</tbody>
</table>

HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USA)
MANAGING DOLLARS AND SENSE – HCA & SIGNIFICANCE

[500]
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
MANAGING DOLLARS AND SENSE – HCA & SIGNIFICANCE
§ 195.6 Unusually Sensitive Areas (USAs).

As used in this part, a USA means a drinking water or ecological resource area that is unusually sensitive to environmental damage from a hazardous liquid pipeline release.

Besides constituting HCAs, proximity to USAs is also used to categorize and set regulatory criteria for some pipelines (§ 195.11-rural regulated gathering lines; § 195.12-low-stress pipelines in rural areas).
Drinking Water USAs include:
(1) Surface water;
(2) Groundwater wells;
(3) Especially vulnerable aquifers.
Honing in on Drinking Water USAs:

(1) The water intake for a Community Water System (CWS) or a Nontransient Non-community Water System (NTNCWS) that obtains its water supply primarily from a surface water source and does not have an adequate alternative drinking water source;
Honing in on Drinking Water USAs:

(1) The water intake for a Community Water System (CWS) or a Nontransient Non-community Water System (NTNCWS) that obtains its water supply primarily from a surface water source and does not have an adequate alternative drinking water source;
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)  
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Honing in on Drinking Water USAs:

(2) The Source Water Protection Area (SWPA) for a CWS or a NTNCWS that obtains its water supply from a **Class I or Class IIA** aquifer and does not have an adequate alternative drinking water source. Where a state has not yet identified the SWPA, the Wellhead Protection Area (WHPA) will be used until the state has identified the SWPA.

*Class I Aquifer* means an aquifer that is surficial or shallow, permeable, and is highly vulnerable to contamination. Class I aquifers include:

1. Unconsolidated aquifers . . .
2. Soluble or fractured bedrock aquifers . . .
4. Covered aquifers with less than 50’ of low permeability cover . . .

*Class IIA aquifer* means a Higher Yield Bedrock Aquifer that is consolidated and is moderately vulnerable to contamination.
Class I Aquifer means an aquifer that is surficial or shallow, permeable, and is highly vulnerable to contamination. Class I aquifers include:
1. Unconsolidated aquifers . . .
2. Soluble or fractured bedrock aquifers . . .
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Class IIa aquifer means a Higher Yield Bedrock Aquifer that is consolidated and is moderately vulnerable to contamination.
Honing in on Drinking Water USAs:

(2) The **Source Water Protection Area (SWPA)** for a CWS or a NTNCWS . . . .

Where a state has not yet identified the SWPA, the **Wellhead Protection Area (WHPA)** will be used until the state has identified the SWPA.

**Source Water Protection Area (SWPA)** means the area delineated by the state for a public water supply system (PWS) or including numerous PWSs, whether the source is ground water or surface water or both, as part of the state source water assessment program (SWAP) approved by EPA under section 1453 of the Safe Drinking Water Act.

**Wellhead Protection Area (WHPA)** means the surface and subsurface area surrounding a well or well field that supplies a public water system through which contaminants are likely to pass and eventually reach the water well or well field.
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MANAGING DOLLARS AND SENSE – USA REGULATIONS
Honing in on Drinking Water USAs:

(3) The sole source aquifer recharge area where the sole source aquifer is a karst aquifer in nature.

*Sole source aquifer (SSA)* means an area designated by the U.S. Environmental Protection Agency under the Sole Source Aquifer program as the “sole or principal” source of drinking water for an area. Such designations are made if the aquifer’s *ground water supplies 50% or more of the drinking water* for an area, and if that aquifer were to become contaminated, it would pose a public health hazard. A sole source aquifer that is *karst in nature* is one composed of limestone where the porosity is derived from connected solution cavities. They are often cavernous, with high rates of flow.
Karst Aquifers
- High velocity flow
- Labyrinth makes flow predictions virtually impossible and remediation difficult!
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MANAGING DOLLARS AND SENSE – USA REGULATIONS

Arbuckle-Simpson Aquifer
Chicot Aquifer
Edwards Aquifer
In a nutshell:

Drinking Water USAs are public water supplies—both surface- and groundwater—that are susceptible to damage resulting from the release from a liquids pipeline (regulated under 49 CFR 195). Drinking water include a point (intake or well) and a protection area around the point.

- The regs prescribe what is protected, and the prescription is fairly well defined.
- The regs do not prescribe the procedures one should use to identify the USAs.
- The National Pipeline Mapping System (NPMS) is not mentioned or prescribed within the Unusually Sensitive Area discussion.
How Are USAs Typically Identified and Used?

- Most operators utilize the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration’s (PHMSA) National Pipeline Mapping System (NPMS) data to identify USAs.

- When conducting a study, such as an HCA analysis, pipeline operators can request Drinking Water and/or Ecological USA data from PHMSA.

- If a modeled pipeline release intersects an HCA (including USAs), operators designate that portion of pipeline as “HCA”.

- If a modeled release from the pipeline doesn’t reach a USAs or another HCA, no designation is assigned.
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MANAGING DOLLARS AND SENSE – HCA & SIGNIFICANCE
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
MANAGING DOLLARS AND SENSE – STANDARD PRACTICES

• Inherent assumptions to this approach are:
  1. The USA data set from PHMSA is accurate and complete.
  2. Protection areas are reasonable and scientifically sound.
  3. The only factor that is important regarding a pipeline’s relationship to the USA is distance.

• If assumptions aren’t true, there is risk that:
  ➢ Real USAs are not being adequately protected.
  ➢ Money is being spent unnecessarily to protect non-existent, misplaced, and/or over-estimated HCAs.

Let’s test the assumptions for Drinking Water USAs
Are the USA datasets from PHMSA accurate and complete?

Most NPMS Drinking Water USA datasets were:

• Collected in 2001,
• Published in 2002, and
• Contain public water supply data published by states during the early to mid 1990’s, and likely gathered well before publication dates.
• Intended to be updated at least every five years, but that has not happened.
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MANAGING DOLLARS AND SENSE – STANDARD PRACTICES

Source Information:

Source Citation:

Citation Information:

Originator: Texas Natural Resources Conservation Commission (TNRCC)
Publication Date: 1997
Title:
Wellhead Protection Areas: whps.dbf
Geospatial Data Presentation Form: spreadsheet
Publication Information:
Publication Place: Austin, TX
Publisher: TNRCC

Online Linkage: http://www.tnrcc.state.tx.us/water/wc/swa/swa.html

Type of Source Media: online
Source Time Period of Content:

Time Period Information:
Single Date/Time:
Calendar Date: 1997
Source Currentness Reference: publication date
Source Citation Abbreviation: none
Source Contribution: Wellhead protection area information

Source Information:

Source Citation:

Citation Information:

Originator: Oklahoma Department of Environmental Quality (ODEQ)
Publication Date: 1996
Title:
Community and NonCommunity Wells, Surface Water Intakes: SRCINFO mdb
Geospatial Data Presentation Form: spreadsheet
Publication Information:
Publication Place: Oklahoma City, OK
Publisher: ODEQ

Online Linkage: http://www.deq.state.ok.us/Water1/home/index.html

Type of Source Media: online
Source Time Period of Content:

Time Period Information:
Single Date/Time:
Calendar Date: 1996
Source Currentness Reference: publication date
Source Citation Abbreviation: none
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
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HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
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NPMS Drinking Water USA data:

• Misses many public water supplies, including all installed since the late 1990’s;
• Includes historic public water supplies that are no longer used;
• Includes some groundwater wells which appear to have never been public water supply wells (misidentified?); and
• Includes public water supplies which appear to be inaccurately mapped (seem to be in the wrong coordinate system).

The first assumption, that the USA dataset from PHMSA is complete and accurate, is not valid.
Are NPMS Drinking Water USA protection areas reasonable and scientifically sound?

Let’s look at surface water intakes first.

The NPMS drinking water USAs set up a buffer within a set radius (five miles) of the surface water intake. The buffer area includes all of the topographically low areas within the radius.
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Let’s consider NPMS groundwater USA data now.

NPMS drinking water USA protection areas around groundwater wells are generally a set diameter, that is NOT directly related to the well attributes that are indicative of susceptibility to impact:

- Well age,
- Well depth,
- Well construction details (casing, seal),
- Soil characteristics,
- Groundwater depth,
- Groundwater flow direction, and
- Subsurface geology (including confining layers above used aquifer).

In many cases, the NPMS protection areas/buffer zones do not agree with state-recommended protection areas.
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MANAGING DOLLARS AND SENSE – STANDARD PRACTICES
Another Example

It is very unlikely that this 60’ deep groundwater well in an unconfined aquifer would be affected by a release from the pipeline approximately 0.25 miles to the southwest because of elevation differences and the general southward directed groundwater flow in this area.
Arbitrary buffer distances and reliance upon using a uniform geometry for buffer shapes may result in unreasonable and unsound drinking water USAs. Also, key data that provides a lot of insight about the likelihood of impact to public water supplies is ignored. Factors other than distance from a pipeline can be very important in assessing likelihood of impact for a public water supply.

None of the three assumptions upon which the use of NPMS drinking water USA data is based are valid.
An operator, member of the public or other government agency may view and download the data from the NPMS home page . . .

However, it is an operator’s responsibility to ensure that it has identified all high consequence areas that could be affected by a pipeline segment. An operator is also responsible for periodically evaluating its pipeline segments to look for population or environmental changes that may have occurred around the pipeline and to keep its program current with this information.

From § 195, Appendix C
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
MANAGING DOLLARS AND SENSE – STANDARD PRACTICES

[Image of the Grinch climbing a chimney]
A better approach is to:

• Use current drinking water PWS data and verify locations with aerial photos and/or other secondary sources, where possible.
• Collect information about the PWSs that can be used to create protection areas/buffer zones and define the USAs.
• Develop algorithms to define and plot the buffer zones.
• Identify “bad” NPMS data and provide explanation for exclusion from HCA assessment (for auditors).
• Assess whether or not USAs could be affected by a release.
• Get buy-in from appropriate regulatory agencies when excluding NPMS data and/or modifying buffer zones.
Current public water supply data is available from state agencies. This is typically current to at least the past 12 months.
Many of the state agencies that oversee public water supply data and mapping also provided detailed information about the water supplies.
Cross-referencing the public water supply databases with other publicly-available databases can provide information about well construction, soil conditions, bedrock, and other characteristics that are important in assessing likelihood of impact from a release.
<table>
<thead>
<tr>
<th>Description and color of formation material</th>
<th>Diameter (inches)</th>
<th>Setting</th>
<th>Diameter (inches)</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-45 Clay and gravel</td>
<td>6&quot;</td>
<td>0</td>
<td>6&quot;</td>
<td>306</td>
</tr>
<tr>
<td>6-22 red clay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22-44 sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44-49 gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49-76 sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76-89 shale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>89-108 sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>108-110 cavity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110-208 shale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>208-215 sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>215-230 shale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>230-240 sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240-307 shale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>307-321 sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7) COMPLETION: Gravel packed to 16 ft.
Well blew 3000 gph

8) WATER LEVEL:
Static level 135 ft. below land surface Date 3/9/70

Well geology and construction
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
MANAGING DOLLARS AND SENSE – A BETTER APPROACH

Area soil, bedrock geology, groundwater depth and flow . . .
Current public water supply data can be accurately plotted and data about the water supply engineering, construction, and surrounding 3-D physical setting can be stored as attributes in GIS.

Well geology and construction
Some states have well developed SWPAs/WPAs:
**HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)**
**MANAGING DOLLARS AND SENSE – A BETTER APPROACH**

- For states that do not have well-developed SWPAs/ WPAs, well construction and environmental data can be used to calculate risk-based protection areas/buffer zones, and buffer zones are used to construct USA polygons.
- A 60’ deep, uncased well in unconfined sand should have a larger protection area than a 600’ deep, cased well that has 200 feet of impermeable rock above the aquifer!

<table>
<thead>
<tr>
<th>Depth to First Screen</th>
<th>Cased?</th>
<th>Cemented and/or sealed?</th>
<th>100’ of at least 20’-thick impermeable zones above seal (verified)?</th>
<th>At least two 20’-thick impermeable zones above seal (verified)?</th>
<th>At least one 10’ thick impermeable zone above seal (verified)?</th>
<th>Buffer Zone Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>218</td>
<td>400 Yes</td>
<td>0 Yes</td>
<td>0 Yes</td>
<td>0 Yes</td>
<td>0 Yes</td>
<td>0 400</td>
</tr>
<tr>
<td>365</td>
<td>400 Yes</td>
<td>0 Yes</td>
<td>0 No</td>
<td>200 Yes</td>
<td>0 Yes</td>
<td>0 600</td>
</tr>
<tr>
<td>500</td>
<td>300 Yes</td>
<td>0 Yes</td>
<td>0 No</td>
<td>200 Yes</td>
<td>0 Yes</td>
<td>0 500</td>
</tr>
<tr>
<td>150</td>
<td>500 Yes</td>
<td>0 Yes</td>
<td>0 No</td>
<td>200 No</td>
<td>200 No</td>
<td>400 1300</td>
</tr>
<tr>
<td>575</td>
<td>300 Yes</td>
<td>0 Yes</td>
<td>0 No</td>
<td>200 No</td>
<td>200 No</td>
<td>0 500</td>
</tr>
<tr>
<td>180</td>
<td>500 Yes</td>
<td>0 No</td>
<td>200 No</td>
<td>200 No</td>
<td>200 No</td>
<td>400 1500</td>
</tr>
<tr>
<td>256</td>
<td>400 Yes</td>
<td>0 No</td>
<td>200 No</td>
<td>200 Yes</td>
<td>0 Yes</td>
<td>0 800</td>
</tr>
<tr>
<td>389</td>
<td>400 Yes</td>
<td>0 Yes</td>
<td>0 No</td>
<td>200 Yes</td>
<td>0 Yes</td>
<td>0 600</td>
</tr>
<tr>
<td>590</td>
<td>400 Yes</td>
<td>0 No</td>
<td>200 No</td>
<td>200 No</td>
<td>200 No</td>
<td>400 1200</td>
</tr>
</tbody>
</table>
Incorrectly plotted/identified NPMS drinking water data can also be plotted, stored, and explained in GIS attribute tables.

**TABLE 1: POTENTIAL UNUSUALLY SENSITIVE AREAS**

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.805938°</td>
<td>Not a PWS, per ODEQ. No groundwater wells (public, domestic, irrigation, or other) are mapped at this location, and there is no surface water body at the location.</td>
</tr>
<tr>
<td>7.389058°</td>
<td>May be recharge area, but is upslope of pipeline. Not USA</td>
</tr>
<tr>
<td>6.933695°</td>
<td>No longer PWS</td>
</tr>
<tr>
<td>6.605949°</td>
<td>No longer PWS</td>
</tr>
<tr>
<td>6.600793°</td>
<td>No longer PWS</td>
</tr>
<tr>
<td>6.608683°</td>
<td>No surface water body or permitted groundwater well is located here, and ODEQ does not list a PWS or WHPA in this vicinity.</td>
</tr>
<tr>
<td>6.878309°</td>
<td>PHMSA plots this as a PWS SWI, but it is not. According to ODEQ, it is a WHPA, with a discrete radius.</td>
</tr>
<tr>
<td>6.877426°</td>
<td>May be recharge area. It is across drainage divide from pipeline. Not USA.</td>
</tr>
<tr>
<td>7.291965°</td>
<td>No longer PWS</td>
</tr>
<tr>
<td>7.046066°</td>
<td>No longer PWS</td>
</tr>
<tr>
<td>6.379378°</td>
<td>This is part of the Walnut Creek drainage basin, completely different and separated from the Okemah Lake PWS drainage basin. The small reservoirs in this area are not PWS lakes and are therefore not DW USAs.</td>
</tr>
</tbody>
</table>
USAs which would not be impacted because of topography, groundwater flow direction, water supply construction characteristics, or other reasons can be explained in GIS attribute tables.

<table>
<thead>
<tr>
<th>Longitude</th>
<th>Phenomenon</th>
</tr>
</thead>
<tbody>
<tr>
<td>-96.514643°</td>
<td>The SWI for the PWS is &gt; 9 miles downstream from the pipeline, and a dammed reservoir is located downstream of the pipeline and upstream of the PWS.</td>
</tr>
<tr>
<td>-96.323872°</td>
<td>A pipeline release could potentially drain into the Walnut Creek drainage basin, completely different and separated from the Okemah Lake PWS drainage basin. The small reservoirs in this area are not PWS lakes and are therefore not DW USAs. There are also numerous apparent weirs between the pipeline and PWS SWI.</td>
</tr>
<tr>
<td>-96.384144°</td>
<td>Pipeline crosses drinking water supply</td>
</tr>
</tbody>
</table>
The result of these efforts is a drinking water USA data set that:

- Contains current public water supply information,
- Excludes inaccurate information,
- Has criteria for exclusion of inaccurate information tied to the appropriate data points,
- Identifies USAs which would not be impacted by worst-case pipeline releases and has justifications for “no impact” characterization attached to the data points.
Temperature Dependence of Viscosity

![Graph showing temperature dependence of viscosity with plots for Maya Crude, WTI, and Unleaded Gas.](image)

n-Butane Evaporation Rate vs. Spill Area

Ev = -0.0447 ln(T) ln(A) + 0.2414 ln(A) + 0.00006 exp(0.032 T)

![Graph showing n-Butane evaporation rate vs. spill area with different temperature curves.](image)
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
MANAGING DOLLARS AND SENSE – CONCLUSIONS

• USAs are public water supply and ecological resource areas, afforded special protection as HCAs under liquid pipeline regulations (49 CFR 195).

• Three HCA truths:
  1. Requisite protection of HCAs cost money.
  2. Protecting misidentified HCAs is a waste of money.
  3. Not correctly identifying HCAs = exposure to risk & liability.

• Almost all industry-standard USA analyses utilizes NPMS data, which is not current and contains known inaccuracies.

• NPMS USA data include large, arbitrary buffer zones, resulting in relatively large amounts of HCA-designated pipeline.
HCA ANALYSIS & UNUSUALLY SENSITIVE AREAS (USAs)
MANAGING DOLLARS AND SENSE – CONCLUSIONS

• A better process is built upon integrating current, publicly-available data about USAs.

• Inaccurate NPMS USA data is easily identifiable, and justification for exclusion and/or revision should be available.

• Buffer zones around public water supply and ecological resources can be defined using science-based algorithms.

• Model impacts to HCAs with actual product characteristics.

• This process and resultant HCA maps have received accolades from pipeline and environmental regulatory agencies.

• The process typically results in:
  ✓ Identification of USAs that traditional analyses miss, and
  ✓ An overall reduction of HCA-designated pipeline.
Use precious $$ to protect real sensitive receptors—not bad data!
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MANAGING DOLLARS AND SENSE