VALIDATION FINDINGS REPORT
FOR
GUIDANCE DOCUMENT
REASONABLE AND PRUDENT PRACTICES FOR STABILIZATION OF OIL AND NATURAL GAS CONSTRUCTION SITES

Terracon Project No. 92067965
May 4, 2007

Prepared for:

INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA
STORM WATER TECHNCIAL WORKGROUP
1201 15th Street NW, Suite 300
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Prepared by:

TERRACON

May 4, 2007

IPAA Storm Water Technical Workgroup
C/O Lee O. Fuller
Vice President of Government Relations
Independent Petroleum Association of America (IPAA)
1201 15th Street NW, Suite 300
Washington, DC 20005

Re: **Validation Findings Report**
Guidance Document Reasonable and Prudent Practices for Stabilization of Oil and Natural Gas Construction Sites
Terracon Project Number 92067965

Dear Mr. Fuller:

Terracon Consultants, Inc. (Terracon) is pleased to submit a draft copy of the Guidance Document Reasonable and Prudent Practices for Stabilization of Oil and Natural Gas Construction Sites Validation Findings Report. This project was performed in accordance with Terracon's proposal dated August 4, 2006 and the Agreement between Terracon and the IPAA dated September 29, 2007.

We appreciate the opportunity to perform these services for the IPAA Storm Water Technical Workgroup. Please contact either of the undersigned if you have questions regarding the information provided in the report.

Sincerely,

Terracon

DRAFT **DRAFT**

Ron Berglund, P.E.
Project Manager

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1.0 INTRODUCTION

1.1 Background

In 2004, the Independent Petroleum Association of America (IPAA) Storm Water Technical Workgroup, in conjunction with a coalition of other organizations, prepared “Guidance Document Reasonable and Prudent Practices for Stabilization (GD-RAPPS) of Oil and Natural Gas Construction Sites”. The objective of GD-RAPPS was to compile the various practices utilized by reasonable and prudent operators in the oil and gas industry in the continental United States to control erosion and sedimentation associated with storm water runoff from areas disturbed by clearing, grading and excavating activities related to site preparation associated with oil and gas exploration, product processing, treatment and transmission activities. Since its development, the approach used in this document and its contents have been presented to industry representatives and to a variety of regulatory and environmental groups as part of a larger effort to highlight the nature of the voluntary programs that have been developed by the industry to minimize pollution from storm water runoff during and following construction at oil and natural gas properties.

The GD-RAPPS was designed to be a concise tool for oil and gas operators and earthwork contractors to provide a clear, uncomplicated approach to selection and practical application of “Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Natural Gas Construction Sites”, given a variety of physical circumstances.

The GD-RAPPS, as the name implies, is intended to provide guidance that results in measures that a “reasonable and prudent” operator would implement irrespective of the presence or absence of local, state and federal regulations or requirements.

Six separate geographic regions are identified within the continental United States in Figure 1 in the GD-RAPPS. Within each geographic area, a decision tree analysis is presented with assumptions regarding soil types, annual precipitation, slopes, percentage of vegetative cover and the distance to a regulated water body. A list of possible RAPPS is presented at the base of each branch of a decision tree. As the instructions indicate, an operator may choose one or a combination of the RAPPS to control runoff from the construction site. The guidance requires minimal additional information from the operator and can be easily adapted for use in the field.

1.2 Scope of Work

Terracon Consultants, Inc. (Terracon) was retained by the IPAA to review and field validate the GD-RAPPS document options available to the oil and natural gas industry during clearing, grading and excavating activities related to site preparation associated with oil and natural gas exploration, production, processing, treatment and transmission activities. Terracon has prepared this GD-RAPPS Validation Findings Report based on the following scope of work: 1) review of the GD-RAPPS including discussions with Horizon Environmental Services, Inc., the author of GD-RAPPS, 2) review of the validity of the geographic regions identified in GD-RAPPS, 3) development of site selection criteria to provide the maximum amount of information, 4) in-field validation activities at 29 sites located throughout the six geographic regions and 5) a literature review.

2.0 VALIDATION ACTIVITIES

2.1 Site Selection Criteria Development

A map was developed by Terracon illustrating the six geographic regions identified in Figure 1 of the GD-RAPPS document relative to the major oil and natural gas producing basins within the continental United States (Figure 2-1). Subsequent to discussions with the IPAA Storm Water Technical Workgroup (STW) regarding oil and natural gas activity of the participating companies in the various oil and gas producing basins, eight of the oil and gas producing basins were selected for field validation activities. The sites were selected to include representation of the six geographic regions identified in GD-RAPPS.

2.2 Field Validation Program

Terracon's field validation program included visiting two to five oil and natural gas sites in different stages of development in each of the eight selected oil and gas producing basins. The varying stages of construction site development included planned sites, sites under construction, and operating sites. The validation program included an evaluation of each site using a checklist (for consistency purposes) by a Terracon representative and a representative of the participating oil and gas company. The Terracon representative inspected the sites to evaluate the RAPPS they typically would have installed based on their professional judgment and experience compared to what RAPPS their interpretation of the GD-RAPPS would have required, if any. The oil and gas company representative similarly evaluated each site to determine the type of RAPPS that would have been recommended by GD-RAPPS compared to the RAPPS the oil and gas company installed or were planning to install.

In some instances during our field validation visits, we witnessed and documented erosion control measures that were clearly influenced by local regulatory (state/BLM) requirements. Although this was unavoidable and may have skewed instances of RAPPS recommendations, we attempted to moderate the effects of regulatory requirements by visiting undeveloped sites and discussing with operators what measures would be prudent regardless of regulatory requirements. Simultaneously, we acknowledge that variable requirements and local pressures are a reality that makes a "one size fits all" document difficult to develop.

During the site visit, each representative observed and noted soil types, slopes, vegetative cover in downgradient positions from the construction site and estimated the distance to the nearest water body. Subsequent to an evaluation of the field parameters and site conditions, the Terracon representative filled out the RAPPS Validation Study Checklist Evaluation documenting each inspector's observations regarding site conditions, RAPPS implemented or planned by the operator, RAPPS recommended by Terracon and the RAPPS recommended by GD-RAPPS.

3.0 FIELD VALIDATION RESULTS

3.1 Field Validation Site Locations

Terracon conducted field validation activities at 29 sites located in eight different oil and natural gas producing basins. The field activities were conducted between November 2006 and January 2007 by eight different Terracon storm water professionals. The site areas, which were field validated, are presented on Figure 1 and summarized in Table 3-1

Table 3-1: RAPPS Validation Study. Locations of Field Validated Sites

Oil & Gas Producing Basin	Geographic Region*	Number of Sites Visited	Location
Raton Basin	XM	2	Colorado
San Juan Basin	D	5	Colorado/New Mexico
Powder River Basin	XP	4	Wyoming
Arkoma Basin	MM	4	Arkansas
East Texas Basin	MP	4	Eastern Texas
Gulf Coast	CP	4	Coastal Texas
Fort Worth Basin	XP	4	Central Texas
Uinta-Piceance Basins	XM	2	Utah

*The designations for the six geographic regions are as follows: Xeric Mountains (XM), Desert (D), Xeric Plains (XP), Mesic Mountains (MM), Mesic Plains (MP), Coastal Plains (CP) (the names of the geographic regions were designated by the authors of GD-RAPPS).

Summary sheets documenting the results of each field validation site visit are presented in Appendix A and include an analysis of the site RAPPS requirements using the GD-RAPPS guidance. Table 3-2 presents an overview of the site visits and RAPPS analysis. A representative completed checklist documenting the parameters evaluated during the site validation is included in Appendix B.

3.2 Use of RAPPS Decision Trees

GD-RAPPS was designed to provide a process as one moves along the path of a decision tree to assess which, if any, storm water controls are needed for a specific location. The decision tree format is user friendly and is easily used by oil and natural gas operators in the field.

Terracon reviewed the geographic regions identified in Figure 1 of the GD-RAPPS by evaluating the source of the geographic regions (Ray Sterner, John Hopkins University) and discussing the basis for the differentiation of the six different zones with the author of GD-RAPPS. Based on our evaluation and discussions, the geographic regions are primarily differentiated by topography and physiographic data rather than erodibility or soil type.

Each of the field validations was initiated with an evaluation of the facility's location to identify the appropriate geographic region in GD-RAPPS. Subsequent to identifying the correct geographic region, the assumptions for each decision tree were evaluated. If the assumptions for the geographic region did not match the local conditions, the Terracon field professional selected a decision tree from another geographical region that better matched local conditions. The assumptions regarding annual precipitation, soil type, slope, vegetative cover and distance to a regulated water body are discussed below.

3.21 Annual Precipitation

Annual precipitation in GD-RAPPS was evaluated by comparing the annual rainfall documented by the U S Department of Agriculture (USDA) for each site area to the annual precipitation assumptions for the geographic regions in GD-RAPPS. Table 3-21 is a comparative analysis of the assumptions in GD-RAPPS versus the actual conditions at the site. The GD-RAPPS annual rainfall assumptions compared to the actual annual rainfall for the respective site areas are listed in Table 3-21. Based on the field validations, the rainfall assumptions appeared to be accurate since 21 of 29 sites (72%) matched the rainfall assumptions in GD-RAPPS. Although there are several areas that do not match available annual precipitation data, the rainfall assumptions were either accurate or over-predicted the actual rainfall. For example, a large area incorporating the sites visited in Wyoming is categorized as XP (< 35 inches of rainfall), whereas the actual annual precipitation is indicative of the D geographic region (< 15 inches). Since the desert region's rainfall is less and encompassed within the XP region's rainfall assumption, the rainfall is generally accurate. However, it should be noted that this discrepancy may result in oil and gas operators installing RAPPS beyond what may have been required for adequate protection if the more appropriate desert decision tree had been utilized.

Table 3-2: Summary of RAPPS Validation Studies

Geographic Region	Location	Type	Size	Soils		Water		Vegetation	Slope
				Type	Fit RAPPS	Type	Distance		
CP	Corpus Christi, TX (Site 1)	Drill Pad (Staked out)	200x200 ft	Silty Loam	Yes	Nueces Bay	>2000 ft	0%	0%
CP	Corpus Christi, TX (Site 2)	Drill Pad (Preparation)	450x400 ft	Silty Loam	Yes	Nueces Bay	>2000 ft	0%	0%
CP	Corpus Christi, TX (Site 3)	Drill Pad (Construction)	400x400 ft	Silty Loam	Yes	Nueces Bay	>2000 ft	0%	0%
CP	Corpus Christi, TX (Site 4)	Drill Pad (Operating)	450x400 ft	Silty Loam	Yes	Nueces Bay	>2000 ft	0%	0%
D	Farmington, NM	Drill Pad	2.6 Acres	Fine to medium sands with some clay/silt	Yes	Ephemeral Surface Wash	Beside Site	~5 %	10 to 40 %
D	Durango, CO (Site 1)	Pipeline	50 ft wide, 1/2 mile long	Clayey Silt	No	Small perennial stream crosses pipeline	Near Center of site	< 5 %	40 to 50 %
D	Durango, CO (Site 2)	Vehicle Bridge	20 x 40 ft	Clayey Silt	No	Spans a small perennial stream "Dry Creek"	Over stream	90%	5 to 40 %
D	Durango, CO (Site 3)	Gas production well pad	1.5 acres	Clayey Silt	No	natural perennial stream	50 ft	90%	5 to 20 %
D	Durango, CO (Site 4)	Gas production well pad	1.5 acres	Clayey Silt	No	Small perennial stream near pipeline	150 ft	90%+	5 to 20 %
XP	Fort Worth, TX (Site 1)	gas pipeline with tank battery with berm	2 Acres	Silty Clay	No	Berry's Creek	1,000 ft	90%	1-2 % on site, 5% from site
XP	Fort Worth, TX (Site 2)	gas pipeline with tank battery with berm	0.75 Acres	Silty Clay	No	Hightower Creek, leading to Paluxi River	~220 ft	70 to 100 %	1-2 % on site, 5% from site
XP	Fort Worth, TX (Site 3)	Tank Battery	2 acres	Silty Clay	No	Creek (with water) - stock pond	300 ft	70%	10%
XP	Fort Worth, TX (Site 4)	Gas pipeline & Liquids Tank Battery	75 acres	Silty Clay	No	Robison Creek	1000 ft	90%	5%
XM	Raton Basin, Trinidad, CO (Site 1)	Drill Pad	1 Acre	Silty Clay	No	Reilly Canyon Creek & Purgatory River	> 150 ft	70%	20%
XM	Raton Basin, Trinidad, CO (Site 2)	Drill Pad	1 Acre	Silty Clay	No	Reilly Canyon Creek & Purgatory River	~ 50 ft	40 - 50 %	20 to 30 %
XM	Chapita, UT	Compressor Station	28 Acres	Silty Sand / Clayey Sand	No	Gully Wash (no water)	Original stream goes under site.	15%	1% slope between edge of site and water
XM	Bitter Creek, UT	Compressor Station	28 Acres	Silty Sand / Clayey Sand	No	Gully Wash (no water)	20 ft	5%	10% to 20% +
MM	Arkoma Basin, AK (Site 1)	Active Drill Pad	5 acres	Silt Loam	Yes	Tributary to Briar Creek	Adjacent to Tributary	>75%	< 10 %
MM	Arkoma Basin, AK (Site 2)	Drill Pad under Construction	2 Acres	Silt Loam	Yes	Unnamed Tributary (with water)	~ 2000 ft	>75%	< 10 %
MM	Arkoma Basin, AK (Site 3)	Preconstruction of Drill Pad	2 Acres	gravelly fine sandy loam	Yes	Unnamed Tributary to Panther Creek	~150 ft	>75%	< 10 %
MM	Arkoma Basin, AK (Site 4)	Active Well	4 acres	Fine Sandy Loam	Yes	Unnamed Tributary to Panther Creek	~750 ft	>75%	< 10%
MP	East Texas (Site 1)	Existing Well Pad	320x320	Sandy Loam	Yes	Meander scar of Hog's Bayou	20 to 50 ft	25 - 75%	0 to 10 %
MP	Eastl Texas (Site 2)	Preconstruction of Drill Pad	320x320	Sandy Loam	Yes	non flowing Tributary Drainage	0 to 100 ft	75+	0 to 10 %
MP	East Texas (Site 3)	Drill Pad and access road	320x320	Sandy Loam	Yes	small ponds in ephemeral drainage, non flowing	~ 100 ft	75+	10%
MP	East Texas (Site 4)	Drill pad, access road and flow line	320x320	Sandy Loam	Yes	unnamed creek	50 ft	75+	30%
XP	Powder River Basin (A-1)	Drill pad and access road	Pad 1 acre, access road 2 acres	Silty Clay	No	dry draw	> 150 ft	30%	40%
XP	Powder River Basin (A-2)	16" pipeline with 100 ft ROW	Pipeline	Silt	No	Powder River	1,000 ft	40%	10% avg (varies)
XP	Powder River Basin (D-1)	Drill Pad with acess road	1 acre	Silt	No	Gully/Wash	50 to 150 ft, or > 250 ft	15% to 50%	20 % average (varies)
XP	Powder River Basin (D-2)	CBM Well-Head, associated road	2 Acres	Silty Clay	No	Gully/Wash	200 ft	40%	40% avg (varies)

Table 3-21 RAPPS Comparative Analysis Table

Site State	RAPPS Region	RAPPS Soil Type	Actual Site Soil Type	RAPPS Annual Rainfall	Actual Annual Rainfall	Actual Vegetation (%)	Actual Site Slope (%)	Do Site Conditions Agree With RAPPS Geographic-Region Assumptions? Soil Type (Y/N)	RAPPS Accommodate Vegetation ? (Y/N)	RAPPS Accommodate Site Slope? (Y/N)	Annual Rainfall (Y/N)	Overall Geo- Region Assumptions Match? (Y/N)	Suitable Alternate Region Found in RAPPS? (Y/N)	Alternate Geographical Region Used? If So, Which One? (Or Did you use the one indicated in Fig 1?)	Estimated Distance To Regulated Water Body (By Site Operator)	Estimated Distance To Regulated Water Body (By Terracon Inspector)	NO RAPPS Based On Distance to Water? (Did not get to Decision Tree) (By Terracon Inspector)	Based on Terracon Site Observations Should Structural RAPPS Be Installed? (Y/N)	At Active Sites, Were Structural BMPs Installed Beyond RAPPS Indications? (Y/N)
Corpus Christi, TX (Site 1)	CP	Loams/Silts	Silty Loam	>50 in	30"-35"	0	0	Yes	Yes	Yes	No	No	No	CP	>2000'	>2000'	Yes	No	Yes
Corpus Christi, TX (Site 2)	CP	Loams/Silts	Silty Loam	>50 in	30"-35"	0	0	Yes	Yes	Yes	No	No	No	CP	>2000'	>2000'	Yes	No	Yes
Corpus Christi, TX (Site 3)	CP	Loams/Silts	Silty Loam	>50 in	30"-35"	0	0	Yes	Yes	Yes	No	No	No	CP	>2000'	>2000'	Yes	No	Yes
Corpus Christi, TX (Site 4)	CP	Loams/Silts	Silty Loam	>50 in	30"-35"	0	0	Yes	Yes	Yes	No	No	No	CP	>2000'	>2000'	Yes	No	Yes
Farmington, NM	D	Sandy	Sandy	<15"	8"-10"	5%	10-20%	Yes	Yes	Yes	Yes	Yes	NA	Used D	150'	150'	Yes	Yes	Yes
Durango, CO (Site 1)	D	Sandy	Clayey Silt	<15"	12"-14"	<5%	5-20%	No	Yes	Yes	Yes	No	No	Used XM	50'	50'	No	Yes	Yes
Durango, CO (Site 2)	D	Sandy	Clayey Silt	<15"	12"-14"	90%	10-40%	No	No	Yes	Yes	No	No	Used XM	0	0	No	Yes	Yes
Durango, CO (Site 3)	D	Sandy	Clayey Silt	<15"	12"-14"	90%	30-50%	No	No	Yes	Yes	No	No	Used XM	0	0	No	Yes	Yes
Durango, CO (Site 4)	D	Sandy	Clayey Silt	<15"	12"-14"	90%	5-10%	No	No	Yes	Yes	No	No	Used XM	0	0	No	Yes	Yes
Fort Worth, TX (Site 1)	XP	Sandy	Silty Clay	<35"	25"-30"	90%	3-5%	No	Yes	Yes	Yes	No	No	Used XP	1000'	1000'	Yes	No	Yes
Fort Worth, TX (Site 2)	XP	Sandy	Silty Clay	<35"	25"-30"	70-100%	5%	No	Yes	Yes	Yes	No	No	Used XP	250'	220'	Yes	Yes	Yes
Fort Worth, TX (Site 3)	XP	Sandy	Silty Clay	<35"	25"-30"	70%	2%	No	Yes	Yes	Yes	No	No	Used XP	300'	300'	Yes	Yes, Pre-Const. Visit	Pre-Const. Visit
Fort Worth, TX (Site 4)	XP	Sandy	Silty Clay	<35"	25"-30"	90%	1%	No	Yes	Yes	Yes	No	No	Used XP	1000'	1000'	Yes	Yes	Yes
Raton Basin, Trinidad, CO (Site 1)	XM	Rocky	Silty Clay	10"-50"	10"-15"	70%	20%	No	Yes	Yes	Yes	No	No	XM	>150'	>150'	Yes	Yes	Yes
Raton Basin, Trinidad, CO (Site 2)	XM	Rocky	Silty Clay	10"-50"	10"-15"	40-50%	20-30%	No	Yes	Yes	Yes	No	No	XM	50'	50'	No	Yes	Yes
Chapita, UT	XM	Rocky	Silty Sand	10"-50"	10"-15"	15%	1%	No	Yes	No	Yes	No	No	Used XM	50' - 100'	100'	No	Yes, Pre-Const. Visit	Pre-Const. Visit
Bitter Creek, UT	XM	Rocky	Silty Sand	10"-50"	10"-15"	5%	10%	No	Yes	Yes	Yes	No	No	Used XM	20'	20'	No	Yes	Yes
Arkoma Basin, AK (Site 1)	MM	Loamy	Silt loam	> 60"	50"-55"	>75%	<10%	Yes	Yes	No	No	No	Yes	Used CP	1000'	10'	No	Yes	Yes
Arkoma Basin, AK (Site 2)	MM	Loamy	Silt loam	> 60"	50"-55"	>75%	<10%	Yes	Yes	No	No	No	Yes	Used CP	2000'	2000'	Yes	Yes	Yes
Arkoma Basin, AK (Site 3)	MM	Loamy	Gravelly fine sandy loam	> 60"	50"-55"	>75%	<10%	Yes	Yes	No	No	No	Yes	Used CP	150'	150'	Yes	Yes	Yes
Arkoma Basin, AK (Site 4)	MM	Loamy	Fine sandy loam	> 60"	50"-55"	>75%	<10%	Yes	Yes	No	No	No	Yes	Used CP	750'	750'	Yes	Yes	Yes
East Texas (Site 1)	MP	clays and loams	sandy loam	>35"	40"-50"	25-75%	<10%	Yes	Yes	Yes	Yes	Yes	NA	MP	10'	20'	No	Yes	Yes
East Texas (Site 2)	MP	clays and loams	sandy loam	>35"	40"-50"	75+%	<10%	Yes	Yes	Yes	Yes	Yes	NA	MP	<100'	<100'	No	Yes, Pre-Const. Visit	Pre-Const. Visit
East Texas (Site 3)	MP	clays and loams	sandy loam	>35"	40"-50"	75+%	10%	Yes	Yes	Yes	Yes	Yes	NA	MP	>100'	<100'	No	Yes	Yes
East Texas (Site 4)	MP	clays and loams	sandy loam	>35"	40"-50"	75+%	30%	Yes	Yes	Yes	Yes	Yes	NA	MP	50'	<100'	No	Yes	Yes
Powder River Basin (A-1)	XP	Sandy	Silty Clay	<35"	10"-15"	30%	25 - 30	No	Yes	Yes	Yes	No	No	Used XP	150'	250'	Yes	Yes, Pre-Const. Visit	Pre-Const. Visit
Powder River Basin (A-2)	XP	Sandy	Silt	<35"	10"-15"	40%	40 - 80	No	Yes	Yes	Yes	No	No	Used XP	>200'	200'	Yes	Yes	Yes
Powder River Basin (D-1)	XP	Sandy	Silt	<35"	10"-15"	15-50%	40	No	Yes	Yes	Yes	No	No	Used XP	50 to 100'	>150'	Yes	Yes, Pre-Const. Visit	Pre-Const. Visit
Powder River Basin (D-2)	XP	Sandy	Silty Clay	<35"	10"-15"	40%	10	No	Yes	Yes	Yes	No	No	Used XP	0-50'	1,000'	Yes	Yes	Yes
								Soil Type	**Vegetation**	**Accom. Slope**	**Rainfall**	**Assump. Match**	**Alt Region Found**				**"No RAPPS" due to Distance:**	**Need St. BMPS**	**Struc. RAPPS Installed**
No. of Instances RAPPS matched site conditions:								13	26	24	21	5	4				17	24	24
Percentage of Time RAPPS matched site conditions:								**45%**	**90%**	**83%**	**72%**	**17%**	**17%**				**59%**	**83%**	**100%**

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3.22 Soil Type and Erodibility

One of the primary assumptions of the RAPPS decision trees is erodibility. Erodibility is a function of soil type, and erodibility factors (K) are commonly used and compiled in erosion control documents. However, the GD-RAPPS bases erodibility on a general soil type for the entire geographic region. Soil classification and characteristics are not directly addressed in the GD-RAPPS text or decision trees. Rather, soils are implicitly included in the assumptions for each of the six geographic regions. The soil classification assumptions for these six regions, as summarized in Table 3-22, were somewhat inconsistent. In some cases, a soil type was referenced for the geographic region, such as for D ("soils are predominantly sand and/or rock"). In other cases a characteristic of the soils is depicted, such as for MP ("soils are moderately erodible"). In four of the six soil categories, soil type and erodibility were presented as underlying assumptions or a characteristic associated with the entire geographic region.

Table 3-22: Assumed Soil Type and Erodibility in GD-RAPPS Decision Trees

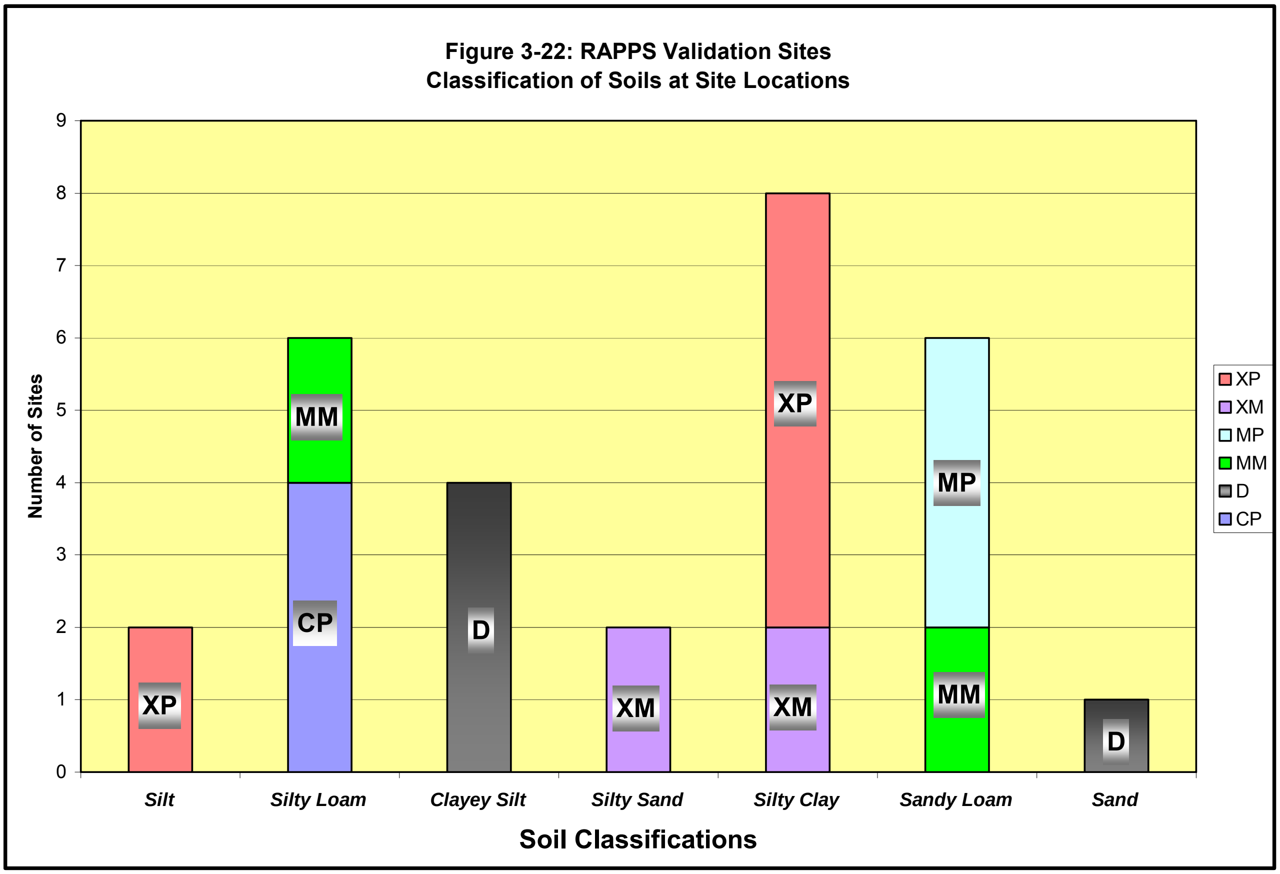
GD-RAPPS Geographic Regions	Assumed Soil Type and Erodibility
D	Soils are predominantly sand and/or rock
CP	Soils are loams or silts and highly erodible
XP	Soils are Primarily sandy with low erodibility
XM	Rocky with low erodibility
MM	Soils are loamy with moderate erodibility
MP	Soils are moderately erodible

One of the six GD-RAPPS geographic regions (CP) was classified as having a highly erodible soil. Two regions (MP and MM) were classified with soils of moderate erodibilty, and three regions were classified as having soils of low erodibility. Three of the RAPPS Decision Trees (D, XP and XM) are based upon the assumption that the soils of those regions can be classified as being of low erodibility. With the exception of the Coastal Plains areas and a small portion of Texas, these three regions (D, XP and XM) encompass the entire western United States. In essence, the GD-RAPPS is based upon the generalization that all the soils in the western United States are of low erodibility and recommends RAPPS accordingly. Of the remaining three regions for which a GD-RAPPS decision tree is available, two are characterized with soils of moderate erodibility (MM and MP) and one is characterized by a soil of high erodibility (CP).

Based on our analysis, the assumption that three of the six geographic regions in the continental United States exhibit low erodibility, appears to be an over-generalization.

The assumption on the MP decision tree that soils are moderately erodible without designating soil types is not sufficiently descriptive and may be misinterpreted by operators.

Numerous soil types were identified in the field validations as documented in Figure 3-22 and Table 3-2.



The soils at the four sites in the CP region and the four sites in the MP region were consistent with the GD-RAPPS decision tree soil type and erodibility designation for those regions (high and moderate erodibility, respectively). The soils at two of the four sites in the MM region were consistent with the GD-RAPPS soil type and erodibility designation for that area (moderately erodible). However, two sites in the MM region were characterized by silty loams, which generally match the soil type (loamy) designation in GD-RAPPS, but are characterized as highly erodible (K factor = 0.42).

The soil type categories in GD-RAPPS were evaluated during the field validations by comparing the soil type identified at each site to the soil type or erodibility assumption for each geographic region in GD-RAPPS. A comparative analysis of the soil types observed during these site visits relative to the GD-RAPPs assumptions for these sites is presented in Table 3-21. It should be noted that Terracon indicated the soil type matched the GD-RAPPS designations for the two sites in the MM region characterized by silty loams (highly erodible) for the purposes of the comparative analysis.

The field validations indicated 13 of 29 soil types (45%) matched the soil type and erodibility assumptions for the geographic regions. Based on our evaluation indicating less than half of the soil types or erodibilities identified during the site inspections were valid for the specific geographic region, the soil type assumptions in RAPPS may commonly be inaccurate. The document oversimplifies the soil types identified in each geographic region. Based on a review of the Natural Resources Conservation Service (NRCS Website, 2007) maps, most, if not all, soil types identified in GD-RAPPS could be found in each geographic region and are not specific to any one area.

In each of the 16 sites where the soil type or erodibility did not match the GD-RAPPS assumptions, the erodibility was under predicted potentially resulting in RAPPS that may not be appropriate or sufficient to reduce sediment loss due to storm water.

3.23 Site Slope

Site slope is used as an assumption for the CP geographic region and is used in the decision tree analysis for the other five geographic regions. Table 3.23 presents the categories of slopes used to select RAPPS in the various geographic regions.

Table 3-23: Categories of Slopes in RAPPS Decision Trees

RAPPS Topographical Classification	Categories for Slope
D	0 to 10%, 10 to 40%, 40%+
CP	Assumption that all slopes are < 10%
XP	0 to 10%, 10 to 40%,
XM	10 to 40%, 40%+
MM	10 to 40%, 40%+
MP	0 to 10%, 10 to 40%,

The slope of a site in RAPPS is defined as the amount of elevation gain over a given distance (vertical rise to horizontal run) and is evaluated between the construction activity and the regulated water body. Table 3-21 summarizes the slopes located in topographic downgradient positions from the 29 field validated construction sites.

The slopes in downgradient positions from 15 of 29 construction sites were less than 10%. This is the assumption of the Coastal Plain region, and the four Coastal Plain sites exhibited slopes less than 10%. Five of the eight construction sites that were located in the Mesic Mountains (MM) or Xeric Mountains (XM) geographic regions also exhibited slopes less than 10%. Slopes of less than 10% are not addressed in the GD-RAPPS MM or XM decision trees. The GD-RAPPs decision trees neither provide an option for determining the needed RAPPS for sites having less than10% slopes within these regions, nor do they specifically exclude such sites as not requiring RAPPS. Although evaluations of slope in the MM and XM regions could be misinterpreted by operators, the field validations indicated that 24 of 29 slopes (83%) were accommodated in the decision trees indicating that most slopes at oil and gas construction sites can be evaluated in the GD-RAPPS decision trees.

Based on our literature search and use of sediment loss models, such as the Revised Universal Soil Loss Equation (RUSLE), shallow slopes (<5%) may result in a significant amount of sediment loss. For example, the RUSLE equation (for a given set of parameters including a soil of low/moderate erodibility and a region with moderate rainfall intensity) indicates that soil loss for a 2% slope is predicted to be 5.2 tons/acre/year. However, the soil loss is increased by a factor of 2.7 (14.0 tons/acre/year) if the slope alone is increased to 5%. The soil loss is increased by a factor of 6.2 (33.1 tons/acre/year) if the slope is increased from 2% to 10%. Furthermore, the soil loss is increased by an overall factor of 40 (207 tons/acre/yr) if the slope is increased from 2% to 40%. It should be noted that the USDA Natural Resource Conservation Service (NRCS) designated 5 tons/acre/year as the threshold for significant soil loss that will affect agricultural use.

Based on calculations using soil loss equations, the slope ranges used in the decision trees to select RAPPS in portions of GD-RAPPS can be very broad, and the actual slopes can be steep resulting in significant soil loss regardless of annual rainfall, vegetative cover and soil type.

3.24 Distance to Water

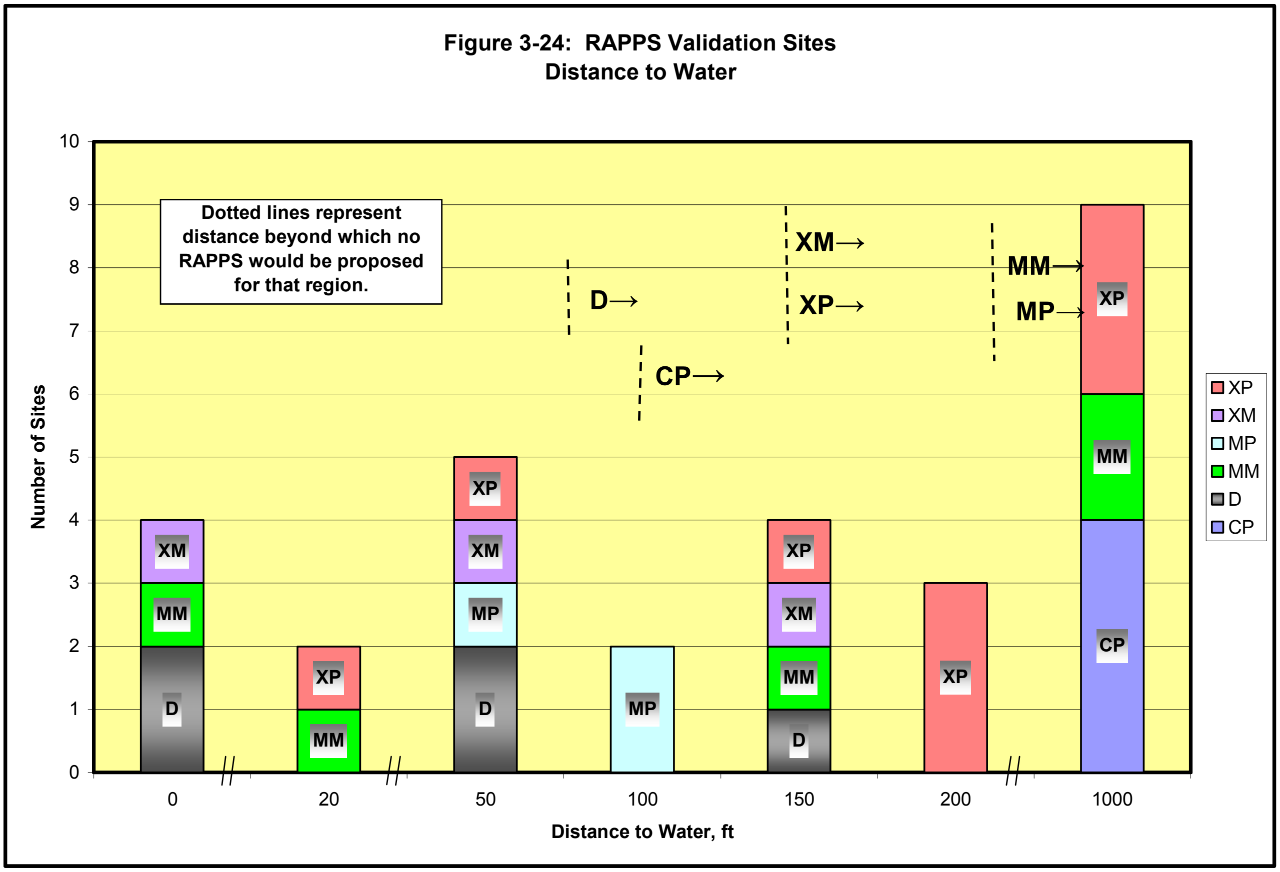
A critical determinant in the GD-RAPPs is the distance from the downgradient edge of the construction site to the nearest regulated water body. Construction sites in excess of a minimum distance from a water body will typically not require RAPPS. The minimum distances for each geographic region is presented in Table 3-24.

Table 3-24 GD-RAPPS Minimum Distance to Water

RAPPS Geographic Region	Minimum Distance to Water, Ft	Minimum Distance to Water, Ft If 75% vegetation
D	75	Not Applicable
CP	100	50
XP	150	50
XM	150	75
MM	250	150 if Slope <40%
MP	250	100

The distance to water assumptions in GD-RAPPS vary from a low of 50 feet for the Desert geographic region to a high of 250 feet for the Mesic Plains and Mesic Mountain classifications.

Figure 3-24 presents a summary of the distances to the closest waters that were observed during the site visits. Note, that most of the distances were not exact measurements, but approximations following the guidance in the GD-RAPPS.



At four of the sites, representing three different geographic regions, the distance to the water was zero because the well pad was constructed adjacent to a regulated water body or water had been diverted around the site.

Overall, the distance to water for eleven of the sites was less than 75 feet. In these cases, RAPPS would be recommended for the six geographic regions. The distance to water for eight of the remaining sites was greater than 1,000 feet. At this distance no RAPPS would have been recommended for the six geographic regions.

Of the remaining nine sites, four of the sites (one D and three XP) were farther than the minimum distance for that geographical region (no RAPPS), while five of the sites were at or below the minimum GD-RAPPS distance (with RAPPS recommended).

The distance to water assumptions in GD-RAPPS were evaluated during the field validations by determining whether RAPPS (included in Appendix A of GD-RAPPS) were recommended by the Terracon field professional at each site based on experience compared to recommendations in GD-RAPPS.

The field validations indicated that RAPPS were required by GD-RAPPS for 12 of 29 construction sites indicating the inspector used the decision tree process 41% of the time due to the distance to water. Terracon inspectors recommended RAPPS at 24 of 29 construction sites (83%), which included the five planned sites where construction activities had not commenced. The operators installed at least one of the RAPPS documented in Appendix A of GD-RAPPS at 24 of 24 construction sites (100%). It should be noted that five sites were in the planning stage, and construction had not commenced; therefore, a total of 24 sites were evaluated where RAPPS could have been installed. The discrepancy between the number of RAPPS installed by operators and the number of RAPPS recommended by Terracon was due to five sites in Texas where RAPPS were not recommended by Terracon. Our evaluation indicates that 41% of the time, an operator would have installed RAPPS based on the GD-RAPPS decision trees compared to Terracon recommending RAPPS 83% of the time. This indicates that the minimum distance to water assumptions may be too short, and the distance to water assumptions should be evaluated.

Distance to water has historically not been used as a factor in evaluating storm water RAPPS, and, if used, the distances documented in RAPPS may not be sufficiently protective of waters of the U.S. Based on our literature search, evidence indicates that once sediment is detached and leaves the site, it may be transported for significant distances and deposited in waterways (USDA, 2001). Although sediment may be filtered and captured by vegetation downgradient of the site, six field validations indicated that sediment had been eroded from the site, and in one case had been deposited in a nearby waterway. This may be due to eroded material being initially captured by vegetation and subsequently transported to a waterway during a high intensity rain event.

The RAPPS document is vague regarding how the nearest regulated water body is determined. The decision trees reference the distance to water, whereas the document text refers to regulated water bodies, which include waterways that may be seasonally dry. This discrepancy may result in the distance to "live water" being confused with waters of the U.S. by oil and gas operators in the field. During five site verifications (Table 3-21), the operator and the site inspector used significantly different distances to water to evaluate RAPPS options because they interpreted water bodies differently. Based on our field validations, operators may misinterpret "distance to water" in the decision trees, which includes waterways that may be seasonally dry.

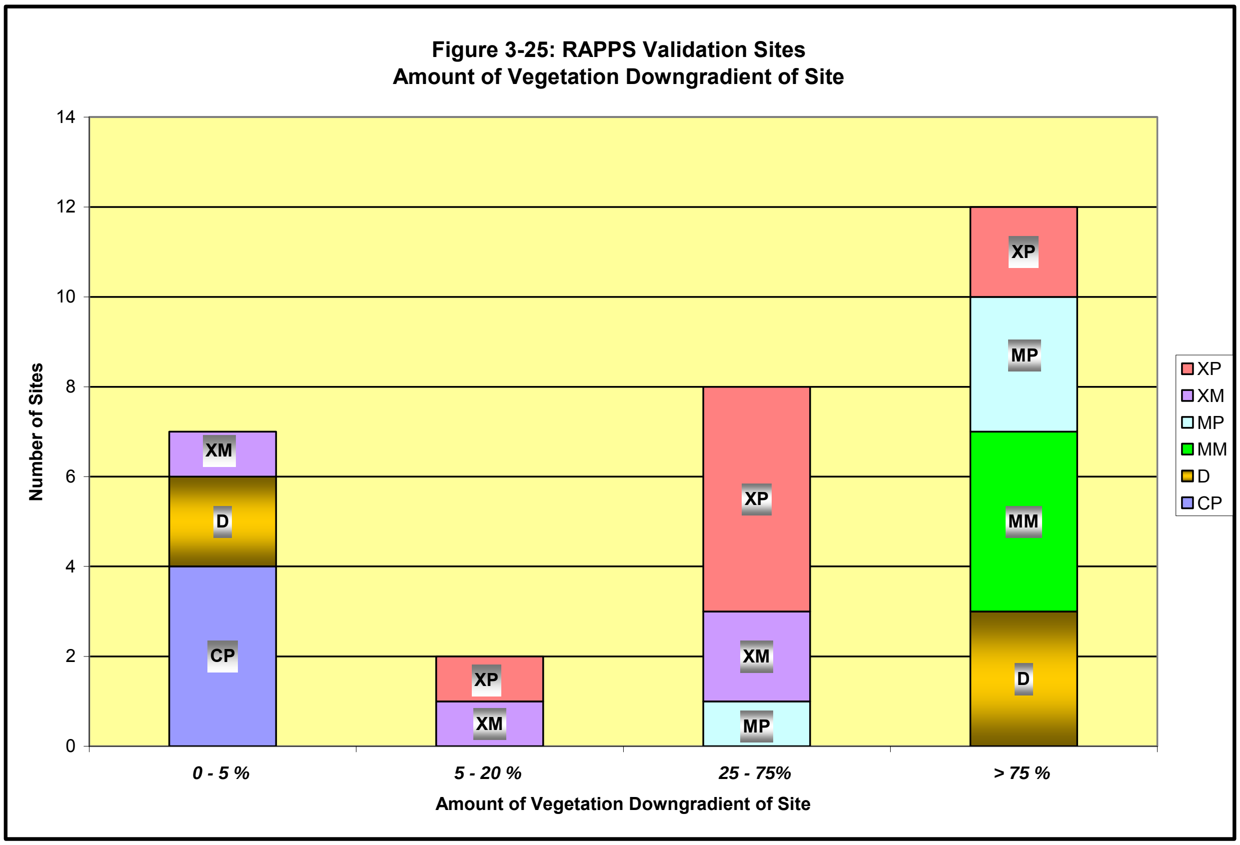
3.25 Vegetation

RAPPS defines vegetative cover as the percentage of ground covered with primarily low-growing, herbaceous vegetation (grasses, forbs and wildflowers). Vegetative cover serves two important roles in reducing sediment loss and transport from an oil and natural gas construction site. The vegetation present at the site can anchor and protect soil that might otherwise be eroded. The vegetation in downgradient positions from the site can also filter and capture sediment that is eroded from the site before it has been transported to the nearest water body. Vegetation also serves to protect the soil by absorbing the initial impact of raindrops and reducing its disruptive effect on the soil. Due to the limited filtration provided by shrubs and trees, these types of vegetation are not factored into the estimate of vegetative cover.

With the exception of the Desert geographic region (where RAPPS assumes that vegetation is nominal), each of the RAPPS decision trees classifies the vegetation into one of three categories including:

1. Less than 25 % vegetation,
2. 25 % to 75% vegetation, and
3. More than 75 % vegetation.

A summary of the amount of vegetation observed in downgradient positions from the sites is presented in Figure 3-25.



The field validations indicated that 14 of 29 sites (48%) had greater than 75% vegetative cover in downgradient positions from the site, while six of 29 sites (21%) had less than 5% vegetative cover. It should be noted that the site inspections were conducted in the fall and winter, and the amount of vegetative cover may have been underestimated in some cases, since the vegetative cover percentage was determined from the vegetation stem structure, even if the green portion of the plant had died. However, in some cases, vegetative cover may have been overestimated because of the tendency of some people to estimate vegetative cover by looking down at the canopy rather than evaluating and estimating the percent of structure (i.e. stems) at the soil level that serves to filter sediment. Those sites that were located in cultivated farmland (CP sites) were reported as having no vegetative cover since the plants had been plowed under.

The Desert geographic region's assumption that vegetative cover is less than 25% was evaluated by comparing the amount of vegetative cover observed in the five Desert sites. Based on the field inspectors and operators evaluation of vegetative cover, three of the Desert sites exhibited greater than 75% vegetative cover, while two of the five sites exhibited five percent or less of vegetative cover. Our evaluation indicates that the vegetative cover assumption may be invalid, and varying vegetative cover percentages could be found in the Desert geographic region or the other geographic regions

3.26 Overall Geographic Region Assumptions Evaluation

The overall geographic region assumptions in GD-RAPPS were evaluated subsequent to the field validations by comparing each of the four GD-RAPPS assumptions including annual rainfall, soil type, slope and vegetative cover to actual conditions at the sites (Table 3-21). If the four geographic region assumptions matched site conditions, then the user would have utilized the decision tree for that respective geographic region. However, if the overall geographic regions assumptions did not match site conditions, an alternate geographic region would have been evaluated. If a suitable geographic region could not be found, the field inspector typically would have used the GD-RAPPS prescribed decision tree for the site's geographic region.

The field validations indicated 5 of 29 sites (17%) matched the four GD-RAPPS assumptions. Based on our evaluation indicating 17% of the sites matched the four geographic region assumptions, the user would typically try to select a different geographic region decision tree 83% of the time.

However, when the user selected a different geographic region decision tree, one if not more of the assumptions would commonly be incorrect, and the user would select RAPPS based on good judgment. Since the assumptions from the decision trees will commonly be inaccurate, the frequency of switching to another invalid geographic region decision tree appears to defeat the process of utilizing the decision trees.

4.0 EVALUATION OF BEST MANAGEMENT PRACTICES IN GD-RAPPS

The GD-RAPPS compiles reasonable and prudent practices commonly used in the exploration and production industry to reduce sediment loss due to storm water. Selection of a RAPPS is based on an evaluation of the geographical region and physical features at the oil and natural gas construction site. The description of RAPPS in Appendix A of the guidance document discusses limitations, installation, construction activities and commonly provides a figure or a detail to assist the operator with the implementation of a RAPPS. Appendix A of GD-RAPPS is the core section of the document and is very helpful for oil and gas operators.

Seventeen RAPPS are summarized in Appendix A of the GD-RAPPS. Appendix B of GD-RAPPS illustrates diagrams of typical water body crossings. The RAPPS summarized in Appendix A of the GD-RAPPS are listed in Table 4-0.

Table 4-0 RAPPS in Appendix A of the Guidance Document.

Vegetative Cover (VC)
Mulch (MVC)
Roughening (RGHN)
Brush Piles (BP)
Straw (Hay) Bales (SB)
Silt Fencing (SF)
Rock Berm (RB)
Diversion Earthen Dikes(DD)
Road Surface Slope (RDSS)
Drainage Dips (DIP)
Stabilized Construction Entrance (SCE)
Road-Side Ditches (RDSD)
Turnouts or Wing Ditches (TO)
Construction Mats (CM)
Cross-drain Culverts (CULV)
Geotextiles Erosion Blankets (GEO)
Sediment Traps (ST)

4.1 Summary of RAPPS Options

The various recommended RAPPS from the six decision trees were statistically examined, and the results are presented in Appendix D. The purpose of this analysis was to evaluate any trends implicit in the RAPPS determination process that could be examined and explicitly documented. Table 4-1 provides a summary of the results of this analysis and lists the number of times (as a percentage) that a RAPPS would be recommended in each of the six decision trees. For example, if a decision tree has six branches, and a particular RAPPS is presented in the six branches, the total would be 100 %. The "No RAPPS" recommendation was not included in the statistical analysis.

Table 4-1 Distribution of Recommended RAPPS by Geographic Region

DESCRIPTION OF RAPPS	CP	XP	MP	D	XM	MM	OVERALL
Vegetative Cover (VC)	0%	0%	0%	0%	0%	0%	0%
Mulch (MVC)	40%	56%	56%	0%	33%	45%	42%
Roughening (RGHN)	0%	33%	0%	60%	0%	0%	13%
Brush Piles (BP)	60%	100%	67%	0%	67%	45%	60%
Straw (Hay) Bales (SB)	60%	100%	78%	80%	89%	91%	85%
Silt Fencing (SF)	60%	56%	67%	100%	0%	55%	52%
Rock Berm (RB)	0%	56%	22%	100%	56%	55%	48%
Diversion Earthen Dikes(DD)	0%	56%	56%	80%	100%	82%	67%
Road Surface Slope (RDSS)	80%	56%	56%	80%	100%	100%	79%
Drainage Dips (DIP)	0%	56%	56%	0%	100%	100%	63%
Stabilized Const Entrance (SCE)	0%	0%	0%	0%	0%	0%	0%
Road-Side Ditches (RDSD)	100%	100%	100%	100%	100%	100%	100%
Turnouts or Wing Ditches (TO)	0%	67%	56%	80%	100%	100%	73%
Construction Mats (CM)	60%	56%	56%	0%	56%	55%	50%
Cross-drain Culverts (CULV)	0%	56%	56%	80%	100%	100%	71%
Geotextiles Erosion Blankets (GEO)	60%	56%	56%	0%	56%	55%	50%
Sediment Traps (ST)	0%	56%	33%	60%	0%	55%	35%

The results presented in this table illustrate several interesting trends. Two of the 17 RAPPS discussed in Appendix A of the document (Vegetative Cover and Stabilized Construction Entrance) are never recommended in the decision trees. On the other hand, the use of Road Side Ditches (RDSD) is recommended in every decision tree, which appears appropriate since all oil and gas construction sites will utilize roads. Since vegetative cover is used in the document as an assumption for the Desert geographic region and is used in the other five decision trees, vegetation as a filter strip and erosion control RAPPS should be included as an alternative in the decision trees.

A more detailed examination of the situations where a particular RAPPS is recommended is beyond the scope of this analysis, but several general observations were made. The use of mulch is recommended when the distance to water is 'greater', and roughening is not recommended in mountainous terrain, or with soils of moderate or high erodibility. The silt fence RAPP is not recommended for use in the Xeric Mountains, whereas silt fences are recommended 55% of the time in the Mesic Mountains. Mulch is not included in the desert region as a RAPPs; however, in our experience, mulch can be a low maintenance RAPPS that is suitable for low vegetative areas.

In nearly two thirds of the decision trees, at least 9 to 12 different RAPPS are recommended for the cited application. Overall, the GD-RAPPS appears to implicitly separate RAPPS into categories that might be more efficient at controlling sediment in certain applications. Except for the discussions presented as limitations in Appendix A of the GD-RAPPS, limited information is provided in the document explaining the conditions when a particular RAPPS should be used or which RAPPS might be preferred.

4.2 Actual RAPPS Implemented at the Sites

An evaluation of the decision tree process and the resultant recommended GD-RAPPS was conducted by comparing the actual RAPPS installed or planned for the 29 sites to the RAPPS recommended in the decision trees for a particular geographic region. If the assumptions for a given geographic region did not match the field conditions, when appropriate, then an alternate decision tree, selected by the field inspector, was used in lieu of the initial decision tree, as discussed in GD-RAPPS. Table 4-2 presents the results of this RAPP comparative analysis and includes: 1) options recommended by GD-RAPPS for the region visited, 2) options recommended by an alternate decision tree selected during the site visit, 3) options implemented at the site, 4) options planned to be implemented at the site and 5) options recommended by Terracon. The field validations indicated that RAPPS were required by GD-RAPPS for 10 of 29 construction sites (34%). Fourteen of the sites that did not require RAPPS were due to distance to water and five of the sites that did not require RAPPS were due to slopes less than 10%, which were not accommodated in the XM or MM geographic regions. However, RAPPS (documented in Appendix A of GD-RAPPS) were actually recommended by Terracon at 24 of 29 sites (83%) and installed by the operator at 24 of 24 construction sites (100%). This comparative analysis indicates a discrepancy in the recommendations of GD-RAPPS versus actual RAPPS installed by operators or recommended by the Terracon field professional. It should be noted that in several cases, numerous RAPPS (up to six) were installed at a single site when GD-RAPPS indicated RAPPS were not required.

4.3 Alternate Decision Tree Analysis

During the field validations, the Terracon field professional commonly used the GD-RAPPS prescribed decision trees even though one or more of the assumptions were not accurate. Therefore, Terracon evaluated the prospect that more RAPPS would have been prescribed if the Terracon field professional had selected a different decision tree based on soil type and erodibility.

Although the soils or erodibility at 16 of the 29 sites (55%) visited by Terracon representatives did not match the decision tree for that region, the Terracon field professional switched to a different decision tree to evaluate RAPPS eight times (4 locations in the D region and 4 locations in the MM region). However, in only one case did the alternate decision tree recommend a RAPPS where the original had not.

TABLE 4-2: RAPPS FROM DECISION TREES UTILIZED (IN THE FIELD) COMPARED TO ACTUAL OR PLANNED RAPPS INCLUDING TERRACON RECOMMENDATIONS

	CP	CP	CP	CP	D	D	D	D	D	XP	XP	XP	XP	XM	XM	XM	XM	MM	MM	MM	MM	MP	MP	MP	MP	XP	XP	XP	XP
NO RAPPS RECOMMENDED																NA		NA	NA	NA	NA								
Alternate DTs Considered (in Field)						XM	XM	XM	XM									CP	CP	CP	CP								
NO RAPPS Recommended by Alternative DT																													
Distance to Water, ft.	2000	2000	2000	2000	0	0	0	50	150	1000	220	300	1000	>150	50	<100	2000	<50	2000	150	750	20	< 100	<100	50	>150	1000	>150	200
Downgradient Slope, %	0%	0%	0%	0%	<40 %	>40 %	10%	10%	10%	5%	5%	10%	5%	20%	30%	1%	>20%	< 10 %	< 10 %	< 10 %	< 10%	< 10 %	< 10%	10%	30%	40%	10%	20%	40%
Vegetative Cover, %	0%	0%	0%	0%	~5 %	< 5 %	90%	90%	90%+	90%	70 %+	70%	90%	70%	50%	15%	5%	>75%	>75%	>75%	>75%	< 75%	>75%	>75%	>75%	30%	40%	< 50%	40%
Vegetative Cover (VC)					X					X					X						R				X	P			X
Mulch (MVC)						X	X	X	X											P	R			X	X		X	P	
Roughtening (RGHN)																		X			X						X		X
Brush Piles (BP)																			X	P	X								
Straw (Hay) Bales (SB)															X				X		R	X		X	R				X
Silt Fencing (SF)							X				R					P	X		X	P		X	P	R	R				
Rock Berm (RB)					X	X		X	X						X	X	X				R					P			X
Diversion Earthen Dikes(DD)					X	X		X			R			X	X	P			X							P		R	X
Road Surface Slope (RDSS)					X															P									
Drainage Dips (DIP)																													
Stabilized Const Entrance (SCE)	P	X	X	X						X	X	P	X									R							
Road-Side Ditches (RDSD)					R													X	X	P							X		
Turnouts or Wing Ditches (TO)					R																						X		
Construction Mats (CM)																													
Cross-drain Culverts (CULV)																		X		P					X				
Geotextiles Erosion Blankets (GEO)															X											P			
Sediment Traps (ST)										X	R			X	X	P	X				X								
Excelsior Logs																													X

Notes Filled Cells — represent options recommended by RAPPS Guidance for Region visited

Dotted Cells — represent options recommended by alternate Decision Tree selected during field visit

NA Decision Tree does not accommodate slope

X represent options actually implemented at the site

P represents options planned to be implemented at the site

R represents options that would be recommended by Terracon

After the field validation results were collected, a systematic evaluation of the GD-RAPPS guidelines was conducted to assess if an alternate decision tree could be found that better represented the soils at the site, regardless of the other factors implicitly included in the RAPPS decision trees (slope, rainfall and vegetative cover). Using the information from the site visits, one of the six decision trees were used to determine what, if any, RAPPS would be required for each of the 29 sites that were included in the validation study. Where the soils were believed to be uncharacteristic of the conditions of the soil for that region, an alternate decision tree was used. This analysis is presented in Table 4-3, which includes 1) options recommended by GD-RAPPS for the region visited, 2) options recommended by an alternate decision tree selected in the field visit, 3) options recommended by an alternate decision tree based on soil erodibility, 4) options actually implemented at the site, 5) options planned to be implemented at the site and 6) options that were recommended by Terrracon.

Analysis of Table 4-3 indicates that no RAPPS would have been recommended for the four CP sites, as the distance to water was in excess of 100 feet. Since the soil types at the site matched the GD-RAPPS soil type and erodibility assumptions, an alternate decision tree analysis was not conducted for the CP region.

The decision tree for the Mesic Plains region recommended that RAPPS be considered at each of the four sites visited.

In the remaining four geographic regions in which the soils or erodibility assumptions at 16 of the 21 sites were not adequately represented in their respective decision trees, an effort was made to select an alternate decision tree that better represented the soil type or erodibility conditions at the site.

The overall approach to assure that a consistent process was used in selecting an alternate decision tree was as follows:

- <u>Highly Erodible soils</u> such as silts and silty loams: Use CP decision tree.
- <u>Moderately erodible soils</u> such as sandy loams and silty clays: Use the MP Decision Tree (plains) or MM Decision Tree (mountains).

The soils at four of the five D sites did not match the soil and erodibility D geographic region assumptions. While the selection of RAPPS for the MM decision tree differed slightly from those that would be determined from the D decision tree, there was only one case where the MM decision tree recommended that RAPPS be considered when the D decision tree did not.

The distance to the nearest water exceeded 150 feet at the eight XP sites; therefore, no RAPPS were required using the decision tree for the XP region. However, as the soils were considered to be moderately erodible, the MP decision tree was also used to evaluate RAPPS. In three of the eight sites, when the distance to water was between 150 feet and 250 feet, the MP decision tree recommended RAPPS options.

TABLE 4-3: RAPPS FROM DECISION TREES BASED ON ERODIBILITY COMPARED TO ACTUAL OR PLANNED RAPPS INCLUDING TERRACON RECOMMENDATIONS

	CP	CP	CP	CP	D	D	D	D	D	XP	XP	XP	XP	XM	XM	XM	XM	MM	MM	MM	MM	MP	MP	MP	MP	XP	XP	XP	XP
NO RAPPS RECOMMENDED																NA		NA	NA	NA	NA								
Alternate DTs Considered						MM	MM	MM	MM	MP	MP	MP	MP	MM	MM	MP	MM	CP	CP	MP	MP					MP	MP	MP	MP
NO RAPPS Recommended by alternative DT																													
Distance to Water, ft	2000	2000	2000	2000	0	0	0	50	150	1000	220	300	1000	>150	50	0	20	<50	2000	150	750	20	< 100	100	50	>150	1000	>150	200
Downgradient Slope, %	0%	0%	0%	0%	<40 %	>40 %	10%	10%	10%	5%	5%	10%	5%	20%	30%	1%	>20%	< 10 %	< 10 %	< 10 %	< 10%	< 10 %	< 10%	10%	30%	40%	10%	20%	40%
Vegetative Cover, %	0%	0%	0%	0%	~5 %	< 5 %	90%	90%	90%+	90%	70 %+	70%	90%	70%	50%	15%	5%	>75%	>75%	>75%	>75%	< 75%	>75%	>75%	>75%	30%	40%	< 50%	40%
Vegetative Cover (VC)					X					X					X						R				X	p			X
Mulch (MVC)						X	X	X	X											P	R			X	X		X	P	
Roughtening (RGHN)																		X			X						X		X
Brush Piles (BP)																			X	P	X								
Straw (Hay) Bales (SB)															X				X		R	X		X	R				X
Silt Fencing (SF)							X				R					P	X		X	P		X	P	R	R				
Rock Berm (RB)					X	X		X	X						X	X	X				R					P			X
Diversion Earthen Dikes(DD)					X	X		X			R			X	X	P			X							P		R	X
Road Surface Slope (RDSS)					X															P									
Drainage Dips (DIP)																													
Stabilized Const Entrance (SCE)	P	X	X	X						X	X	P	X									R							
Road-Side Ditches (RDSD)					R													X	X	P							X		
Turnouts or Wing Ditches (TO)					R																						X		
Construction Mats (CM)																													
Cross-drain Culverts (CULV)																		X		P					X				
Geotextiles Erosion Blankets (GEO)															X											P			
Sediment Traps (ST)										X	R			X	X	P	X				X								
Excelsior Logs																													X

Notes Filled Cells — represent options recommended by RAPPS Guidance for Region visited
Dotted Cells — represent options recommended by alternate Decision Tree selected during field visit
Hatched Cells — represent options recommended by alternate Decision Trees based on soil erodibility

NA Decision Tree for region does not accommodate slope
X represent options actually implemented at the site
P represents options planned to be implemented at the site
R represents options that would be recommended by Terracon

The soils at the four XM sites did not match the GD-RAPPS XM soil and erodibility assumptions. RAPPS were recommended at two sites in the XM geographic region, and were not recommended at the other two XM sites using the XM decision tree. The MM decision tree recommended RAPPS in one case where the XM decision tree indicated no RAPPS would be required. The MP decision tree recommended RAPPS at the two sites where the XM and MM decision trees did not recommend RAPPS.

The four MM sites had slopes of less than 10%, which were not accommodated by the GD-RAPPS MM decision tree; therefore, no RAPPS were recommended. The CP alternate decision tree characterized by highly erodible soils was used to evaluate RAPPS. The CP decision tree did not recommend RAPPS for three sites due to the distance to water and recommended RAPPS for one site.

The alternate decision tree analysis indicated that six additional sites would have required RAPPS if a decision tree based on soil type and erodibility had been utilized.

4.4 Additional RAPPS Observations

Field validation efforts indicate that the majority of oil and gas operators are implementing operational or procedural RAPPS (i.e. minimal disturbance of vegetation, managing slopes, minimizing the footprint of the disturbed area, project phasing/scheduling, good housekeeping, etc.) to reduce storm water runoff even when structural RAPPS are not required. Since operators typically use operational or procedural RAPPS, it may be more appropriate to indicate “Operational RAPPS Only” rather than “No RAPPS”. The use of “Operational RAPPS Only” reflects the practices that operators are typically using and documents the efforts that are a part of normal operations rather than indicating “nothing is required”.

Appendix A of GD-RAPPS includes descriptions and diagrams of 17 RAPPS. It includes three “operational” RAPPS (vegetative cover, surface roughening and mulch) and 14 structural RAPPS. Although the diagrams and descriptions are relatively useful for oil and gas sites, several RAPPS that are commonly used by operators are not included, such as: interceptor swales, pipe slope drains, wattles (also called Excelsior Logs®), rip-rap lined channel, etc. Some of the descriptions and diagrams in Appendix A do not reflect current industry practices. For example, the use of re-bar or steel rickets for straw bale anchors is discouraged in most areas and biodegradable stakes are preferred, and geotextiles/erosion blankets (GEO) are typically referred to as erosion control blankets and are available in a wide variety of materials, weaves and thicknesses depending on the application. Maintenance requirements associated with each RAPPS are not described and, in some instances, are the most important aspect of a RAPPS’ effectiveness.

5.0 FINDINGS & RECOMMENDATIONS

The findings and recommendations of the review and field verifications of the GD-RAPPS are described in the following paragraphs.

5.1 Findings

Geographic Regions

Terracon evaluated the geographic regions identified in Figure 1 of the GD-RAPPS by reviewing the source of the geographic regions (Ray Sterner, John Hopkins University) and discussing the basis for the differentiation of the six different zones with the author of GD-RAPPS. Based on our evaluation and discussions, the geographic regions are primarily differentiated by topography and physiographic data rather than erodibility or soil type..

Annual Precipitation

Although there are several areas that over predict annual precipitation data, the rainfall assumptions are generally accurate. The assumptions used in the decision trees provided accurate or conservative estimates of the precipitation at the sites.

Soil

Three of the RAPPS Decision Trees (D, XP and XM) are based upon the assumption that the soils in those geographic regions can be classified as being of “low erodibility”. With the exception of the Coastal Plains areas and a small portion of Texas, these three regions encompass the entire western United States. In essence, the GD-RAPPS is based upon the generalization that all the soils in the western United States are of low erodibility and recommends RAPPS accordingly. Of the remaining three regions for which a GD-RAPPS decision tree is available, two are characterized with soils of moderate erodibility (MM and MP) and one is characterized by a soil of high erodibility (CP)

Of the seventeen sites visited in the D, XP and XM regions, the soils at only a single site (sand at one site in the D region) would be characterized as being of “low erodibility”.

The soils at the four locations in the CP region, and the four locations in the MP region were consistent with the GD-RAPPS decision tree soil type and erodibility designation for those regions.

The soils at two of the four sites in the MM region were consistent with the GD-RAPPS soil type and erodibility designation for that area (moderately erodible). However, two sites in the MM region were characterized by silty loams, which generally match the soil type (loamy) designation in GD-RAPPS, but are characterized as highly erodible.

The assumption on the Mesic Plains decision tree that soils are moderately erodible without designating soil types is not sufficiently descriptive and may be misinterpreted by operators.

Overall, the soils at 45% of the sites visited were adequately characterized by the GD-RAPPS soil assumptions for their respective geographic region. Based on our evaluation indicating less than half of the soil types or erodibilities identified during the site inspections were valid for the specific geographic region, the soil type or erodibility assumptions in GD-RAPPS may commonly be inaccurate. The document oversimplifies the soil types identified in each geographic region. Based on a review of the NRCS maps, most, if not all, soil types identified in GD-RAPPS could be found in each geographic region and are not specific to any one area.

In each of the 16 sites where the soil type or erodibility did not match the GD-RAPPS assumptions, the erodibility was under predicted potentially resulting in RAPPS that may not be appropriate or sufficient to reduce sediment loss due to storm water.

Slope

Slopes of less than 10% are not addressed in the GD-RAPPS MM or XM decision trees. The GD-RAPPs decision trees neither provide an option for determining the needed RAPPS for sites having less than 10% slopes within these regions, nor do they specifically exclude such sites as not requiring RAPPS.

Although evaluations of slope in the MM and XM regions could be misinterpreted by operators, the field validations indicated that 24 of 29 slopes (83%) were accommodated in the decision trees indicating that most slopes at oil and gas construction sites can be evaluated in the GD-RAPPS decision trees.

Based on our literature search and use of sediment loss models, shallow slopes (<5%) may result in a significant amount of sediment loss.

The slope ranges used in the decision trees to select RAPPS in portions of GD-RAPPS can be very broad, and the actual slopes can be steep resulting in significant soil loss regardless of annual rainfall, vegetative cover and soil type.

Distance to Water

The field validations indicated that 41% of the time, an operator would have installed RAPPS based on the GD-RAPPS distance to water assumptions compared to Terracon recommending RAPPS 83% of the time. It should be noted that operators installed RAPPS at 24 of 24 constructed sites (100%).This indicates that the minimum distance to water assumptions may be too short, and the distance to water assumptions should be evaluated.

Distance to water has historically not been used as a factor in evaluating storm water RAPPS and , if used, the distances documented in GD-RAPPS may not be sufficiently protective of waters of the U.S.

The GD-RAPPS is vague regarding how the nearest regulated water body is determined. The decision trees reference the distance to water, whereas the document text refers to regulated water bodies, which include waterways that may be seasonally dry. This discrepancy may result in the distance to "live water" being confused with waters of the U.S. by oil and gas operators in the field.

Vegetation

The Desert geographic region's assumption that vegetative cover is less than 25% was evaluated by comparing the amount of vegetation observed in the five Desert sites. Based on the field inspectors and operators evaluation of vegetative cover, three of the Desert sites exhibited greater than 75% vegetative cover, while two of the five sites exhibited five percent or less of vegetative cover. Our evaluation indicates that the vegetative cover assumption may be invalid and varying amounts of vegetative cover could be found in the Desert geographic region.

Selection of RAPPS

The field validations indicated that RAPPS were required by GD-RAPPS for 10 of 29 construction sites (34%). However, RAPPS (documented in Appendix A of GD-RAPPS) were actually recommended by Terracon at 24 of 29 sites (83%) and installed by the operator at 24 of 24 construction sites (100%).

An evaluation of the four GD-RAPPS assumptions indicated 5 of 29 sites (17%) matched the four GD-RAPPS assumptions. Based on our evaluation indicating 17% of the sites matched the four geographic region assumptions, the user would typically try to select a different geographic region decision tree 83% of the time. However, when the user selected a different geographic region decision tree, one if not more of the assumptions would be commonly incorrect and the user would select RAPPS based on good judgment. Since the assumptions from the decision trees will commonly be inaccurate, the frequency of switching to another invalid geographic region decision tree appears to defeat the process of utilizing the decision trees.

During the site visits, an alternate decision tree was used by the field inspector to evaluate RAPPS at eight sites. The decision trees indicated that RAPPS would be recommended for one additional site than the original decision tree.

The subsequent alternate decision tree analysis using different geographic regions based on soil type and erodibility resulted in RAPPS for six additional cases.

RAPPS Options

Seventeen different RAPPS are presented in the Appendix of the GD-RAPPS. Of the RAPPS summarized there, two of the RAPPS (vegetative cover and stabilized construction entrance) are never recommended in the various decision trees, and one of the RAPPS (road side ditch) is always recommended.

Field validation efforts indicate that the majority of oil and gas operators are implementing operational or procedural RAPPS (i.e. minimal disturbance of vegetation, managing slopes, minimizing the footprint of the disturbed area, project phasing/scheduling, good housekeeping, etc.) to reduce storm water runoff even when structural RAPPS are not required. Since operators typically use operational or procedural RAPPS, it may be more appropriate to indicate "Operational RAPPS Only" rather than "No RAPPS". The use of "Operational RAPPS Only" reflects the practices that operators are typically using and documents the efforts that are a part of normal operations rather than indicating "nothing is required".

Several RAPPS that are commonly used by operators are not included in Appendix A, such as: interceptor swales, pipe slope drains, wattles (also called Excelsior Logs®), rip-rap lined channel, etc. Some of the descriptions and diagrams in Appendix A do not reflect current industry practices. For example, the use of re-bar or steel rickets for straw bale anchors is discouraged in most areas and biodegradable stakes are preferred, and geotextiles/erosion blankets (GEO) are typically referred to as erosion control blankets and are available in a wide variety of materials, weaves and thicknesses depending on the application.

Maintenance requirements associated with each RAPPS are not described and, in some instances, are the most important aspect of a RAPPS' effectiveness.

5.2 Recommendations

If a geographical region map is to be used, it should be based on physical features relevant to hydrogeology on a site-wide basis, such as rainfall intensity, rather than nation-wide topography.

The GD-RAPPS approach should address soil type and erodibility as a parameter of significant importance at each site rather than for an entire geographic region..

If slope is to be used in a RAPPS derivation, then the evaluation should include a 0 to 5% slope range as well as other increments.

Distance to water should not be a primary decision-making tool in RAPPS development because sediment can be transported significant distances depending on soil type, vegetative cover, slope and rainfall intensity, and because the term "water" or "regulated water" can be significantly misinterpreted.

The term "water" or "regulated water" should be replaced with a more generic and less legally significant term. One example of a suitable term is "drainage feature".

GD-RAPPS should include commonly used RAPPS, such as: interceptor swales, pipe slope drains, wattles (also called Excelsior Logs®) and rip-rap lined channel.

GD-RAPPS should include information explaining the conditions when a particular RAPPS should be used or which RAPPS might be preferred.

A RAPPS guidance document should recommend operational or procedural RAPPS as minimum measures at all oil and gas construction sites.

6.0 LIMITATIONS

Terracon's RAPPS Validation Findings project was conducted in accordance with Terracon's proposal dated August 4, 2007, as authorized by Mr. Lee Fuller with the Independent Petroleum Association of America (IPAA) on September 29, 2006.

6.1 Standard of Care

Terracon's services were performed in a manner consistent with generally accepted practices of the profession undertaken in similar studies in the same geographical area during the same time period. Terracon makes no warranties, either express or implied, regarding the findings, conclusions or recommendations. Please note that Terracon does not warrant the work of regulatory agencies or other third parties supplying information used in the preparation of the report.

6.2 Reliance

All reports, papers, and other documents developed and the right to copyright such reports, papers, and other documents, shall be the property of IPAA. All such materials are prepared for IPAA, and reliance upon them for any purpose by any other party is at that party's sole risk unless otherwise expressly provided for in a written agreement signed by duly authorized representatives of IPAA and Terracon. IPAA may use such materials in any manner which IPAA, in its sole discretion, deems fit and proper, including submission to governmental agencies, use in litigation, or use in proceedings before governmental bodies. Any unauthorized distribution or reuse is at the client's sole risk. Notwithstanding the foregoing, reliance by authorized parties will be subject to the terms, conditions and limitations stated in the proposal, report, and the Terms and Conditions of the Agreement between Terracon and the IPAA dated September 29, 2006. The limitation of liability defined in the terms and conditions is the aggregate limit of Terracon's liability to the client and all relying parties unless otherwise agreed in writing.

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