

Advanced Decline Curve Model for Stripper Well Production Analysis (METEOR)

Lead Organization: Advanced Resources International, Inc.

Key Contact: Larry Pekot (703-528-8420 or lpekot@adv-res.com)

Other Participants: Equitable Production, Belden & Blake

Level of Funding: \$80,000

Executive Summary

Successful stripper well production requires careful attention to cost control and this requirement extends to engineering and geologic evaluations to determine a stripper well's potential for remediation or production improvement. Thus, a premium should be placed on evaluation techniques that are fast, simple and reliable.

This project will meet this need by refining the use of advanced decline curve techniques into a fast and easy to use program that is designed specifically for low permeability, multiple completion gas wells. The availability of this program will provide a new tool to help analyze stripper wells allowing operators to make more informed decisions when considering well remediation, recompletion or drilling options in stripper production areas.

The applicant proposes to build upon an existing visual basic decline curve program, named *METEOR*, and incorporate additional advanced decline curve analysis techniques. Results of the program will be verified against a series of reservoir simulation cases constructed from real data taken from a variety of stripper well conditions. Based on industry feedback, considerable attention will also be given to create features that are fast and easy to use, especially concerning data input and output handling. This will allow the user an opportunity to evaluate low rate and low revenue stripper wells with a minimum of time and effort.

The project cost share will be supported by a \$25,000 cash grant from Equitable Production Company (Equitable) and a \$5,000 cash grant from Belden & Blake Corporation (BBC). Advanced Resources International (ARI), the project applicant, will also contribute \$5000 in unbilled labor and expenses. Equitable will also provide the well and reservoir data necessary for the program verification study. To complete the project as proposed, a sum of \$80,000 is requested from the Stripper Well Consortium.

Analysis of the Taylorstown Injectivity Problem

Lead Organization: Penn State University

Key Contact: Robert Watson (814-865-0531 or bob@pnge.psu.edu)

Other Participants: East Resources

Level of Funding: \$77,141

Executive Summary

During recent years, the Appalachian basin has experienced a regional drought. Surface water that could be used for oilfield purposes such as waterflooding and hydrofracturing has been in short supply and as a consequence, operating companies have been forced to look elsewhere for supplies of water. Water from sources such as abandoned coalmines and produced oilfield brine have been used to augment and/or replace water obtained from fresh water sources. Given the complexity of most formations in terms of composition, there is the possibility of a deleterious impact on field injectivity and well performance given a mixture of various waters.

The objective of this study is to undertake an analysis of the injection practices at the Taylorstown Field in Washington County, Pennsylvania, where the Gordon sandstone is under waterflood. Initial injection began in March of 1996 using a mixture of water obtained from an abandoned coalmine and brine obtained from Oriskany wells. In December of 1999, freshwater injection began. The rate of injection has steadily dropped from 4000-barrels/day in 1996 to 800-barrels/day at the present. The plan is to drill a well off-pattern, obtain a core and evaluate the core for the impact of different fluids on injectivity and develop a water/formation treatment plan.

The significance of this project in terms of the stripper well consortium is that operators are facing the need to use water from unconventional sources for oil field operations. This project will address some of the issues attendant to the complex chemistry of formations and the use of multiple water sources.

Analysis of the Wileyville Waterflood

Lead Organization: Penn State University

Key Contact: Robert Watson (814-865-0531 or bob@pnge.psu.edu)

Other Participants: East Resources

Level of Funding: \$59,054

Executive Summary

Gordon sandstone is one of many reservoirs located throughout the Appalachian basin that were developed for production during the nineteenth century and early twentieth century. Recovery of the remaining oil contained in the Gordon requires the implementation of secondary recovery methods such as waterflooding. The field infrastructure necessary for a waterflood is significant and its ultimate design a question of economics. Evaluation of the design often requires months given the fact that response at the production wells demands significant water injection. If no response is realized, the operator must reevaluate the project and consider a redesign of the injection pattern. Such is the case at the Wileyville Field in Wetzel County, West Virginia, which was designed using a line drive injection pattern. To date, approximately 5,000-Mbarrels of water has been injected with no response in the production wells. The principal objective of this project is to develop a mathematical model that can be used to assist the operator in revising the injection strategy.

The model will be developed using existing well and historical field data. Using the model, the location of a well to be drilled and cored will be made. The oriented core will be analyzed to determine the direction of maximum permeability and permeability contrast. The results of these analyses will be then be used to revise the model. Strategies for improving the performance of the waterflood will then be developed using the model.

One objective of the stripper well consortium is to enhance the production of stripper oil wells. Many stripper wells are found in areas undergoing waterflooding. Improvements in design methodologies and operating strategies will result in improving the performance of these wells.

Applying and Developing New Approaches for Maximizing Recovery in the Barnett Shale Gas Play: From Understanding Capillary Forces to Improving EUR's

Lead Organization: Republic Energy, Inc.

Key Contact: Jason Lacewell (940-683-5795 or jlacewell@republicenergy.com)

Other Participants: Texas A&M University

Level of Funding: \$73,000

Executive Summary

Development of new approaches and application of proven production engineering technology for improved shale gas recovery are the basis for this funding request. Republic Energy Inc. (REI) is an independent operator in the highly active Barnett Shale area in Ft. Worth Basin in north Texas, and is looking to applying stripper well technology in a pro-active manner. While the Barnett Shale is perceived to be one of the nation's hottest gas plays, the sizeable number of marginal and underperforming wells from an initial productivity and EUR standpoint makes this area ripe for support of improved production technology.

Water-fracturing completions have gained acceptance in this area in recent years (moving away from MHF's), improving fracturing economics and stimulating growth and activity throughout the play. However, the REI project team plans to improve upon (and hopefully redefine) a "successful" Barnett Shale completion by testing gas-water co-production application as an initial well completion / flowback method. The goals of the project are to drive investigation and development of the actual pore-level mechanisms that control well productivity and fractured reservoir cleanup – through a three-phase laboratory testing and operational plan. Large scale successes using co-production / dewatering have been applied in south Texas and Delaware Basin fields, and serve as models for application in the Barnett Shale. Significant benefit will be derived from university personnel expertise and facilities, where detailed analyses on capillary pressure / drawdown relationships, surfactants, mutual solvents will be integrated with field tests.

Once the pore-level production mechanisms are rigorously tested and understood, wide-scale benefit could be realized by applying this production technology– both from an initial productivity and gas EUR perspective - to maximize the Barnett Shale area resource.

Chamber Lift -A Technology For Producing Stripper Oil Wells

Lead Organization: Penn State University

Key Contact: Robert Watson (814-865-0531 or bob@pnge.psu.edu)

Other Participants: Bretagne GP

Level of Funding: \$53,162

Executive Summary

Arguably, the largest expense associated with operation of most stripper oil wells and many stripper gas wells is the lifting costs associated with the removal of fluids from the wellbore. Of the 400,000 plus stripper oil wells, half of the production is from reservoirs undergoing secondary recovery. Most of the remaining wells produce a small amount of fluid relative to the initial production. The predominant artificial lift method used is rod pumping. In most cases, the pumping equipment has not changed since the first production and thus the lifting system is inefficient. Moreover, much of the equipment is outdated and the maintenance costs large and increasing. The problem faced by the operator is how to upgrade the production systems at a low enough capital cost that the typical well can show a reasonable economic return on investment.

The proposed chamber lift system addresses the problem of minimizing capital investment. Gas is injected into the oil column via a small diameter tubing string that is set in the production tubing. This gas then displaces the accumulated fluid to the surface via the annular space between the injection string and the production string. The process is controlled using a sensor and motor valve located at the surface.

The proposed project calls for a field demonstration of the process. Prior to the field demonstration, a laboratory prototype of the system will be fabricated and tested. Pressure and flow measurements obtained will be used as input data to a hydrodynamic computer model that will provide to the well operator insights with respect to the field test. The field demonstration will be used to test the viability of the process.

Design, Development and In Well Testing of a Gas Operated Automatic Lift Pump

Organization: Brandywine Energy and Development Company
Key Contact: Gerald Swoyer (610-388-3824 or yanigapm@aol.com)
Level of Funding: \$60,000

Executive Summary

Much of the known natural gas reserves of the United States are not readily recoverable by conventional techniques. Natural gas usage in the United States is projected to double in the next two decades inviting improved methods of gas recovery. Tens of thousands of existing “stripper wells” lie dormant or under producing gas due to the build up of brines in the well bore. These “watered out stripper wells” could supply part of that projected increased demand if more efficient methods of brine removal or in well separation of brines from gas were available.

The primary objectives of this study will be to develop, deploy, monitor and evaluate an alternative technique for the enhancement of natural gas production from stripper wells. A unique gas pressure controlled functioning tool will be constructed. The tool will subsequently be tested in a “watered out” gas “stripper well”. Performance of the tool will be compared against current standard industry techniques for production of gas from brine-laden wells.

The tool/ technology will be constructed as a “gas operated automatic lift” pump. This tool will use the natural down hole pressure at the production zone of the well to operate a pressure sensitive automatically operated total fluids pump that will lift the fluids [brine and other fluids] to the surface. The well bore subsequently, sans brine, will allow natural gas flow to be restored from the well. The tool post delivering the brine to the process unit will automatically open its’ pressure sensitive valve at such time as the pressure in the well drops below the preset valve pressure. The tool with valve assembly held open by the pre-charged pressure subsequently will return to the production zone. There the tool will allow all fluids to pass through the tool until such time as a column of fluid builds atop the tool is greater than the preset pressure control of the internal valve. Once the valve is closed all subsequent pressure will again build behind the tool, once again lifting the tool and brine load to the surface with subsequent promotion of natural gas production. This automatic regular purging or lifting of the fluids to the surface when successful will be superior to the current variable and often ad hoc methods of brine removal that are dependant on work over rigs, installation of siphon tubing or pump jacks and manpower.

The tool/ technology will be tested in an existing water producing well. The technical performance/ differences and commercial viability will be evaluated and compared to currently employed conventional techniques such as “tubing and soaping” and other common production techniques for “watered out” wells.

The project being successful could significantly increase natural gas production from wells while decreasing the capital cost of currently deployed brine process hardware, operational cost of “well tending” and potentially decrease by products and environmental impacts of natural gas production.

This program will develop a novel tool for the production of natural gas from wells. Where successful this tool could improve the recovery and production from tens of thousands of low productivity natural gas “stripper wells”. This program could provide a more comprehensive environmentally benign technology for the production of gas from wells to supply the nations increasing domestic demand for clean energy.

Developing Methods to Identify Unstimulated and/or Ineffectively Stimulate Reservoirs Resulting From Multi-Stage Hydraulic Fracture Treatments

Lead Organization: Schlumberger Holditch-Reservoir Technologies, Inc.

Key Contact: Joseph Frantz (412-787-5403 or frantz@pittsburgh.oilfield.slb.com)

Other Participants: Equitable Production, Schlumberger Dowell

Level of Funding: \$100,000

Executive Summary

This proposal is submitted by Schlumberger Holditch-Reservoir Technologies (H-RT), Dowell, and Equitable Production (Equitable) to perform an evaluation in the area of reservoir remediation, characterization, and operations. Several groups of Equitable's Appalachian Basin wells in West Virginia (WV) and Kentucky (KY) will be used in this study. The objective of this project is to identify unstimulated and/or ineffectively stimulated reservoirs in stripper wells treated with multi-stage hydraulic fracture treatments. Multi-stage involves pumping two to four hydraulic treatments in a well with many low-permeability formations perforated and open to each treatment. Multi-stage treatments are common in the Appalachian Basin and in many low-permeability wells across the U.S., because multiple sand, shale, and carbonate reservoirs often occur over a thick, stratigraphic interval. Based on our experience, it is unlikely that all perforated intervals are treated effectively when performing multi-stage stimulation treatments due to the large gross interval open in the wellbore.

Using existing data and by collecting new downhole diagnostic data, we will determine the extent of stimulation in the perforated intervals in three groups of study wells. The downhole diagnostic data includes spinner surveys, isolation, communication, and injection/falloff tests, hydraulic fracture data analysis, tracer log analysis, and production data analysis. The three study groups will be located in WV and KY to evaluate a representative sample of Equitable's wells. In one or more test wells, Equitable plans to stimulate the unstimulated and/or ineffectively stimulated intervals identified by this study. The wells treated with multiple nitrogen stimulations will be of special interest, since many operators in the Appalachians Basin have switched to this method as the fluid of choice over the past five years. We will also evaluate wells treated with nitrogen-foam and possible other fluids depending on the data available for study.

At the end of the project, an evaluation methodology will be developed for use by any Appalachian Basin operator to determine which formations were ineffectively stimulated with past treatments. We anticipate that this methodology will also be useful for other operators throughout the United States where multi-stage treatments are pumped. Finally, we plan to identify new field test procedures and/or tools that should be developed to better assess stimulation effectiveness in the future. These procedures and/or tools can be included in future solicitations by the Stripper Well Consortium (SWC).

Ultimately, we believe that this work could result in paradigm shift for operators. If they understand that certain formations were not simulated and/or not effectively stimulated, they will restimulate these formations in existing stripper wells. This project could result in substantial new production from stripper wells for Appalachian Basin operators. Given the high value of natural gas, even very low flow rates resulting from restimulations may be economic. Operators may also change their field stimulation procedures in new wells to treat all formations more effectively.

The potential benefit to the Appalachian Basin stripper well community may be significant. We believe that about 75% of the 66,000 stripper wells in Pennsylvania (PA), WV and KY were stimulated with multi-stage treatments. We estimate that 50% of these (about 25,000 stripper wells) may have restimulation potential, but only half of them (12,500 wells) may be in sound mechanical condition for restimulation. If the restimulation treatments result in a 10 to 20 Mscf/d production increase per well, the overall significance to the Appalachian Basin is large. We estimate a potential impact to the Appalachian Basin of 187 MMscf/d or 68 Bscf/year if all the mechanically-sound stripper wells in PA, WV and KY were restimulated. This represents a 20% increase in the current total stripper well gas production level in these 3 states. This could represent \$273 million in new revenue.

Development of Diagnostic Techniques to Identify By-Passed Gas Reserves and Badly Damaged Productive Zones in Gas Stripper Wells in Rocky Mountain Laramide Basins

Lead Organization: Innovative Discovery Technologies

Key Contact: Ronald Surdam (307-745-4464 or rcsurdam@idt-gti.com)

Level of Funding: \$29,770

Executive Summary

In Rocky Mountain Laramide Basins (RMLB), over 80% of gas production is from anomalously pressured rock volumes that extend from an upper regional pressure surface boundary (i.e., boundary between normal and anomalous pressure regimes) to 2000 ft below this boundary. Until recently and certainly during drilling of most gas stripper wells, the position of the pressure surface boundary in the RMLB was unknown. Experience led drillers to anticipate only overpressuring at depth, which led them to increase mud weights during penetration. However, in most of the RMLB, the rocks *immediately* below the regional pressure surface boundary are underpressured and form a transitional zone between the boundary and deeper, overpressuring rock volumes. The lack of understanding of the transition between pressure regimes led to considerable bypassed pay and damaged productive zones in ostensibly the most productive part of the RMLB, and this resulted in numerous gas stripper wells (or drilled and abandoned wells). The potential to recover significant gas reserves from these wells in the RMLB is huge.

The essential problem to be addressed in the proposed work is how to identify bypassed gas and badly damaged productive zones in RMLB gas stripper wells and convert the significant gas resource residing in these wells to reserves. These objectives will be accomplished by completing the following tasks:

- Acquire/evaluate sufficient data to determine the extent to which bypassed gas and damaged productive zones occur in RMLB gas stripper wells in underpressured regimes.
- Develop analytical techniques that allow operators to efficiently determine the potential for bypassed gas and damaged production in their gas stripper wells.
- Enable RMLB operators to design effective remediation and recompletion strategies for gas stripper wells in the underpressured zone beneath the regional pressure surface boundary (i.e., the regional velocity inversion surface).
- Transfer technology to RMLB operators at workshops in Denver, CO and Casper, WY.

The proposed work will result in a detailed description of the (1) thickness of the underpressured zone; (2) distribution of gas-charged sands and fractured shales; (3) production characteristics of representative gas stripper wells; and (4) distribution of the rock-fluid system that has been exposed to overcompensated mud weight (i.e., the potential damage zone). Integrating these data will allow development of new diagnostic techniques and analytical procedures to identify bypassed pay and badly damaged productive zones in RMLB gas stripper wells, and will allow operators to design vastly improved remediation and recompletion strategies for their gas stripper wells.

Environmental and Regulatory Issues Relating to the Utilization of Recycled Produced Water from Oil and Gas Operations: 1: A Study of Existing Policies of State and Federal Agencies, 2: Development of an Approved Program for Re-Use of Water

Lead Organization: Texas A&M University

Key Contact: David Burnett (979-845-2274 or burnett@gpri.org)

Level of Funding: \$56,649

Executive Summary

The Texas Water Resources Institute (TWRI) at Texas A&M University funds an interdisciplinary faculty team to focus on the re-use of water resources in the oil and gas industry. That project is being led by the Department of Petroleum Engineering at A&M. It is proposed that the Stripper Well Consortium participate as we work with the regulatory agencies to change their policies regarding re-use of this valuable resource. For this project with the SWC, we will conduct our study in two regions, the Eastern U.S. region (New York, Pennsylvania, West Virginia) and the Southwestern region (Texas, New Mexico, and Oklahoma).

The objective of this project is to create a program to effect change in the regulations governing the reuse of treated oilfield brine for use as a resource to the public.

The methods to be used are:

- 1) To document the existing policies of the two oil and gas producing regions.
- 2) To work with the independent operators and appropriate agencies to develop guidelines for companies to follow for making this new source of fresh water available for productive use.
- 3) To develop new practices to meet the needs of the oil and gas operator while maintaining the safety of the community..
- 4) To establish a Directory of Regulatory Information for the use of members of the SWC. A&M will maintain and update the Directory for the benefit of the Consortium members who wish to plan projects involved recycled produced water.

The program will utilize the resources of Texas A&M University in the field environmental assessment, decision support modeling, environmental risk modeling, toxicology, environmental remediation, waste management and waste water handling with emphasis on agricultural and industrial related natural resource and environmental quality issues. Water treatment programs include a robust and technically advanced oversight and audit program, administered by specialists in the field of genetics and toxicology. The resources of these groups will be available to members of the Stripper Well Consortium.

Identification of Effective Fluid Removal Technologies for Stripper Wells

Lead Organization: James Engineering

Key Contact: Tim Knobloch (740-373-9521 or jeitsk@ee.net)

Level of Funding: \$85,070

Executive Summary

James Engineering, Inc., a petroleum engineering consulting firm in Marietta, Ohio presents the following proposal to the Stripper Well Consortium to develop and deliver a procedure guide to identify cost-effective fluid removal technologies for stripper wells.

James Engineering, Inc. proposes leveraging its years of experience with stripper wells combined with prior work performed for the Department of Energy to develop a procedure guide to address the problem of abnormal production decline resulting from fluid accumulation in stripper wells.

The prior study performed for the Department of Energy yielded the surprising fact that the largest problem contributing to abnormal production decline in stripper gas wells was the result of fluid accumulation in the wellbore. This study proposes to develop methodologies including decision trees and procedure guides to economically identify the most effective fluid removal technology for specific stripper well characteristics. The application of systematic methodologies and techniques will increase the efficiency of problem assessment and implementation of fluid removal solutions for stripper wells. Effective fluid removal from stripper wells will benefit every producer by increasing production and ultimate recoveries since it is the most common production decline problem.

The results of this study will be presented at Petroleum Technology Transfer Council meetings and or in a Society of Petroleum Engineering paper to be presented at the Society of Petroleum Engineers Eastern Regional Meeting, and on the Internet.

New Technologies for Lifting Liquids from Natural Gas Wells

Lead Organization: Colorado School of Mines

Key Contact: Richard Christiansen (303-273-3965 or rchristi@mines.edu)

Level of Funding: \$93,944

Executive Summary

Objective. Test and develop new technologies for lifting liquids from natural gas wells, focusing on methods to enhance production of droplets at low gas flow rates.

Motivation. When initially completed, many natural gas wells are capable of lifting liquids to the surface. But, with depletion of the reservoir pressure, there comes a time when liquids can no longer be lifted to the surface and they begin to accumulate in the bottom of the well, dramatically inhibiting or stopping gas production. The cause of diminished liquid-lifting ability is the decline of liquid droplet production at gas flow rates below the Turner-Hubbard-Dukler critical velocity.

Specific Directions. Listed below are three proposed tasks for developing technologies that enhance droplet production and facilitate lifting at low gas flow rates. Tasks 1 and 2 will be completed during the first year of this work. If SWC chooses to fund a second year or if a suitable industrial partner is found during the first year, Task 3 will be implemented.

- 1. *Enhancing droplet production.*** To overcome the limitation of diminished capacity for droplet generation at the low gas velocities of stripper gas wells, devices that stimulate droplet production by sonic and ultrasonic means will be tested and developed in the flow loop. Suitable methods of application in well-bores will be developed.
- 2. *Integrated modeling of gas well production.*** Test and develop a numerical model that combines the complexities of two-phase flow in the wells and the adjacent reservoir with the droplet-stimulation technologies. Use this model to develop plans for field testing.
- 3. *Field testing of new technologies.*** Using the results of Tasks 1 and 2, proceed to field testing of the most promising technologies. Find a suitable business partner for these tests.

On-Site Treatment of Brine

Lead Organization: Hart Resource Technologies
Key Contact: Paul Hart (724-349-8600 or harthrt@microserv.net)
Other Participants: Penn State University
Level of Funding: \$57,975

Executive Summary

Hart Resource Technologies Inc. (HRT), has a unique technology to provide a comprehensive wastewater treatment system to meet the wastewater disposal demands of the Appalachian oil and gas industry and is requesting to develop it. The process will prove to be efficient and cost effective, compared to existing methods, for the treatment of brine water, a wastewater by-product of oil and gas production. HRT plans to initiate research and development of the process in cooperation with Pennsylvania State University, pending federal funding. Completion of this study will enable HRT to focus on those areas that have the greatest cost savings to the industry and positive effect on the environment. Paul Hart, President of HRT, has 16 years of experience with treatment and disposal of wastewater from the oil and gas industry. HRT is the only approved disposal facility with experience in designing, constructing, and operating an evaporator for the treatment of gas well brines.

Through researching previous failed attempts to provide an on-site treatment of the brine water, HRT has discovered that pretreatment is necessary. HRT has perfected the pretreatment process at its existing plant in Creakside, PA. Research assistance is needed to develop a mobile process to evaporate all the treated brine water at the site where the brine is generated. All the equipment needed for treatment of the brine water will be included on one mobile vehicle. Also, only one employee will be needed to perform the required process, which in turn will keep costs low. The focus of the research will be on the development of a mobile evaporator designed to reduce the volume of the treated brine water at the well site.

The market for brine water disposal encompasses all oil and gas producing regions in the Appalachian Basin which includes New York, Pennsylvania, West Virginia, Eastern Ohio, Kentucky and Tennessee. This is a vast area for existing companies to cover by means of permanent centralized facilities for treating water because of high transportation costs. Injection wells for disposal have not been successful in New York, Pennsylvania, West Virginia, and other areas. The development of this new portable brine treatment process will lower costs to producers with marginal wells to allow them to be more competitive. The costs of on-site treatment will be considerably lower than centralized treatment due to lower capital costs, fewer man-hours, and lower transportation costs. Less time is needed for on-site treatment, so up to four different sites can be completed in a given shift of an employee depending on the location, volume, and quality of brine. HRT recognizes that this process technology will change the disposal market dramatically by providing the industry more convenience at a lower cost.

Optimization of Plunger Lift Performance in Stripper Gas Wells

Lead Organization: Colorado School of Mines

Key Contact: Erdal Ozkan (303-273-3188 or eozykan@mines.edu)

Other Participants: Marjo Operating Company

Level of Funding: \$95,261

Executive Summary

Low volume, stripper gas wells are usually produced by plunger lift. These wells are put on a timer clock that regulates the production and shut in periods. Some techniques are available to determine the production and shut in periods but they do not use the reservoir performance as their bases. The objective of the proposed work is to develop an algorithm that can optimize the production and shut in periods based on the knowledge about the reservoir parameters.

The technical approach will be the development of a solution for the flush production problem. This is a solution of the diffusion equation for a mixed inner boundary condition that reflects the sequences of constant pressure production and constant rate shut in periods. This solution is then used to develop an optimization algorithm for the performance of the well. The reservoir parameters required by this approach will be obtained by matching the prior production performance of the well and will be regularly updated. The algorithm will, then, be put in an electronic box that will monitor the casing pressure continuously, and based on the pressure information, send a signal to either shut in or produce the well.

The proposed approach is practical and cost effective. The validation of the proposed method will be checked on stripper gas wells in Oklahoma that will be provided by Marjo Operating Co., Inc. The technology will be transferred to the interested parties, through progress reports, publications, and informal contacts.